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<td>McGrath, S., Madden, E., Madden, M., Corcoran, P., Keane, M. (eds.) (2012) UL - NUI Galway Alliance Second Annual Research Day - Book of Abstracts</td>
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UL – NUI Galway Alliance
Second Annual

Research Day

Faculty of Science + Engineering, UL
Faculty of Engineering and Informatics, NUIG

3rd April 2012
University of Limerick
Welcome to the Faculty of

The Faculty of Science and Engineering welcomes you to the second annual UL- NUI Galway Alliance Research Day.

The Faculty of Science and Engineering is a vibrant faculty with 250 faculty and staff supporting over 3500 students studying on some 40 academic programmes.

Research is central to the Faculty mission combining academic excellence and application in meeting industrial and social needs. The Faculty has developed extensive research capabilities across all academic departments and associated centres, in addition to three world-class research institutes.

Three Faculty Learning Support Centres in Science, Mathematics and ICT offer one-to-one support to students with drop-in centres and supervised study areas. Access to personal tuition and additional learning resources are open to all our students.

Centre for Excellence in Mathematics and Science Teaching and Learning which is associated with the Faculty provides assistance to both teachers and pupils.

The Faculty offers taught and research postgraduate programmes at Graduate Diploma and Masters Degree level having over 500 researchers currently pursuing a doctorate qualification.

PROFESSOR KIERAN HODNETT
Dean
Faculty of Science and Engineering

Editors:
Dr Sean McGrath
Ms Eileen Madden
Dr Michael Madden
Dr Peter Corcoran
Dr Marcus Keane
### University of Limerick & NUI Galway

**Faculty of Science and Engineering Research Day**

*“Collaboration”*

**Tuesday 3\(^{rd}\) April 2012**

**FG042, Foundation Building, University of Limerick**

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<td>Welcome Address – Prof. Kieran Hodnett, Dean of Faculty</td>
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<td>10.00</td>
<td>Midas Consortium Ireland – John Blake</td>
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<td>10.30</td>
<td>UL and NUI Galway Collaboration on Materials for Energy - Sean Leen</td>
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<td>11.00</td>
<td>Research in the Fast Lane - Risks and successes of academic/industrial collaboration – Daniela Butan</td>
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<td>11.30</td>
<td>Research Collaboration on a European Project between UL and NUIG – Alan Bourke</td>
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<td>12.00</td>
<td>European Research Overview – Sharone O’Loughlin</td>
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<td>12.30</td>
<td>Lunch &amp; Poster Viewing</td>
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<td>1.45</td>
<td>Vehicle Trials with Sustainable Biofuels – Orla Madden</td>
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<td>2.15</td>
<td>EI Strategic Partnership – Cormac Cantwell</td>
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<td>Post-Graduate speakers - Five Selected (10mins each)</td>
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ABSTRACT
Biodegradable materials have received major attention as they offer the possibility to overcome the many clinical limitations of Bare Metal Stents (BMS) and Drug Eluting Stents (DES). To date, biodegradable polymers have been successfully used for medical applications such as implants, cell scaffolds, sutures as well as surface coatings for local drug delivery [1-3]. The rationale of biodegradable solutions for circumventing clinical stenting obstacles (i.e. restenosis, in-stent thrombosis and vessel patency) stems from their material characteristics. More specifically, ability to degrade over time and deliver biologics and pharmaceutics to specific diseased lumen sites [1-2, 4].

1. INTRODUCTION
In order to realise the full potential of these materials as viable stents, the limitations of biodegradable polymer stent modelling need to advanced so as to simulate in-vessel conditions more accurately over time. There is clear lack of long-term experimental data which accurately represents real geometries in-vivo [2-3]. More specifically, there is a lack of data on the factors that influence degradation rates and how this behaviour affects the load-carrying capacity that an implanted stent would need to maintain its mechanical stability within the vessel for the desired period.

2. MATERIALS AND METHODS
Work to date has focused on implementing theoretically derived models of mechanical behaviour presented in literature into FE simulation software Abaqus. For the purpose of understanding how the change of mechanical properties as a function of time affects stent models. Fundamental stress/strain studies of the real stent geometry imported into Abaqus facilitated stent expansion on a rigid cylinder inside a hyperelastic artery representation. For this study PLLA material properties have been used. A fundamental understanding has thus been established that has provided a research platform for future experimental and simulation analysis.

3. RESULTS
Figure 1 shows an FE simulation of a PLLA stent partially expanded on a rigid cylinder representing balloon expansion, prior to degradation. A non-uniform stress distribution is observed, which may have implications on local degradation rates across the stent structure.

4. FUTURE WORK
Future work will focus on the implementation of experimental elastic-plastic polymer data to evaluate the potential of selected material. Thus more complex parameters will be integrated (through the use of USDFLD and UMAT’s within Abaqus) to accurately portray how biodegradable materials break down as a function of time and to evaluate the mechanical strength needed to keep a stenosed vessel open. It is envisaged the ultimate model will generate a biodegradation framework for polymeric materials that can be used to optimise stent materials and structural designs. Facilitating knowledge of a much broader spectrum of biodegradable materials via prompt simulation targeted at the healthcare sector has the potential for real commercial impact.

5. ACKNOWLEDGEMENTS
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MICROWAVE IMAGING FOR BREAST CANCER DETECTION USING FORWARD-BACKWARD TIME-STEPPING

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Abstract
In this work, an inverse scattering technique known as forward-backward time-stepping method is used to reconstruct two dimensional images from an MRI-derived heterogeneous model of the human breast. To compensate for the dispersion and attenuation effects, a space-time filter is applied in the inversion process. The effectiveness of the technique is assessed by numerical simulation.

1. Introduction
Breast cancer has become one of the most significant threats to women’s health worldwide which has led researchers to investigate and develop systems for early stage cancer detection and categorisation. Microwave imaging has received much attention recently, being non invasive, non ionising and more economical compared with other modalities such as MRI, PET, X-rays, and Ultrasound.

Microwave breast imaging can be classified into two categories: a radar based approach which constructs an image based on scattered data from abnormalities in the breast, while the second technique called microwave tomography, reconstructs the spatial distribution of dielectric properties of the breast tissue using inverse scattering algorithms. The radar based technique is faster but gives only the location and size of the tumour while tomography is computationally expensive but produces a complete dielectric profile of the breast giving the locations, shapes and sizes of any abnormalities present. In this work an inverse scattering approach known as the Forward-Backward Time-Stepping (FBTS) method is used to reconstruct the dielectric properties of breast tissue. This method was proposed by T. Takenaka [1], and again in [2] with the introduction of a low pass filter to improve the convergence of algorithm. FBTS, involves implementation of the Time-Reversed Finite Difference Time Domain (FDTD) technique which has shown issues when used on a dispersive medium as found in human breast tissue. The attenuation and deformation introduced in a transmitted signal by the dispersive nature of human tissue is compensated by space-time filtering applied at the receiver.

2. Methodology
Numerical simulation is performed by formulating the breast model and antennas using the FDTD method. An array of antennas is placed around the breast where each antenna transmits, one at a time while all the others receive. A set of recorded signals from all the antennas in an MRI derived numerical model of breast is compared with data recorded from an equivalent estimated model. Reconstruction of the target region is achieved by minimising following cost function:

\[ Q(p) = \int_0^T \sum_{m=1}^{\infty} \sum_{k=1}^{\infty} K_{mn}(t) \left| V_m(r_n, t) - V_m(r_n, t) \right|^2 dt. \]

Where \( V_m(r_n, t) \) and \( V_m(p; r_n, t) \) are electromagnetic fields recorded at receiving point \( r_n \) in the MRI derived numerical model of the breast and an equivalent estimate of the reconstruction region due to transmitter \( m \). The set of electrical parameters \( p \) is estimated by using a gradient based optimisation technique. The term \( K_{mn}(t) \) is a non-negative weighting factor.

A discrete Short Time Fourier Transform is performed on the received signals to apply time windowing and selective filtering. As the signal undergoes different levels of attenuation at different frequencies and different temporal positions, it requires selective filtering to compensate for the attenuation and deformations introduced by the propagation medium.

References
Computational Investigation into the Mechanics of a Thin Film Coating used on an Orthopaedic Implant upon Insertion into the Femur

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Abstract

It has been proposed to use drug eluting, thin film coatings on cementless orthopaedic implants. High contact stresses are observed at the bone-implant interface at a macro level, these stresses are further enhanced at asperity tips on a micro level. The present study incorporates multiscale finite element analysis and complementary experimental work to assess any damage or delamination which may occur to the coating.

1. Introduction

Cementless total hip arthroplasty is increasingly becoming the hip replacement surgery of choice with common design features including bioactive surface coatings [1]. Also, the delamination of thin film polymer coatings used on cardiovascular stents has previously been investigated [2]. The novel use of thin film coatings on orthopaedic implants is proposed.

During the implantation of press-fit femoral stems, high contact stresses develop at the bone-implant interface. At the micro-scale, such stresses are further magnified due to asperity interaction between the rough bone and HA coating surface profiles. Resulting stress concentrations potentially lead to problems associated with coating damage, buckling and delamination.

In the present study; a multi-scale computational framework is implemented in order to determine the primary modes of failure of orthopaedic coatings during device implantation.

2. Materials and Methods

Figure 1a shows a macro-scale, axisymmetric finite element model of the insertion of a femoral stem into the femur. Isotropic, linear elastic material properties were assumed throughout the model (Abaqus v6.9). A parametric study was performed to investigate the influence of friction, insertion depth of the stem and interference fit on resultant bone and coating stresses. The normal and shear contact stresses at the bone-coating interface were computed.

Micro-scale models were created using trabecular bone and coated surface geometries determined from profilometry. The coated surface was partitioned such that a distinct layer was formed with unique material properties, representing our thin film coating (Figure 1b). The stress was computed between the two surfaces in normal compression, using results derived from our macro models as the nominal stress.

3. Results

Macro-scale modelling identified regions of high normal and shear stress at the bone-coating interface. High contact stresses were computed at the proximal portion of the stem. Increasing the coefficient of friction from 0.3 to 1.0 and increasing the depth of insertion of the stem into the femur, increased the maximum contact stress by 36% and 10% respectively. The inclusion of an interference fit lead to a general increase in the contact stress state of the interface.

Nominal stresses applied to our micro model were derived from our macro model. Micro-scale modelling predicted compressive stresses at asperity tips in the coating ~4 times higher than those computed using macro-scale analyses.

4. Discussion

We have identified regions of high contact stress on the femoral stem through our macro-scale computational models. These regions are potential sites of coating damage and are investigated further using micro-scale models. This analysis predicts a four fold increase in compressive stresses over that of the applied nominal stress. Cohesive zone modelling will be implemented in future studies to predict micro-scale coating buckling due to elevated compressive coating stress.

5. References

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Heat-Shock Induced Cellular Responses to Orthopaedic Cutting

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Abstract
During surgical cutting, bone and the surrounding tissue are exposed to harsh conditions including elevated temperatures. Such elevated temperatures may result in thermal necrosis and apoptosis and the thermally damaged bone must be removed before healing can begin. In contrast, mild heat-shock has been shown to induce bone cell regeneration. We propose that there is a synergistic effect of minimising heat-shock to ≤47°C, which minimizes cell mortality and also induces mineralized matrix production.

1. Introduction
Orthopaedic cutting procedures critically rely on engineering technology that allow the surgeon to access organs of the body, or replace defective joints, while minimising harm to surrounding tissue. Severe heat shock (≥47°C) can cause thermal damage to bone cells [1] and tissue [2] causing cell death and initiating a resorptive response to remove dead cells. These events delay healing and may prevent osseointegration of orthopaedic implants [2-4]. In contrast mild heat-shock (≤47°C) has been proposed to induce bone tissue regeneration [5]. To date there is a specific lack of knowledge regarding the precise thermal elevations that occur during surgical cutting and how these influence cellular viability and postoperative tissue regeneration. There is a distinct need for continual innovation of surgical instrumentation to reduce the time required to complete procedures and enhance post-surgical patient outcome by minimising healing time. Our objectives are to investigate (a) the immediate and long term effects of heat shock on bone cell necrosis, apoptosis and viability, b) the regeneration capability of osteoblastic cells following heat shock.

2. Materials and Methods

Cellular Heat-Shock: Balb/c Mesenchymal Stem Cells (MSC), osteocyte-like MLO-Y4s and osteoblast-like MC3T3-E1s exposed to media at 37°C (control), 45, 47 or 60°C for 30seconds or 1minute and then cultured for 12, 24 hours, 4, 7 and 14 days recovery.

Cellular Viability: Apoptosis and necrosis in MLO-Y4 and MC3T3-E1 cells immediately after exposure and following 12, 24 hours and 4 days recovery was performed by flow cytometry (BD FACS CANTO) using propidium iodide (PI) and Annexin V-FITC.

Cellular Regeneration: Alkaline phosphatase (ALP): ALP was measured colorimetrically using p-nitrophenyl phosphate. Mineralization: Cells stained with alizarin red, the stain was extracted using cethylpyridium phosphate.

Cell Proliferation: Cell lysate was measured for DNA content using Hoechst dye.

3. Results

Cellular Viability: An immediate depletion in both cell populations was observed after exposure to 60°C with a negligible healthy cell population at 4 days. An initial necrotic response to heat-shock occurs at elevated temperatures, and was most prominent in cells exposed to 60°C in both cell lines (Fig 1). An additional longer-term apoptotic response was seen in MLO-Y4s after 24 hours, and was not observed in MC3T3-E1s.

Figure 1: Effect of heat-shock on osteoblasts and osteocytes immediately after and following recovery of 24 hours and 4 days.

Cellular Regeneration: After 7 and 14 days recovery an increase in both ALP secretion per cell and calcium deposition is seen in MSCs exposed to mild heat-shock (≤47°C) when compared to control and cells exposed to 60°C. Interestingly, MSCs exposed to severe heat-shock produced the most mineral per cell.

4. Discussion
This study shows the effects of exposure to heat-shock are dependent on temperature, duration of exposure and phenotype of the cell. Osteocyte-like cells are more resilient to heat-shock than osteoblasts which might reflect their role as sensory cells, detecting damage and initiating a response in neighbouring cells.

ALP production following mild heat-shock (≤47°C) indicates MSC osteogenic differentiation and mineralisation, which are consistent with our Alizarin Red results. Mineralization results are particularly intriguing, indicating increased calcium production per cell with increased heat-shock. However, we see a hugely depleted cell population size after exposure to severe heat-shock. Thus confirms the importance of a critical temperature having a synergistic effect of minimising cell mortality and inducing mineralisation. These studies will provide a pre-clinical tool to inform the design of next generation surgical instrumentation, having an advanced understanding of post-operative healing, and an overall goal to improve patient outcome.

8. References:
Combining Customer and Firm Expertise for Medical Device Innovation: A Practical Framework

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Abstract
This research sets out to construct a best practice framework from practical observations and academic findings to increase the development of marketable products. The framework facilitates Irish Medical Device Sector firms increase their product innovations, by capitalising on both customer end user expertise and infirm product knowledge. Current ‘inspiration and ‘ideation’ phase practices at firm level observed through empirical are combined with prescriptive findings from literature to construct the framework, in which the engineer plays an important continuous role from ‘inspiration’ to product launch. The resulting framework is iterative, cyclical, and holistic contributing to increases in the production of Medical Devices.

1. Introduction
Ireland must regain both its market position and competitiveness if it is to attract new investment [1]. This is achievable through innovation in general and product innovation in particular [2]. The study focuses on the Irish Medical Device Sector which employs 24,000 people in 160 firms generating sales in excess of €6bn. It includes many of the world’s leading corporations. The sector’s viability and growth therefore is of great importance to the economy. However, their survival depends on their ability to develop successful products. As experts in the field of product or potential product use, customers are valuable assets to innovating firms. How that asset is optimised for successful product development in practice is area explored in this research.

2. Research Goal
Satisfying customer needs in the development of a successful product continues to generate much academic research. The models and solutions offered by research however are prescriptive in the main [3, 4], highly focused [5] and provide little in the way of practical guidance for implementation or navigating challenges. In contrast, the practicalities of involving customers and capitalising from their field expertise in product development, remains virtually unexplored. The goal of this research therefore is to provide a practical framework to assist firms improve or increase their level of product innovation through customer involvement.

The constructed framework builds on previous models which are cyclical [3] iterative [4] and use empathic [6] and customer focused design [3]. It is also dependent on the involvement of the engineer/designer (inventor[4]) from customer interface to market launch.

3. Method
Qualitative research design and an empirical study in the Irish Medical Device Sector using survey and case study methods uncover the practicalities and current level of customer involvement in product innovation. While literature synthesis in the ‘Ideation’ and ‘Inspiration’ phases of product development provide an abundance of studies and models. By combining the empirical findings with iterative and cyclical models from literature, the framework is constructed.

4. Conclusion
This study constructs a best practice framework which capitalises on customer field expertise. The framework is offered to Medical Device firms and contributes to ongoing research in the area of increasing product output through customer expertise and firm knowledge.

5. References
Estimating the optimum timing for chondrogenic priming of MSCs to recreate the
Endochondral Ossification Process in vitro

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Abstract

During early fetal development long bones are developed by means of a process called endochondral ossification, which begins when chondrocytes condense, proliferate and produce a cartilage template. Over time the cartilage matrix is invaded by blood vessels, osteoclasts, bone marrow stromal cells (MSCs) and osteoblasts, which deposit bone upon this template [1]. In this study we propose to use tissue engineering approaches to recreate the endochondral ossification process. The first step is to estimate the optimum timing for chondrogenic priming of MSCs.

1. Introduction

Previous in vitro tissue engineering approaches to regenerate bone have shown that osteoprogenitors grown in the presence of specific growth factors and on biodegradable scaffolds can initiate an osteogenic response indicative of bone formation [2]. However existing tissue engineering strategies are limited and novel bone tissue engineering approaches are required to replace degenerated bone.

In our studies we propose that delivering biochemical and mechanical factors in a temporal fashion that recreates endochondral ossification will enhance bone tissue regeneration in vitro.

2. Materials and Methods

MSCs harvested from BALB/c mice were maintained in expansion media (IMDM supplemented with 10% FBS, 10% HS and antibiotics) prior to experiments. Once the cells reached confluency pellets were formed (500,000 cells/pellet). These pellets were then cultured under different experimental conditions to encourage chondrogenesis or osteogenesis at varying time points as follows; Osteogenic: MSC pellets were cultured in osteogenic media only for 49 days (expansion media plus β-glycerol phosphate, ascorbic acid and dexamethasone); Chondrogenic: pellets were cultured in chondrogenic media (CDM plus TGF-β1, linoleic acid, ascorbic acid and dexamethasone) for 49 days; Chondrogenic and Osteogenic: pellets were cultured as follows; C&O1: pellets were cultured in chondrogenic media for 10 days followed by osteogenic media for 39 days; C&O2: Chondrogenic media for 21 days followed by osteogenic media for 28 days; C&O3: Chondrogenic media for 28 days and followed by media for 21 days; and C&O4: Chondrogenic media for 35 days followed by Osteogenic media for 14 days.

DNA content (Hoechst assay), Alkaline Phosphate (ALP) activity, proteoglycan content (DDMB), Calcium Content (Calcium assay), mineralisation (von Kossa & Alizarin Red), GAG content (alcin blue) and collagen production (Picrosirius Red) were analysed for each experimental conditions after time periods of 1, 10, 21, 28, 35 and 49 days.

3. Results

Preliminary results comparing the Osteogenic group to the C&O2 group are presented in Figure 1. These results reveal that there is an increase in cell number between Day 7 and 21 (Fig 1. (a)) in both the Osteogenic and C&O2 group. There was a higher cell number seen in the osteogenic group when compared to the C&O2 group at Day 7 and Day 21. GAG content was higher in the chondrogenic primed group (C&O2) than the osteogenic primed group at all time points (Fig 1. (b,c)). ALP activity was higher in the osteogenic group compared to the C&O2 group at all time points (Fig 1. (d)). There was also an increase in ALP activity from Day 21 to Day 35 in the C&O2 group which was a pattern not seen in the osteogenic group.

4. Discussion

An increase in cell number observed in the both groups indicates that even within pellet form the cell number is increasing and the cells are proliferating seen in previous studies [3]. However the difference in cell number between the two groups also indicates that the osteogenic growth factors facilitate cell proliferation more than the mixture of both chondrogenic and osteogenic growth factors. Previous 14 day pellet culture studies have shown that GAG content can reach a peak at approximately 9 days but subsequently drop by Day 14 [4]. This study shows that the peak GAG content in the C&O2 group is seen on Day 7 and continuously drops till Day 35. It also shows a drop from Day 21-35 after the addition of the osteogenic growth factors. The increase in ALP activity in the chondrogenic group on Day 35 shows that early chondrogenic priming can have a positive effect as seen in other studies [5]. However, in this current study osteogenic media alone has the best result for osteogenesis. Ongoing analyses will provide an understanding of the optimum timing for chondrogenic priming of MSCs.

5. References

Abstract

One material that has found particular favour within the biomedical industry is the near equi-atomic NiTi alloy, Nitinol. This can be directly attributed to its characteristic shape memory and superelastic behaviour. It has proven advantageous in many minimally invasive biomedical device applications [1]. Nitinol self-expanding endovascular stents are effective in the treatment of peripheral artery diseases. However, fracture rates of 65.4% in stents used in the superficial femoral artery have been reported [2]. Such failures have been attributed to cumulative fatigue damage. Accurate characterisation of the fatigue behaviour of such stents is therefore essential for their prolonged safe use in human arteries.

1. Introduction

During manufacture, stents are crimped to fit within a catheter to allow in vivo deployment. This process exerts a significant crimping strain on the stent geometry. Consequently, the focus of this study is to investigate the effect of crimping strain on the fatigue life of Nitinol stents under strain control conditions.

2. Materials and Methods

Nitinol 'v-strut' stent-like specimens were custom fabricated in conjunction with Veryan Medical. Excess material at both ends, along with support struts, was included in the design to provide precise alignment, structural stability and secure gripping during testing. To accurately characterise the material properties, uniaxial tensile tests were performed on the support strut. The EnduraTEC ELF/3200 was employed for this study. The crimping/deployment process is equivalent to the loading/unloading path of the super elastic material, see Figure 1. Therefore, to simulate the crimping process, a load-unload procedure was performed on the 'v-strut' component. The investigation was carried out at 37°C to represent in vivo conditions using an environmental chamber with air-heating fan.

Displacement-controlled fatigue testing was also performed on the 'v-strut' at 37°C. Fatigue data was collected for strains amplitudes from 0.2 to 0.8% for crimp strains up to 14%. In previous testing of this nature [3, 4], stent components are simply subjected to a single crimp cycle to simulate the deployment process. In this study, however, the effect of multiple crimping cycles was also investigated. All fatigue tests were conducted with 1.5% mean strain and at a frequency of 50 Hz until failure or run-out at 10^7 cycles.

3. Discussion

The effect of cyclic loading on the fatigue behaviour of the NiTi stent-like components was successfully investigated. Fatigue data is presented on a constant life diagram to demonstrate the effect of strain amplitude on the fatigue life of the single cell of the stent geometry; the 'v-strut'. In addition, the influence of the crimping procedure was identified and explored. The Finite Element Analysis software ABAQUS/Standard ver6.10, in combination with the user-defined material subroutine UMAT, will be used to calculate the stress and strain fields in the specimens. The FEA models will be validated against the load-deflection curves from the load-unload procedure specimens, taking into account inaccuracies due to geometry factors as well as the non-linear behaviour of Nitinol.

The combination of the crimping, fatigue loading and the computational models offers insight into the detrimental effects on fatigue life of the initial crimping process on Nitinol endovascular stents. The ultimate aim of this work is to contribute to the development of design rules and testing guidelines for maximising the fatigue performance of Nitinol medical devices.

4. References


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Mechanoregulation in Ceramic-based Bone Tissue Engineering Scaffolds

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Abstract
Biomaterial bone scaffolds are required to have an optimal combination of mechanical properties and high porosity to ensure cell differentiation. In this work, a mechanoregulation model is implemented within finite element analysis and is used to determine the effects of varying scaffold parameters such as material properties, geometry and loading conditions on tissue formation within the scaffold.

1. Introduction
Mechanoregulation algorithms have been developed to predict the differentiation of bone tissue during fracture healing. The model used here determines tissue phenotype based on a mechanical stimulus that incorporates both scaffold deformation and fluid flow. The aim of this research is to implement this algorithm in a high resolution finite element model of a bone tissue scaffold. The influence of scaffold geometry on tissue formation within the scaffold can then be examined and this method can be used to optimize scaffold geometry for maximum bone regeneration potential.

2. Methods
High resolution finite element models of repeatable scaffold geometries were generated from μ-CT scans of a 50/50wt% PCL-TCP scaffold using the FEEBE software developed at NUI Galway [1], see Fig. 1. Two meshes were generated, one of the scaffold and one of the negative space surrounding the scaffold. This second (tissue) mesh is the space in which new tissue can form. Cell migration into the scaffold was modeled as a diffusion process with a diffusion coefficient of 0.34mm²d⁻¹ with 100% concentration of MSCs at the outer surfaces, and the mechanoregulation algorithm of Prendergast [2] was implemented using a user-defined field to assign mechanical properties to each tissue phenotype. A compressive displacement was applied to the top surface of the scaffold and tissue meshes as shown in Fig.1. In these initial simulations fluid flow through the scaffold was neglected.

3. Results
The results illustrate the migration of cells into the scaffold, as a diffusion process, and the differentiation of cells into different tissue phenotypes (Fig. 2a). Fig. 2b clearly demonstrates that increasing the deformation of the scaffold results in an increase in the percentage of mature and immature bone formation.

4. Conclusions
These models clearly demonstrate the ability of this algorithm to simulate the processes of cell migration into a bone scaffold and cell differentiation as a function of the load applied to the scaffold.

The incorporation of migration to this initial model as a diffusion process assumes that all space within the scaffold can be occupied by cells, which neglects the need to allow fluid flow in the pores. The inclusion of fluid flow would improve the accuracy of this modeling method. It is also worth noting that the Prendergast model does not account for factors such as substrate stiffness, pore size and oxygen/nutrient supply which have all been shown to influence tissue differentiation [3-5]. Further work in this area aims to include both the presence of bone marrow and to account for the effects of some of these factors on tissue differentiation.

7. Acknowledgements
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Characterisation of Polymer Films for Biomedical Implant Applications

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I. INTRODUCTION

Biomaterials interact with biological systems through their surfaces. It is, therefore, vitally important to control the surface properties of a biomaterial so that it integrates well with host tissues. Polymeric films are very attractive as biomaterial coatings to protect the bare surface of the implant from corrosion attack caused by the biological environment. In order for a biomaterial coating to function it must have sufficient mechanical stability to have the ability to withstand cracking and delaminating during the lifetime of the implant [1]. Nano-indentation is a technique widely used to characterise the mechanical properties of many coating materials, and is particularly useful in measuring the hardness and stiffness of thin films. The specific aims of the work presented here are to prepare a metallic sample coated by a thin polymer film and then to determine the chemical, physical and mechanical properties of the coating. Future work will involve the development of a computational (FE) model to accurately simulate the mechanical performance of the coating.

II. MATERIALS AND METHODS

Two homo-polymers of Poly (lactic acid) (Purasorb PL 65) and poly (caprolactone) (Sigma Aldrich) were used in this study. Poly (ethylen glycol) was adopted as a plasticizer to control the degradation rate. PLA and PCL were dissolved in chloroform to produce different concentrations of 1, 5, 15, 29 mg/ml, then PEG plasticizer was added into the solution under concentration of 1%, 10%, 20% W/w. The films were prepared by the solvent casting method on the stainless steel plates as metal substrates. The prepared samples were placed in desiccators in a chloroform environment for 12 hrs to reduce the rate of evaporation of the solvent and then in a vacuum oven at 40°C for further 4 hrs. The coated samples were analyzed using FTIR spectroscopy and were observed under atomic force microscope (AFM). The thickness of the thin films was measured with a Micrometer (Mitutoyo, USA). Nano-indentation trials are being performed on a nano-hardness tester (CSEM, Instruments, Switzerland) with a Berkovich diamond tip.

III. RESULTS AND DISCUSSION

The thickness of the prepared thin films was determined to be between 5-70 μm. Figure 1 represents the results of the FTIR and AFM analysis. FTIR (Shimadzu) confirmed that the chloroform was completely evaporated resulting in a high quality homogenous film. AFM measurements indicated a surface roughness of around 0.56 nm. Nano-indentation measurements of modulus and hardness are underway. Figure 2 shows a matrix of several imprints on a coated sample performed by the indenter.

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Flow-associated thrombosis model

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Abstract
After 50 years of intensive research, the biomaterials community has still not succeeded in producing a truly blood compatible material due to the complexity of the mechanisms of blood coagulation. Numerical models may help to deal with this complexity with means to predict in vivo effects and associate experimental results with clinical data. We propose the building of a computational fluid dynamics (CFD) model to address many aspects of thrombi formation. We hope that this approach will be able to aid the design of new medical devices and blood-compatible biomaterials.

1. Introduction

The biomaterials community has been unable to produce truly non-thrombogenic materials in spite of 50 years of intensive research on the subject. The advances in this field have been limited to minimize coagulation protein and platelet activation. However, the cell and molecular biology of blood activation and coagulation are immensely complex. Platelet membranes are decorated with numerous protein receptors. Activation of the intrinsic clotting system, through reasonably well understood, still offers surprises. Less is known about the roles of white cells in coagulation. The role of hydrodynamics for cell and protein kinetics is another relevant factor for the dynamics of thrombogenesis, but is still scarcely considered. Thus, patients whose blood frequently contacts foreign material must take a significant dose of anticoagulation drugs, which brings a considerable risk to their health [1,2].

Blood thrombogenesis is very difficult to analyze due to its complexity. Mathematical modeling is one means of addressing complexity. Computer simulations can validate such models and help to associate experimental results with clinical data. With this motivation Basmadjian et al. (1997) [3] developed an analytical model coupling fluid flow, mass transfer and chemical kinetics of the intrinsic and common pathways of the blood coagulation cascades [4]. Their model is capable to predict several possible steady states, but only for a 2D idealized tubular geometry. More general geometries can only be assessed by implementing similar models in CFD algorithms.

The model of Basmadjian et al. [3] take only the proteolytic aspects of coagulation into account. To the best of our knowledge, no numerical model acknowledges the reaction of platelets, the other classical aspect associated with thrombosis. Nesbitt et al. (2009) [5] have gathered very clear experimental observation of platelets being activated by high shear stress flows completely free of soluble coagulation factors. However, those activated platelets were only able to aggregate in downstream low shear stress sites. A CFD model can help to predict how different concentration of activated platelets may react with distinct concentrations of coagulation factors.

2. Objectives
1. Build a CFD model for thrombogenesis coupling, flow, mass transfer, coagulation kinetics and platelet interactions.
2. Validate the model comparing experimental results and clinical data. Cases of hemodialysis, vascular grafts and artificial heart valves are candidates for the validation.

3. Methodology
The CFD model will be built using OpenFOAM [6], which is a finite volume method (FVM) open source suite for CFD simulations.

8. References
Examining the Use of Regional Mechanical Properties in FE Modeling Of Abdominal Aortic Aneurysms

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Abstract
An important aspect of any FEA study should be the inclusion of accurate material properties. Our technique takes into account patient-specific regional properties to convert the regional stress to a specific regional rupture risk, which represents a departure from the “one size fits all” criterion currently in use. A greater understanding of the local material properties and their use in FE models is essential for greater accuracy in rupture prediction. The incorporation of additional patient-specific parameters into the FE modeling criteria may reduce the uncertainty associated with rupture prediction.

1. Introduction
Cardiac gated CT and finite-element (FE) analysis are valuable tools in analyzing cardiac mechanics. The purpose of this study was to examine the use of regional variations of mechanical properties in FE reconstruction to assist in the assessment of AAA rupture risk. This study utilized patient-specific local properties and strain data obtained from ECG-gated CT scans and related them to the local strength to determine the risk of rupture. The approach may be clinically useful in improving AAA diagnostic methods.

2. Materials and Methods
2.1. CT Scan Acquisition
Scans were obtained at 2 surgically relevant locations (Fig.1A). The time series with maximum area was referred to as systole and minimal area as diastole (Fig.1B).

2.2. Biomechanical Material Properties
The circumferential cyclic strain and the modulus calculated from the CTs were used in conjunction with Raghavan and Vorp’s [1] average aneurysm behavior (Fig.2) to generate a stress-strain relationship for each segment (Fig.2A X–Y) and the entire aneurysm.

2.3. FE Analysis
The model was segmented into 4 sections – (posterior, lateral (left, right), anterior) allowing local patient properties to be applied to each section. Each geometry, both segmentally and treating the entire aneurysm as a homogeneous material, were used FE models.

3. Results and Discussion
There was disparity in the magnitudes of peak stress and contours between homogeneous models and the segmented models for each patient (Fig.3).

4. References
Constitutive Modeling of Aorta Tissue

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Abstract
The ultimate objective of our project is to develop a constitutive model to describe deformation and failure behaviour of aorta tissue. This part of our work is focused on the development of a constitutive model for a healthy aorta tissue, which takes into account its internal material structure, and hence can be described in terms of physical parameters.

1. Introduction
An accurate constitutive model describing the aorta behaviour can help clinicians in predicting the evolution and rupture of aorta aneurysms. Hence, numerous constitutive models for aorta tissue were proposed in the past. However, those models are frequently of phenomenological nature, and thus are not described in terms of physically meaningful parameters. Therefore, there is a strong need for developing constitutive models that predict the aorta deformation from an internal structure of aorta tissue.

Histological studies show that aorta tissue consists of two major constituents – elastin and collagen. The elastin provides the elasticity of the aorta similar to that of rubber-like materials, while the collagen has high stiffness and gives strength to aorta tissue [1]. Those two components can form a complex network composed of junction points, similar to an entangled and cross-linked rubber. As it has been assumed frequently in the literature (see e.g. [1]), soft biological tissues, including arterial tissues, behave similar to rubber-like materials. Therefore, in our first attempt we have adopted a model proposed for entangled and cross-linked rubbers. That model is expressed in terms of physically-meaningful parameters that can reflect the internal structure of the tissue formed by the elastin and collagen network. Details of this model are presented in the next section.

2. Edwards-Vilgis Model
As mentioned above, our starting point to capture healthy aorta behaviour is a polymer model developed by Edwards and Vilgis [2], which accounts for the presence of entanglements (or slip-links) and cross-links. Also, this model accounts for the finite extensibility of polymer chains. The Edwards-Vilgis (E-V) model consists of two parts – part related to crosslinks, $W_c$, and slipp links (entanglements), $W_s$ [2]

$$ W = W_c + W_s $$

$$ \frac{W_c}{kT} = \frac{N_c}{2} \left( \frac{\left(\alpha - 1\right)^2 \sum \lambda_i^2}{1 - \alpha^2 \sum \lambda_i^2} + \log \left(1 - \alpha^2 \sum \lambda_i^2\right) \right) $$

where $N_c$ and $N_s$, the number of crosslinks and slipp links, respectively; $k$, Boltzmann constant; $T$, absolute temperature. $\alpha$ defines a limit of chain extensibility and $\eta$ defines the degree of chain slippage at the entanglements. Thus, the general form of deviatoric principal stresses can be calculated as follows using Eqs. (1) – (3):

$$ \sigma_i = J \left( \frac{\alpha}{\lambda_i} \frac{\partial W}{\partial \lambda_i} - \frac{2}{\sum \lambda_k} \frac{\partial W}{\partial \lambda_k} \right) $$

where $J$ is the volume ratio.

3. Predictions of E-V Model
The E-V model was implemented into a FE package ABAQUS, and their predictions are given below. Each parameter in the EV model has certain effect on the stress-strain behavior. Therefore, Fig. 1 demonstrates effects of those two parameters, $\alpha$ and $\eta$. An increase in $\alpha$ leads to an upswing of stress with increasing strain. On the other hand, an increase $\eta$ leads to a softening effect, which is mainly due to a less restricted movement of the chains at the slipp links.

![Fig. 1 Stress-strain curves in uniaxial tension for different values of $\alpha$ and $\eta$](image)

All necessary parameters of the E-V model will be determined with various experimental tests and validated using biaxial mechanical tests performed on a healthy aorta.

4. References
Cell-Material Interactions: Assessment of Compatibility & Performance

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Abstract

To attain comprehensive pre-clinical evaluation of biomaterials, the seeded materials must be exposed to the relevant physiological shear stresses in order to assess and understand the cellular mechano-transducdory pathways - often regulated by inherent properties of the underlying material. This study uses a cone and plate bioreactor to produce atheroprotective and atherogenic flow regimes to cell-seeded scaffolds and study the respective cellular behaviour.

1. Introduction

This study focuses on the Endothelial Cell (EC) attachment and behaviour of naturally derived cell-seeded Extracellular Matrix (ECM) materials, namely Urinary Bladder Matrix (UBM) and Small intestinal Submucosa (SIS). To provide valuable pre-clinical evaluation of these materials, the cell seeded substrates were exposed to physiological Wall Shear Stress (WSS) conditions utilising an in vitro bioreactor system. This field of testing facilitates the assessment of matrix specific endothelium integrity as well as providing an accurate prediction of the anticipated host response, under various WSS regimes.

2. Materials and Methods

A cone and plate bioreactor system was modified to facilitate the incorporation of 3D cell-seeded scaffolds. The idealised WSS profiles chosen were representative of physiological atherogenic and atheroprotective flow profiles. The graft materials analysed included both UBM and SIS ECM materials. EC metabolic activity was evaluated pre- and post-shear through quantification of alamarBlue® assay. Proliferation/apoptosis was monitored using LIVE/DEAD® cell viability assay.

3. Results

Following the four day EC culture period (baseline seeding density of 3 x 10^4 cells/cm^2 for all materials analysed), the metabolic activity of EC-seeded materials was quantified (Figure 1a). The greater cellular/metabolic activity on UBM, compared to SIS, has been previously reported. The results obtained indicate that cellular activity for each of the materials tested was either maintained or increased when exposed to the atherogenic WSS profile, in comparison to that of the atheroprotective profile - see profiles in Figure 1(c). The confocal microscopy imagery, presented in Figure 1(b) (UBM only), depicts distinct patterns of cell alignment. The atherogenic flow (Profile 1) resulted in a disorganised cell orientation in comparison to the alignment evidenced for the forward flow (Profile 2).

4. Discussion

The results obtained suggest that UBM ECM material, with its unique natural structure, facilitates a more favourable cellular performance in comparison to the other ECM materials assessed, yielding significantly higher cellular growth pre-shear during the culture period. For both the “atheroprotective” and “atherogenic” WSS profiles, UBM promoted greater cellular adherence and distribution post-shear compared to SIS. Further analysis includes the assessment of differential gene responses to all materials, utilising PCR techniques, to predict the anticipated host response for potential materials. The methodology described, in conjunction with results obtained, describes an accurate in vitro simulation and analysis to help predict potential in vivo performance of such materials.

5. References

Developing a Process for the Conversion of 2D Ultrasound Images to 3d Reconstructions for use in Vascular Applications

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Abstract
Phantom models were used to represent a vessel of increasing CSA followed by a bifurcation, buried in soft tissue. Images were taken at known locations. A series of image processing techniques were applied to remove background scatter and increase boundary definition. A Hounsfield threshold was then applied for segmentation. Segmented images were imported to their relative position in CAD software to generate 3D reconstructions.

1. Introduction
Numerical modelling conducted on vessel reconstructions has been shown by various researchers to be useful diagnostic aids. Models are generally created from computed tomography (CT) data. Although this yields clear scan data it is expensive and prolonged use can be damaging to health, limiting the possibility of regular check-ups. Ultrasound imaging, although has poorer image quality it has no known side effects and is inexpensive. Producing reconstructions from ultrasound scans could allow numerical modelling to be used on a much greater scale.

2. Methodology
An ultrasound phantom was created to represent a vessel of increasing cross sectional area (CSA) followed by a bifurcation, buried in soft tissue. Due to their acoustic material properties an agar based material [1] replicated the soft tissue, silicone acted as the vessel while water was a blood substitute. To generate a 3D representation of the vessel, a series of scans were taken with a linear transducer held 90° to the phantom and moved along the length of the vessel, taking images at 5mm intervals while incorporating the bifurcation. Once the scan images were obtained they were individually imported into MATLAB (Mathworks, USA) to undergo the image processing technique ‘mathematical morphology’ to find the most suitable for removing background scatter while maintaining the outer boundary of the vessel producing images which are more suitable for the application of a Hounsfield threshold in MIMICS (Materialise, Belgium). The ‘opening by reconstruction’ technique was utilised with a variety of structuring elements (SE), e.g. a disk filter, in various dimensions, to find the most suitable. A number of codes were applied to the same set of scans and the images were segmented. Each group of post processing images were imported to their relative position in computer-aided design (CAD) software to generate 3D reconstructions from images processed by different techniques.

3. Results
A selection of reconstructions post image processing were analysis to determine the accuracy of the results. The overall appearance of each reconstruction was compared to the original as were CSA taken at numerous locations.

4. Discussion
It is clear from the graph that the disk r=7 SE produces the most true to reality dimensions. Applying this morphology removes the greyscale speckles, improving the contrast between vessel and soft tissue, allowing for easier segmentation. Both the image processing technique and the tracking system produce promising results for 3D reconstruction. Future plans to incorporate an optical tracker will improve the flexibility of the system while maintaining exact scan location, moving towards a system suitable for patient use.

5. Reference
The Uniaxial and Biaxial Properties of Intraluminal Thrombus (ILT)

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Abstract
The development of a constitutive model to describe the role of the intraluminal thrombus (ILT) is necessary for the successful implementation of Finite Element Analysis (FEA) as a tool in Abdominal Aortic Aneurysm (AAA) rupture prediction. This study aims to determine the mechanical properties of ILT. The ILT structure was separated into the luminal, medial and abluminal layers and was subjected to uniaxial and biaxial testing. The results suggest that the ILT is both inhomogeneous and isotropic. This may provide a valuable insight into the properties of ILT and improve the reliability of FEA in the prediction of AAA rupture.

1. Introduction
AAA is the gradual enlargement of a balloon like dilation in the distal region of the aorta. If undetected or untreated AAA can rupture which in 90% of cases results in death [1]. It has been hypothesised that regions of elevated stress of the AAA wall may be linked to sites of AAA rupture. Thus, FEA is a tool that could prove to be clinically useful by aiding in the prediction of AAA rupture. The use of appropriate constitutive models to describe the mechanical properties of the ILT, commonly found in the AAA sac, are necessary for the successful implementation of this tool. At present the role of the ILT in AAA rupture is unclear. Studies have shown ILT to reduce the AAA wall stress by acting as a mechanical buffer [2] while others have discovered that the underlying AAA wall is weaker due to the presence of ILT [3]. This study aims to determine the patient specific mechanical properties of ILT within the AAA sac.

2. Materials and Methods
ILT samples from 3 patients were harvested from patients undergoing open AAA repair surgery at the Mid-Western Regional Hospital, Limerick. Where possible the ILT structures were separated into the luminal, medial and abluminal layers. A total of 54 square shaped samples were prepared for biaxial tests and the samples were tested using the following strain based protocol $\lambda_{LL} = 1:1, 0.75:1, 1:0.75, 1:0.5, 0.25:1, 1:0.25$ and $1:1$. The maximum strain applied was 15%. A total of 35 circumferentially orientated dog bone samples were prepared for uniaxial tests and samples were strained to failure. All samples were tested using a strain rate of 0.2mm/s and all tests were performed in saline at 37°C. Biaxial and uniaxial tests were performed using the CellScale Biotester and Zwick/Roell type Z2.5 tester.

3. Results
The results revealed an approximately linear stress-strain relationship for all three layers ($r>0.98$) however; it was found that the ultimate tensile strength (UTS) and the maximum tangential stiffness (MTS) decreased across the ILT’s radial direction. The UTS values for the luminal, medial and abluminal layers were found to be $0.089 \text{MPa} \pm 0.035$, $0.05 \text{MPa} \pm 0.013$ and $0.042 \text{MPa} \pm 0.019$. The MTS values for the luminal, medial and abluminal layers were found to be $0.173 \text{MPa} \pm 0.035$, $0.11 \text{MPa} \pm 0.013$ and $0.064 \text{MPa} \pm 0.023 \text{MPa}$. The luminal layer was found to be significantly stronger and stiffer than the medial and abluminal layers. Furthermore, biaxial tests showed no significant difference in the mechanical properties between the longitudinal and circumferential directions and the strain ratio protocols show a reduction in the tissues stiffness due to unequal loadings.

4. Discussion
The evaluation of the mechanical properties of the ILT reveals an approximately linear stress-strain relationship for the ILT structure. This relationship is unusual for the majority of biological tissues which have a non-linear stress-strain relationship. These results also suggest that the ILT structure is both inhomogeneous and isotropic and shows a reduced stiffness response due to unequal loading. Such information is invaluable when developing a constitutive equation to describe the ILT.

5. References
Composite Electrospun Nanofibre / Acellular Extracellular Matrix Scaffolds for Improved Regenerative Medicine Outcomes
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Abstract
Cardiovascular tissue replacements require many properties to provide functionality and performance. The current study investigates a potential composite biomaterial, consisting of bi-layered electrospun polycaprolactone (PCL) / decellularised porcine Urinary Bladder Matrix (UBM) scaffolds.

Introduction
UBM cardiac patches have been previously reported to outperform synthetic material (ePTFE), progressing toward myocardial tissue replacement after 3 months in vivo1. In this study it is hypothesised that the combination of a synthetic biomaterial with ECM to create a composite cardiovascular repair material, benefits from the advantages of both: controllable mechanical anisotropy and degradation properties of the synthetic component coupled with the bioactivity of ECM.

Methodology
Acellular UBM sheets were prepared from porcine bladders as previously detailed2. PCL was dissolved at a concentration of 10 %w/v in a 3:1 co-solvent mix of chloroform / methanol and electrospun onto a UBM tube segment using an automated 3 axis electrospinning system developed in-house. A solution volumetric flow rate of 33 μL/min and electrical charges of 1-1.2 kV/mm were applied. Random, rotationally aligned (0.31 – 0.94 m/s) and highly aligned scaffolds were fabricated. To fully quantify the fibrous scaffold structure, a novel image processing technique3 was applied to scanning electron micrographs. Scaffold bulk properties were analysed via tensile testing and water contact angle analysis. Scaffolds were seeded with Human Aortic Endothelial cells (HAECs) and proliferation quantified by MTS assay after 1, 5 and 10 days culture in vitro.

Results and Conclusions
A range of scaffolds were electrospun and extensively characterised through SEM image analysis. The algorithm operated robustly at optimised levels of magnification, brightness/contrast to quantify the distributions of fibre diameters, intersections, porosity, connectivity and orientation (Fig 1. d-f). A threshold surface speed of 0.63 m/s was established to significantly induce scaffold anisotropy. Lower velocities resulted in less alignment with a broader distribution of fiber diameters and porosity. HAECS displayed increased spreading, with greater stress fiber formation and highest proliferation on PCL film. Preferential alignment was visible parallel to electrospun fibre orientation. vWF expression indicated retention of endothelial phenotype (Fig. 2). UBM promoted more HAEC proliferation than ePCL scaffolds, suggesting an optimum blood-facing UBM lumen configuration. The anisotropic 3D ePCL scaffold may be best suited to facilitate SMC proliferation and capillary ingrowth. These scaffolds show promise for a range of soft tissue repair applications, combining the remodelling properties of ECM with the slower degradation rate and of an ePCL sheath. Pre-seeding or bioreactor conditioning under flow conditions prior to implantation may hasten development of a confluent monolayer and will be the subject of future investigation.

References
A review of Pre and post-operative monitoring of abdominal aortic aneurysm behaviour- A review

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Abstract

Since the first endovascular aneurysm repair (EVAR) was performed by Parodi et al in 1991, a steady increase in the usage of EVAR has been seen¹. A number of issues are associated with EVAR such as rupture, endoleak, fracture, cost and kinking. The concept of implanting a sensor with the stent graft has been formulated to quantify some of these issues.

1. Background

Abdominal aortic aneurysms (AAA) are defined as a permanent and irreversible localised dilation of the vessel². It is estimated that approximately half of those with a ruptured AAA (RAAA) will die before they reach the hospital and that the overall mortality rate of RAAA is between 65% and 85%³. RAAA and its surgical complications are held responsible for over 15000 fatalities per annum in the United States⁴.

2. Objectives

This project aims to generate improved diagnostic tools for detection of device behaviour following implantation. The project will seek to create new sensing tools which will be capable of providing information relating to position, force response and pressure, using approaches which will be readily applicable in a clinical environment.

3. Diagnosis and Assessment

Ultrasound, Magnetic Resonance Imaging (MRI), Computed Tomography (CT) and Computed Tomography Angiography (CTA) are used in the diagnosis and assessment of AAA. Ultrasound is non-invasive, cheapest and can depend on operator experience. CT can detect graft migration; however concern has been expressed regarding to the radiation exposure involved. MRI is non-invasive, displays good soft-tissue contrast, is technically demanding and can visualise features of the vessel such as the thrombus. MRI is expensive and limited by the presence of pacemakers and persons in whom ferromagnetic clips have been placed. Angiography is useful in defining the continuity and morphology of vascular anatomy; however some studies have shown that angiography measurements of the neck diameter are approximately seven percent smaller than CT measurements. CTA uses the technology of CT and the benefit of contrast medium injection of angiography. Macari et al showed that speedy data acquisition is CTA’s chief advantage.

4. EVAR

EVAR in comparison with open repair is less invasive, allows a decreased duration of hospital stays and is associated with lower perioperative rates⁵-⁶. Rupture following EVAR procedure is seen as one of its major limitations and endoleaks, of which there are five main types, are a primary concern. Fracture can occur on any of the metallic components of the stent graft which can result in separation from the main body of the stent graft resulting in rupture. EVAR is more expensive than an open repair procedure, noting that the device cost accounts for the largest single cost for EVAR. Development of kinks has been associated with the use of iliac extensions during EVAR procedure and geometric changes in the stent graft, which can lead to stent graft kinking. The risk of device migration increases over time. Short proximal fixation lengths of the stent graft to the infrarenal neck, neck enlargement and preoperative AAA diameter of 55mm have been linked with device migration.

5. Sensors

CardioMems EndoSure pressure sensor is currently the only AAA pressure sensor with FDA approval. It consists of a resonant circuit and is surrounded by a nitinol basket. A change in the pressure surrounding the sensor will alter the position of the plates, hence changing the capacitance and resonant frequency of the sensor. This change in resonant frequency can be observed externally via the antenna permitting measurement if the pressure in the aneurysm sac.

6. Future work

Research into the current state of the art will continue. Further assessment of current sensor technology will be investigated. Define specifications for implantable sensor including minimising the size of the sensors, increasing the quality of the signal while establishing methods for inclusion sensing devices in an implantable graft.

7. References

Utilising Hydrated Storage of Naturally Derived ECMs as a Potential Off-the-Shelf Cardiovascular Device: Influence on Mechanical and Cellular Performance

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Abstract
Established treatment modalities for cardiovascular diseases include arterial substitutes and synthetic graft materials, however, these have associated issues such as low patency and compliance mismatch. A tissue engineering approach in the form of extracellular matrix (ECM) based vascular graft materials offers many mechanical, chemical and biological advantages over their synthetic counterparts. In order for these to be successful, a suitable biocompatible storage environment is required to allow migration, adhesion and proliferation of host cells upon material implantation. This study analysed the mechanical and bioactive effects of hydrated storage of two scaffolds, small intestinal submucosa (SIS) and urinary bladder matrix (UBM) in both stented and un-stented configurations for up to 4-months.

1. Introduction
Naturally derived biological scaffolds offer huge potential although it is unknown if storage of these scaffolds, particularly in a hydrated and stented configuration, is a viable option for the future. The study aim was to demonstrate the viability, mechanical integrity and bioactive potential of xenogeneic ECMs as potential off-the-shelf vascular prosthetic devices.

2. Methodology
Multilayered scaffolds were immersed in a hydrating solution in stented and un-stented configurations simulating the catheter environment for periods of up to 4-months. Mechanical evaluation was conducted on pre-conditioned specimens with cellular metabolic activity and proliferation examined using HAECs and alamarBlue® cell viability reagent for up to 96-hours in culture. Furthermore, the concentration of various nucleic acids and proteins leached during storage were also analysed.

3. Results
Favourably, the average UTS of all ECM samples evaluated were noted to be above the average aortic tissue failure strength and more compliant than current synthetic materials employed. Cellular performance analysis indicated that both ECM scaffolds investigated were unaffected by increased hydrated storage duration and exhibited a positive cellular bioactivity when compared with the lyophilised controls.

4. Discussion
Overall, this study has demonstrated that ECM materials under storage and stenting environments retain sufficient mechanical integrity and cellular performance, indicating that long term storage of such materials has no negative effect under the parameters investigated. Furthermore, such tissue engineered scaffolds offer great potential as an off-the-shelf implant and for use in minimally invasive treatment approaches.

5. References
Davis et al. 6th World Congress on Biomechanics, pp.139-142, Singapore, 2010.

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An Experimental and Numerical Analysis of the Dieless Drawing of Nitinol used in Biomedical Devices

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Abstract
The effect of a dieless drawing process on commercial grade Nickel Titanium rods, of 5 mm diameter, was investigated by varying the established critical process parameters of temperature, cooling rate, drawing velocity, and heating/cooling velocity. The rods were successfully dieless drawn with a maximum steady state reduction in cross-sectional area of 54%.

An accurate, reliable finite element (FE) model capturing the heating/cooling rate, applied force, and strain rate characteristics of the process as applied to the shape memory alloy Nickel Titanium is being developed. FE modelling using ABAQUS is being carried out to optimise the process, and results obtained from experimental runs using the dieless drawing rig are being used to validate the initial FE model.

1. Introduction
Nitinol is widely used in wire and tube form in the biomedical [1, 2]. The traditional process of metal wire and bar production involves pulling the wire/bar through a conically shaped orifice called a die to reduce its diameter in successive steps. The considerable die wear that occurs at the tool-die interface, coupled with the additional lubrication and pre-cleaning costs, add considerably to the overall cost of the process [3]. A process known as dieless drawing is under development as an innovative method for the production of wire, bar and tubing without the use of reduction dies. This process is best suited to material forms that currently have high production costs and are difficult to produce using the conventional method. Nitinol presents such difficulties during production due to its high toughness and work-hardenability [4].

2. Experimental Methods
An initial test of ten NiTi rods of 5mm diameter was carried out on a dieless drawing machine. As the process ratio determines the percentage reduction in cross-sectional area of the rod, the drawing velocity was incrementally increased giving process ratios of 0.33, 0.42 and 0.5. Chemically etched samples of the drawn rods were studied using Differential Interference Contrast (DIC) and also Vickers micro-hardness tested.

3. Results and Discussion
The percentage reduction per pass was measured over the steady state length of drawn rod to be 54%. A smooth, even, oxidized surface resulted from the single pass dieless draw. The resulting changes in microstructure and hardness were investigated. The grain structure was highly deformed in the drawing direction and increased porosity was observed as a result of the process. The longitudinal section hardness of the rod was significantly reduced as a result of the dieless drawing process. The finite element model developed has accurately predicted the nature of the process deformation. The heating/cooling rate and interaction between the heater, the cooler, the rod surface and the environment were found to be the main controlling factors on results obtained from the model. An appropriate material definition is required to capture a true representation of experimental results.

4. Conclusions
The cross-section of 5 mm diameter NiTi rods were successfully reduced using the dieless drawing method. Varying the process ratio resulted in varying cross-section reductions. A study of the microstructure has revealed grain growth and distortion due to the temperatures and forces experienced by the material during the dieless drawing process. Further work is required to define the material behavior under load at elevated temperature in order to allow accurate predictions to be produced by the finite element model at various drawing conditions. A more accurate definition of the interaction between the rod and the heating/cooling environment of the machine is also required. Coupling the thermomechanical effects of the dieless drawing process with a cold drawing processing step has the potential to produce a NiTi wire in fewer passes, and therefore at a reduced cost.

5. References
Barriers to and facilitators of diabetes self-management in Ireland: A qualitative exploration

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Abstract
Little is reported on the barriers and facilitators experienced by adults in relation to self-management of diabetes in Ireland. The purpose of this qualitative study was to identify the barriers to diabetes self-management in order to inform the development of a tailored, theoretically driven, culturally appropriate diabetes self-management intervention to support patients with type 2 diabetes in their self-management efforts.

1. Introduction
As soon as a patient is diagnosed with type 2 diabetes (T2D) they are expected to play a major role in the management of their disease on a daily basis [1]. Self-management is complex and requires lifelong attention. Each day patients make many decisions about managing their diabetes based on their knowledge, beliefs, attitudes and support systems. Being sensitive to the barriers experienced by patients can work to facilitate the development of effective self-management programmes.

2. Methods
A qualitative descriptive design was implemented in which focus groups were used to elicit data from patients with diabetes and their family caregivers. Focus group methodology was suited to this particular study as it allowed for assessment of the target groups’ diabetes experiences of maintaining diabetes self-management lifestyle behaviours.

Participants were recruited purposively from the University of Limerick where both staff and students were invited to take part. A total of 3 focus groups were conducted by experienced moderators, using open-ended questions and a detailed protocol guided the 45 minute sessions, which were audio recorded and analysed using NVivo software. Qualitative Content analysis was used and codes were inductively developed and clustered.

3. Results
Findings revealed significant diabetes self-management information, motivational and behavioural skills barriers and deficits.

Participants reported poor knowledge of diabetes and were particularly eager to know more about diet. Many noted that whilst they had received information from their GP’s their knowledge was incomplete and insufficient. Participants also noted that whilst information was provided it was not necessarily relevant nor appropriate to the individual “you know they give you all this information and you’re not going to remember it all – it’s not going to all apply as well at the same time to you cos like every diabetic is different”.

The support of family and friends was clearly illustrated as a facilitator to diabetes self-management “I think having my friends and family know is a big thing about it”. Family members were seen as central particularly in restricting and limiting access to temptation.

A scarcity of diabetes self-management behavioural skills was noted. Participants found it problematic to maintain dietary recommendations when food was present outside of their normal routines and in social contexts such as family gatherings or special occasions. Participants noted motivational difficulties despite knowing certain foods are to be avoided. Having a ‘sweet tooth’ and liking foods that are to be avoided had a negative impact on motivation and highlighted a lack of information and knowledge on how to incorporate sweet foods into their diet whilst still maintaining dietary control. Participants felt a lack of both confidence and ability to monitor carbohydrates i.e. identifying carbohydrate information from food labels and accurately calculating portion size from this amount.

4. Conclusion
For T2D patients self-management plays a crucial role in enhancing quality of live and active life expectancy. Whilst current medical care and education for T2D are becoming more patient-centred [2], adherence to diabetic self-management regimens and behaviours is far from ideal [3], with many patients finding it problematic to sustain adequate self-management.

T2D patients struggle to integrate their self-management plans into everyday living and how each patient reacts to their diabetes differs depending on their psychological state and the barriers which they encounter. This elicitation research has revealed critical informational, motivational and behavioural skills deficits which need to be addressed.

5. References
A Medical Hand Tool Physical Interaction Evaluation Approach for Prototype Testing Using Patient Care Simulators

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1. Introduction
Endoscopy has been described as a hazardous profession [1]. Buschbacher [2] in a survey of over 300 endoscopists, found that many reported musculoskeletal disorders due to endoscopic procedures, impacting severely on some their careers. In the study, 32% of respondents claimed to suffer from carpal tunnel syndrome, 19% of thumb pain and 15% of elbow pain. Hansel et al. [3] performed a controlled study on prevalence and impact of musculoskeletal injury among endoscopists. A group of Gastro Interologists (GI) (n=115) were compared with a group of non procedure orientated internal medicine specialist and sub-specialists (n=230). The frequency of musculoskeletal injury was higher in the GI group (74%) than the non GI group (35%). The most common sites of injury were for the thumb (19%), hand (17%), back (12%) and neck (10%). Of the GI group reporting musculoskeletal injury, 69% reported that they had modified at least one part of their work endoscopic practice to reduce injury risk.

The purpose of this study was to develop a flexible ergonomics design stage evaluation approach for medical device handles. Specifically the objective was to provide ergonomics data on upper limb forces and wrist joint angles specific to individual task elements of medical procedures as collected using patient care simulators.

2. Integrated muscle force and wrist posture evaluation approach
ElectroMyoGraphy (EMG) sensors (Biometrics Ltd.) were attached over three muscles of the dominant forearm. Wrist posture data (flexion/extension) were recorded using a Biometrics SG65 electrogoniometer. A Datalink module (Biometrics Ltd. Biometrics Data Link DLK900) was used to integrate the data from the electrogoniometers and EMG sensors with Observer software, enabling a common time line to be attached to the data. The Observer software was used to perform a task analysis of the video recordings and also to calculate average muscle activity and wrist movement data by task element.

A gastro intestinal tract patient care simulator was used to test an Endoscopic Ultra Sound Scope and needle. The simulator comprised a manikin head with throat and gastrointestinal tract. Simulated sampling of a stomach wall biopsy was performed on an apple at the end of the tract. This involved aspiration of the needle in the EUS device once in position. The equipment was setup to closely resemble use by physicians in the theater. A laptop was used to display the image from the endoscope camera.

3. Case study
Eight right-handed and two left-handed novice participants performed five simulated biopsy sampling trials with the EUS biopsy sampling device. The EUS needle device involved using a two finger tip pinch type grip, as in using a large syringe, to aspirate the needle. The task involved inserting the EUS needle through the endoscope to take a biopsy sample. The results indicated specific design features of the devices which resulted in high muscle forces and wrist deviations.

4. Main findings about the approach
Few commercial solutions for task analysis based upper limb ergonomics assessment are available and this precludes a more widespread use of detailed ergonomics evaluations of medical products at the design stage. This approach used Observer software to simultaneously log multiple data streams from separate devices (EMG and electrogoniometers) with video recordings. In the present study one wrist posture (flexion/extension) and three muscles were studied. But for different devices and applications it may well be desirable to include more postures, such as radial/ulnar deviation and supination/pronation. In addition, for some products or for more complex medical procedures, it may be desirable to study more muscles than in the current study to elicit more information on musculoskeletal loading.

5. References
The Role Of Smartphones As An Assistive Aid In Mental Health
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Abstract
Recent developments in wearable sensors and smartphone technology have demonstrated the applicability and viability of such devices to the successful and cost effective treatment of mental illness, particularly depression. This document describes a phone based physical activity algorithm developed at the University of Limerick that will be used to monitor and assist clinical professionals in analyzing physical activity and physiological data. A trial was performed to assess the algorithms and the resulting data is presented.

1. Introduction
Depression is strongly linked to a patient’s level of physical activity[1]. Various scientific studies have shown the important role physical activity plays in depression and it is widely known that depression tends to result in lower patterns of physical activity. From this perspective, it is interesting to measure the levels of physical activity for patient’s diagnosed with depression to obtain an insight of the disease progression. However, it has also been shown that a regime of increased physical activity can be used to reduce the severity of depression [1]. Several reasons for the positive effect of physical activity on mood and depression have been suggested. Firstly, exercise may act as a distraction from negative thoughts. Secondly, participation in physical activities often leads to social interaction with others. This in itself can have positive outcomes for a patient’s mental state. Finally, physical activity may have physiological effects such as changes in endorphin and monoamine levels, or reduction in the levels of the stress hormone cortisol which all may improve mood. Exercise has been found to be effective in the treatment of depression in more than 20 randomized controlled trials [2]. Moreover, Blumenthal reported in 1999 that 16 weeks of group exercise training was as effective as antidepressant treatment with sertraline and that the 10-month relapse rate for the group that performed exercise was 8% whereas this same rate was at 38% for the group treated with Sertraline [3]. In any case, physical activity can be measured quite accurately by using a MEMs based accelerometer found in many modern smartphones.

2. Project Description
The physical activity monitor was developed and tested using Samsung Galaxy S GT-I9000 smartphones. These integrate Bosch’s SMB380 tri-axial accelerometer, which uses just 290μA during usage. Due to the sporadic sampling rate associated with the Android OS, data was interpolated from an average of 90Hz, to a fixed 120Hz. These used a simple on-board linear interpolation technique, whereby we let: x = {x_{m+1}, x_{m+2},\ldots x_{n-1}} be the vector of missing data points bounded either side by the known points (x_m, y_m) and (x_n, y_n) where n>m. The n-m-1 missing data points can be found using linear interpolation between the two known points:

\[ y_i = y_m + \frac{y_n - y_m}{x_n - x_m} (x_i - x_m) \]

The data stream was then median filtered, followed by both band and low pass filtering stages. Resulting data was then converted to a world fixed coordinate system before feature extraction occurred. Features included counts per minute and coefficient of variation.

The physical activity monitor was tested in a trial conducted at the University of Limerick. The former trial consisted of N=6 healthy participants. Sitting, standing, walking, running and cycling on an indoor bike were amongst the activities recorded. Results appear promising, with the confusion matrix for this trial appearing in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>Lie</th>
<th>Sit</th>
<th>Stand</th>
<th>Walk</th>
<th>Run</th>
<th>Cycle</th>
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<tr>
<td>Lie</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
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<td>0</td>
</tr>
<tr>
<td>Run</td>
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<td>0</td>
<td>0</td>
<td>.13</td>
<td>.85</td>
<td>0.02</td>
</tr>
<tr>
<td>Cycle</td>
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<td>0</td>
<td>0</td>
<td>.01</td>
<td>.17</td>
<td>.82</td>
</tr>
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Table 1: Confusion Matrix

Future work will include an investigation of machine learning based classification running on the smartphone, and differences in activity patterns between healthy and depressed individuals. Work has also been carried out on a “Proxiometer” application whereby levels of social and physical activity are measured using a non-linear metric.

8. References
Activity Recognition Using Dynamic Multiple Sensor Fusion in Body Sensor Networks
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Abstract
Multiple sensor fusion is a main research direction for activity recognition. However, there are two challenges in those systems such as the energy consumption due to the wireless transmission and the hierarchical classifier design because of the missing feature value. This study proposes a multiple sensor fusion framework consisting of the sensor selection module and the two-stage classifier, which combing of the Naive Bayes classifier and the Decision Tree classifier. The dataset collected from 8 subjects, who performing 8 scenario activates, was used to evaluate the proposed system.

1. Introduction
The importance of monitoring activities of daily living (ADL) to promote a healthier lifestyle is now widely accepted. Therefore, there has been a substantial amount of research studies using wearable sensor network for monitoring activity of daily living. Currently, inertial sensors such as accelerometers and gyroscopes are appropriated and widely used for activity recognition.

There have been significant studies carried out on activity recognition using multiple sensors attached to different body positions. However, when employing the dynamic multiple sensor fusion framework, there are two challenges introduced as the followings:
- Sensor selection algorithms have been heavily investigated in the field of signal processing. However, there is little work applying these algorithms to body sensor networks.
- There has been a number of work applying modern classifiers to single-sensor systems for activity recognition. A hierarchical classifier which is efficient and suitable for dynamic sensors fusion systems need be investigated and proposed.

In this study, a novel wearable system based on dynamic multiple sensor fusion is proposed for activity recognition, in which a real-time sensor selection algorithm and a hierarchical classifier based on the decision tree are the main contributions. The dataset collected in the eCAALYX [1] project is used to evaluate the system.

2. Methodology

![Figure 1: The dynamic multi-sensor fusion framework](image)

In this study, a framework consisting of a master node, for which a smart phone is usually adopted, and several sensors is proposed for activity recognition as shown in Figure 1. There is also an accelerometer in the master node, which works simultaneously with other sensors. The feature vector from the inertial sensor of the master node is fed into the preliminary classifier. The sensor selection scheme in the master node, combining the result from its preliminary classifier and the expert knowledge, chooses the sensor subset, and sends the data query to these sensors. The multi-sensor fusion module collected the chosen sensor data, and each sensor flushes the memory cache. Finally, the classifier in the master node distinguishes the activity using the feature vector collected.

In the master node, the Naïve Bayes classifier is used for the preliminary classification due to its easy implementation and its suitability to attain a priori probability. The expert knowledge is defined as the distinguishing ability of sensor subset for recognizing different activity, which is obtained using the training dataset. The combination of a priori probability and the expert knowledge can predict the best sensor subset for real-time activity recognition. The Decision Tree classifier is used as the final classification algorithm due to its excellent performance for activity recognition. The feature vector fuses the information both from the preliminary classifier and selected sensor subset.

3. References
An Investigation of Physical Activity Patterns and Fall-Risk Factors in Community-Dwelling Older Adults Participating in a Falls Prevention Intervention

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Abstract
This research aims to investigate the effects of participation in a six-week physiotherapy-led programme of exercise and education on outcomes related to function, activity and participation in community-dwelling older adults, using a combination of wireless sensor technology and commonly-used clinical assessments.

1. Introduction
Falls prevention programmes can reduce falls incidence among older adults, but it is unclear whether this is primarily achieved via the training effects of increased exercise and physical activity (PA) or via activity avoidance to reduce risk exposure [1]. Using wireless sensors to objectively monitor PA has numerous advantages over the commonly-used self-report PA measures in this population, and may help to clarify this issue.

Wireless sensors also present a means of quantifying performance in clinical tests of balance and mobility through a range of kinematic and kinetic measures. Their validity for this purpose has been proven but not yet applied in a clinical context [2].

Thus, the main purposes of this study are to investigate PA patterns and falls risk-related physical performance factors in community-dwelling older adults participating in a falls prevention intervention, using current clinical measures and also wireless sensor technology. Secondary aims include monitoring long-term falls incidence and exercise adherence, and exploring the effects on selected falls risk-related psychosocial factors.

2. Methods
In this observational study, approximately 50 community-dwelling older adults aged 65 or over are being recruited in collaboration with physiotherapists in St. Joseph’s Hospital, Ennis, Co. Clare and North and South Lee Primary, Community and Continuing Care Services, Cork. Cross-sectional data for the outcomes of interest (Table 1) are being obtained before and immediately after the 6-week falls prevention intervention, and in a random sample at 12-months. Falls incidence and exercise adherence are monitored prospectively throughout the follow-up period.

3. Future Work
Further work will focus on obtaining normative data sets for the outcomes of interest in a healthy older population. Some of the selected fall-risk features extracted from the sensor data may also require validation using appropriate reference measures.

4. References

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Measure(s)</th>
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<tbody>
<tr>
<td>7-Day Physical Activity</td>
<td>Waist-worn Shimmer⁵ Physical Activity Scale for the Elderly</td>
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<tr>
<td>Fall-Risk (Physical Performance)⁶</td>
<td>Chair Stand Test Timed Up-and-Go Test 5m Walk Stand (10s) Stand Eyes Closed (10s) Stand Feet Together (10s)</td>
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<td>Falls Incidence</td>
<td>12-month calendar</td>
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<tr>
<td>Exercise Adherence</td>
<td>12-month calendar</td>
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<td>Falls Efficacy</td>
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<td>Fall-risk Behaviours</td>
<td>Falls Behavioural Scale</td>
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<td>Depression</td>
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<td>Quality of Life</td>
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</table>

b. Determined by standardized test plus Shimmer with 9 degree of freedom expansion module (triaxial accelerometer, gyroscope and magnetometer)
National Electronic Prescribing Systems: A Blueprint for Ireland
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Abstract
Prescribing medicine to a patient is one of the most universal treatments in the medical world, and a prescription is one of the most common medical records. In the last few decades, computer technology has spread to all sectors of society, and is now beginning to make an impact at a national level in some countries in the prescribing domain. Electronic prescribing (e-prescribing) systems in primary care and secondary care are beginning to appear, and are now included in the national electronic health record strategies of many countries. A growing body of evidence over the past twenty years suggests that the introduction of e-prescribing can reduce medication errors, improve patient safety and prevent fatalities. However, adoption is very uneven among countries. In Ireland for example, the development and adoption of e-prescribing on a national basis has not yet occurred, and the majority of the 30 million or so prescriptions per year are still handwritten. Are national e-prescribing systems too expensive, difficult or complex to tackle, or are there other reasons why Ireland is lagging behind in this area? Is there a blueprint for countries who wish to develop national e-prescribing systems?

Introduction and Objectives
Delivering healthcare involves an element of risk. It has been estimated that up to 7,000 people die in the United States of America each year from medication errors, and it is suspected that the situation is similar in other countries [1, 2]. In recent years some national policy makers viewed e-prescribing as the “low hanging fruit among information technologies that could improve the quality and efficiency of healthcare”[3], and many countries are now pursuing that goal. But have any countries successfully adopted e-prescribing? What are the critical success factors that influence the development and adoption of e-prescribing? What are the lessons for Ireland on the e-prescribing journey? Are there national e-government systems in other Irish public domains that can inform the e-prescribing context in Ireland?

Methods
The evaluation of national health information systems is both complex and difficult [4], so both qualitative and quantitative methods are used, including fieldwork.

Definition
The definition of e-prescribing chosen for this research is “a prescriber’s ability to electronically send an accurate, error-free and understandable prescription directly to a pharmacy from the point of care” [2]. This definition makes it clear that e-prescribing is not sending prescriptions by fax, telex or e-mail, but the replacement of the written or printed prescription with an electronic file, which is transmitted electronically.

Preliminary Findings
Preliminary research examined e-prescribing in 30 European countries in detail, and used the data gathered to create a European e-prescribing index. This index was then compared to similar published research and indices to validate the findings, and reach conclusions. It is clear that there is a great deal of activity at national level in e-prescribing at this time in Europe, although there are still very few examples of successful national systems. Less than 10% of prescriptions in Europe are transmitted electronically, and many countries are in the early stages of national e-health and e-prescribing projects. Denmark and Sweden, the e-prescribing pioneers, have been joined in recent years by the early adopters - Iceland, the Netherlands, and Estonia - as these countries have successfully implemented e-prescribing on a national basis in both the primary and secondary care sectors. Estonia is perhaps the most interesting example, as the national project commenced in January 2010, and less than two years later the adoption of the system is approaching 100%, a level that has taken the pioneers up to 25 years to reach. While most of the 30 European countries examined are developing their organisational and technical capacity for national e-health systems, the regulatory and legal areas were found to be the most difficult for all countries.

Further Research
Comparative research is under way into the Irish Government’s Revenue-on-line (ROS) system.

Acknowledgements
This research has been possible thanks to support from the Department of Computer Science & Information Systems, University of Limerick, and the John and Pauline Ryan Scholarship.

References
[1] IOM, ed. To err is human: building a safer health system. 2000, Institute of Medicine, USA.
Subjective workload assessment of Medical Physicists’ tasks during monthly Quality Assurance in Radiotherapy department using NASA-TLX

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Abstract
Monthly QA (Quality Assurance) is a necessary procedure to ensure correct machine calibration of Linear Accelerator (Linac) for correct and safe treatment delivery to patients diagnosed with cancer. NASA-TLX (Task Load Index) questionnaire was administered to two Medical physicists while performing monthly QA in the Radiotherapy department in Galway University Hospital (GUH). Results have shown QA requires high performance, time pressure, and results in negative human performance factors.

1. Introduction
Monthly QA in Radiotherapy takes approximately four hours which ensures that Linac, a high-end machine for cancer treatment, is calibrated correctly. It is an essential procedure to ensure correct treatment delivery to patients diagnosed with cancer. Electrometer and ion chamber are some of the calibrating measurement devices used for measuring QA of photons, as well as thermometer and barometer, which can influence the calibration.

QA is often regarded as a less wanted procedure amongst the staff and is often related to negative human performance factors, such as boredom, fatigue, sleepiness, tiredness, stress, etc. One monthly QA is done per Linac machine, requiring two medical physicists to work in a team.

NASA-TLX, a self-reported subjective method for measuring workload was developed by National Aeronautics and Space Agency (NASA). It is a multidimensional rating procedure which is based on the ratings of six factors: mental demand (MD), physical demand (PD), temporal demand (TD), performance (PE), effort (EF), and frustration (FR). The weight of contribution of each factor is based on pair-wise comparison of these factors, and by depth of the ratings reported on a scale from 0 to 100. Each factor, as well as total overall workload can be presented graphically. NASA-TLX is a highly validated method for measuring human performance, and has been in use since 1988.

2. Methods
NASA-TLX questionnaire was administered to two Medical physicists while performing monthly QA in the Radiotherapy department in GUH. It was administered after three tasks: mechanical tests with ultrasound Image-Guided Radiation Therapy (IGRT), standard dosimetric test, and beam characterisation test.

3. Results

Fig 1: Total overall workload of three assessed tasks

The highest values were in mechanical tests with ultrasound IGRT (1), with the total workload value of 44, standard dosimetric test (2), with the total workload value of 32, and in beam characterisation test (3), with the total workload value of 36, as seen in Fig 1.

4. Discussion
The highest workload values in mechanical tests with ultrasound IGRT were in PE (49%), TD (23%) and FR (12.5%) during the 60 minute test. The highest workload values in standard dosimetric test were in PE (25%), FR (22%) and TD (20%) during the 80 minute test. The highest workload values in beam characterisation test were in PE (31%), TD (25%), FR (16.5%) during the 90 minute test.

Despite a relatively low percentage of individual contributing factors during the tests, all tests overall showed medium to high mental workload. Not one test exceeded NASA-TLX threshold value of 50, which would mean “high” workload, though the highest value was very close to it.

Highest results among three tests were PE, TD, and FR, which proves all three tests require high performance, time pressure, and result in negative human performance factors mentioned above.

5. Conclusion
Monthly QA is an important procedure which cannot be avoided and has to be done correctly. Incorrect QA could result in incorrect machine set-up, which could result in incorrect treatment delivery. Measured workload has shown QA results in high performance, high temporal demand and high level of frustration.
### CIVIL ENGINEERING

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The Quasi-Rotation Method for Long Beams Undergoing Large Deflection with Coupled Torsion, Bending and Axial Deformation
Adrian Connaire, Dr Annette Harte, Dr Patrick O’Brien
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Abstract
Nonlinear analysis of beams undergoing finite deflections and rotations has been the subject of extensive research with much attention given to the formulation of finite elements for moderate deformations and coupled torsion, bending and axial response.

This study deals with a beam finite element analysis formulation based on the convected co-ordinates method which uses a quasi-rotation definition for long slender beam subject to large deformations and rotations. This provides for the representation of path dependent rotations in three dimensions and the definition of consistent strain measures which account for coupling of twist, bending and axial deformations.

The particular contribution from this work, in the context of other research, is with respect to methods by which a two-angle definition of rotation deformation, denoted the twist-bend angle set, is incorporated in a solution scheme which allows for the analysis of a structure with limited boundary constraints.

Numerical examples show the application of this method is of particular use for offshore subsea risers where multiple flexible, long, slender, compliant, interconnecting structures are subject to large distributed time-varying loads in the time domain and undergo large deflection.

1. Coupled Beam Deformations
The quasi-rotation vector quantity, \( \mathbf{w} \) and its use in dealing with finite path-dependent rotations was first presented by O’Brien et al. [1], and unlike the true rotation measure \( \mathbf{\omega} \), \( \mathbf{w} \) is a true vector. The time derivative of \( \mathbf{w} \) is the rate of rotation vector and is defined as

\[
\mathbf{w}(t) = \int_0^t \mathbf{\omega}(\tau) d\tau
\]

Rotational deformation for a beam can be shown to be represented by the quantity, \( \mathbf{w}_{\text{def}} \), which is essentially a two-angle vector representation of rotation deformation from the convected coordinates axis and denoted here as \( (\theta_2, \varepsilon_2, \varepsilon_3) \) where \( \theta_2 \) represents twist about the beam axis and \( \varepsilon_2 \) and \( \varepsilon_3 \) are two components of bending in a deformation bend plane.

Writing equations of motion in local convected coordinate components yields an expression which demonstrate that the rate of rotation is linearly related to the local components of the rate of change of \( \mathbf{w}_{\text{def}} \) along the beam axis, denoted here as \( \frac{d\mathbf{w}_{\text{def}}}{dx} \). This demonstrates the validity of \( \mathbf{w}_{\text{def}} \) as a basis for computing rate of rotation along a deformed beam.

Expanding local components of \( \frac{d\mathbf{w}_{\text{def}}}{dx} \) for a beam in the convected axes yields an expression for torsional strain of the following form

\[
e_t = \frac{\frac{d\theta_2}{dx}}{2} - \frac{1}{2} \left( \frac{d\varepsilon_2}{dx} - \frac{d\varepsilon_3}{dx} \right)
\]

This shows that beam torsional strain can be computed directly from the rates of change of the local convected axis components of \( \mathbf{w}_{\text{def}} \). Similar relations can be derived for curvatures and axial strains.

3. Application
The method is used to characterise the response of a high flexible beam undergoing bend and twist loading, where a time varying forced displacement is applied and a contact surface is present. The conditions represented in this example have particular application for risers in an offshore subsea environment. The beam structure response is determined over time as shown for a regime of high axial strain, high curvature and intermittent localised tension and compression.

4. References
A Preliminary Numerical Study of the Improvement to Secondary Settlement offered by Granular Columns

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Abstract
The settlement reduction offered by vibro stone columns is conventionally quantified using the ‘settlement improvement factor’. Two-dimensional axisymmetric finite element analyses have been carried out using PLAXIS 2D to derive separate ‘settlement improvement factors’ for the primary and creep phases of settlement. Preliminary results indicate that the columns result in a significant improvement to primary settlement; whereas the effect on secondary settlement, although positive, appears to be significantly less.

1. Introduction
The settlement improvement factor (n) is defined as the ratio of the settlement of the untreated ground ($s_{untreated}$) to the settlement of the ground treated with stone columns ($s_{treated}$), i.e. $n = s_{untreated}/s_{treated}$. A field database of n values for stone columns at soft cohesive soil sites has been compiled by [1]. It has been noted that n varied with the proportion of ground plan area replaced by stone in a similar fashion to that predicted by [2], a popular semi-empirical analytical design method. Reported n values tended to be ‘lumped’ values with no distinction between primary consolidation and creep settlements.

The duration of monitoring time serves as the main impediment for measuring long term creep settlements in the field. In this study, the PLAXIS 2D Soft Soil Creep Model is used to carry out a series of preliminary analyses to establish whether stone columns are effective in reducing creep settlements and how the improvement factors compare with corresponding improvement factors for primary settlement.

2. The Soft Soil Creep (SSC) Model
The SSC model is an isotropic model suitable for modelling creep in normally consolidated clays, silts, and peat. The SSC model is based on creep Hypothesis B, which states that creep is significant during primary consolidation. Because the model predicts that creep occurs concurrently with primary consolidation, Casagrande’s log time method for separating primary consolidation and secondary compression is unsuitable, since it doesn’t account for creep during primary consolidation. Instead, the primary and secondary settlement components under a load increment have been separated using a method of extrapolation based on the creep coefficient, $\mu_s$, assuming creep to begin at a reference time, $\tau$, of 1 day.

3. PLAXIS 2D Numerical Model
An axisymmetric unit cell approach (Fig. 1a) has been adopted to represent the behaviour of an infinite stone column grid. The unit cell analyses are performed for a range of area-replacement ratios $2<A/A_c<10$ (Fig. 1b).

4. Results
Settlement-log time curves are presented in Fig. 2. Separate primary and secondary settlement improvement factors have been calculated and the predictions have been compared with a selection of analytical settlement design methods. The numerical predictions of the primary settlement improvement factor are in reasonable agreement with the analytical design approaches. However, the n values for secondary settlement are significantly lower.

5. Acknowledgements
The lead author would like to acknowledge the support of the Irish Research Council for Science, Engineering and Technology (IRCSET).

6. References
A 3-D finite element study of the response of pile groups in soft clay

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Abstract

This paper presents predictions of the behaviour of a small pile group using the finite element software package PLAXIS 3D Foundation with the advanced Hardening Soil model. In particular, the suitability of this model to the prediction of the response of a well documented single pile and pile group load test at a soft clay test site in Belfast, Northern Ireland is examined. Although the 'wished-in-place' pile installation in PLAXIS does not take into account the complex effective stress regime set up in the soil during pile installation, predictions of pile group behaviour are shown to compare well to measured data.

1. Introduction

There are two factors which distinguish group pile behaviour from that of single piles, namely load interaction and group installation effects. Finite element (FE) analysis is the most rigorous means of modelling load interaction, and is capable of modelling soil stiffness non-linearity, large group sizes and various non-standard geometries.

McCabe and Lehane [1] employed a simplified 2D FE analysis coupled with a nonlinear constitutive model for the prediction of the response of the same pile group. The present study upgrades this earlier work to a 3D finite element analysis using PLAXIS 3D Foundation (Version 2.2). The Hardening Soil constitutive model is used for the soft clay/silt soil and calibrated from soil test data from the same site.

2. Belfast soil profile

Load test data from the pile test programme reported by McCabe and Lehane [2] at Belfast, Northern Ireland is modelled in this paper. The Belfast soil profile consists of a layer of made ground which extends to a depth of ~1.0m, a layer of silty sand from 1.0m to 1.7m, and a lightly overconsolidated soft estuarine silt (locally known as sleech) to a depth of 8.5 m. A stratum of medium dense sand exists at 8.5 m below ground level.

3. Soil model

The basic soil properties used for the constitutive model were derived from laboratory tests reported by McCabe and Lehane [2] The Hardening Soil (HS) model was chosen to model the behaviour of the fill and sleech in PLAXIS. The main advantage of the HS model over an elastic perfectly-plastic model is that the yield surface is not fixed in principal state but instead can expand due to plastic straining.

4. PLAXIS results

PLAXIS 3-D Foundation was used to simulate the single pile field test (S) for partially-drained loading believed to have occurred in the test. The partially-drained analysis appears to predict the initial measured stiffness of the single pile, its nonlinearity and the pile load at 15mm displacement very well.

The load-displacement response of the centre pile of the 5-pile group (C) has also been plotted with that simulated by a partially-drained analysis in PLAXIS. It can be seen from Figure 1 that PLAXIS under-predicts the stiffness of the centre pile slightly but the nonlinear load-displacement response and load at 15mm are captured well.

5. Conclusions

A finite element study on the behaviour of a small pile group in soft clay has been presented using the advanced HS model in PLAXIS 3D Foundation. Although it is recognised that the HS model cannot capture any additional group installation effects over-and-above what might be anticipated for each pile’s own installation, pile group stiffness and capacity appear to be captured very well.

6. References

The Analysis of Shear and Load Transfer in Void-Formed Flat Slab Systems, Including In-Situ Measurements from a Building

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Abstract

Void form flat slab systems are an innovative and novel form of flat slab system. They consist of high density polyethylene void-formers, positioned in the middle of a concrete cross section to reduce the overall self weight of the slab. The reduction of self-weight, up to 35\%, allows for savings in overall materials, a reduction in overall costs and also permits longer spans allowing for more complex geometry. The aim of this research is to analyse the performance of this system and characterise its shear and load sharing behaviour.

1. Introduction

Void form flat slab (VFFS) systems can be constructed using two methods; a traditional in-situ concrete option or through the use of pre-cast elements in combination with in-situ concrete. This research will focus directly on the use of the semi-precast elements (Fig. 1). Unlike hollow core slabs VFFS’s manage to maintain full flexural strength, allowing two-way or bi-axial load transfer. However, when using the precast elements the two-way action of the bottom steel reinforcement is restricted. To ensure that this two-way action is achieved between the different slab panels a series of reinforcement or ‘stitching’ bars are provided. These ‘stitching’ bars are centred on the joint between the pre-cast elements. The assumption is that these will provide sufficient bond between the slab panels to ensure transfer of load across the slab joints rendering the joints irrelevant to the completed structural performance.

2. Methodology

The project forms a small part of the structural instrumentation of the new Engineering building at NUIG. The building represents a milestone in the construction of engineering educational facilities by incorporating the use of numerous types of sensors to create an interactive learning environment for students. It is the first building in Ireland to utilise a VFFS system. During its construction over 160 gauges (Fig. 2) were installed in a VFFS element and these are continuously monitoring the temperatures and strains. The data from site will allow a detailed understanding of exactly how VFFS’s react during the various stages of a buildings construction and throughout its lifetime.

3. Acknowledgements

The first author is extremely grateful for the ongoing support of Arup Consulting Engineers and the Irish Research Council for Science, Engineering and Technology (IRCSET) through the Enterprise Partnership Scheme.
Cost-effective sustainable construction technology: Learning from developing countries.

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Abstract

One construction technology used in developing countries that has very low impact on the environment is stabilised soil blocks (SSBs). Although there is ample literature on the application of SSBs in tropical countries, their potential use in a European climate has not been fully investigated. Through this research project, the development of this novel, cost-effective, sustainable, composite building technology or product for use in a European context is investigated through extensive testing in terms of durability, strength, stiffness and appearance.

1. Introduction

Stabilised soil blocks (SSBs), as seen in Figure 1, are masonry units formed by compressing a suitable mixture of soil, cement and water into a mould. The blocks are low-cost as their main component, the soil, is usually local in origin, with minimal transport costs incurred. SSBs are predominantly used in the construction of both structural and non-structural elements in many developing countries throughout the world. These blocks are interlocking in nature, built dry stacked without the need for mortar joints. In general, SSBs have a lower environmental impact than alternative masonry technology, such as clay-fired bricks or concrete masonry blocks.

Figure 1: Interlocking stabilised soil blocks.

2. Investigation into alternative binders

The most commonly-used stabiliser employed in the manufacture of SSBs is Ordinary Portland Cement (OPC), which is the most expensive and energy-intensive ingredient. Due to the manufacturing process associated with cement production, approximately 750kg of CO₂ is released into the atmosphere for every tonne of cement produced. Therefore, it is imperative that alternative cement replacements are developed. The replacement of OPC with alternative waste materials and by-products is a cost-effective process, and their use in SSBs can benefit the environment, especially where disposal to landfill is the alternative. A wide range of agricultural and industrial waste products are examined in terms of their physical and chemical properties and their suitability as a cementing material in an attempt to convert waste products into useful construction materials. It has been revealed that the use of these materials in SSBs not only reduces their cost and embodied energy, but also can improve their structural performance.

3. Stabilised Soil Block Testing

In terms of masonry blocks, compressive strength isn’t the most critical characteristic. Assuming the soil is adequately compressed and suitable soil is used in the making of the blocks, avoiding the use of topsoil with high levels of organic matter, the target strength should be met. Durability tends to be the more stringent criterion to meet, and the ability of the soil in the blocks to resist prevailing rain, wetting/drying cycles, freezing/thawing cycles and chemical attack deserves special attention if they are to be applicable in a European climate. SSBs containing 5%, 7.5% and 10% cement by dry weight and containing a combination of cement and various proportions of alternative binders were tested in terms of compressive strength, tensile strength and stiffness at 7, 14, 28 and 56 days. Durability tests included cyclic freeze/thaw tests, cyclic wetting/drying, absorption, sorptivity (capillary test), spray test (spraying blocks with water), placing blocks in rainfall simulator and exposing blocks to natural weather conditions.

4. Conclusions

Through this extensive experimental testing program, it is expected that the successful development and implementation of stabilised soil blocks (SSBs), incorporating a waste material as a cement replacement, will be confirmed for a European climate. Currently, the commercial development of SSBs as a sustainable building product or technology seems to be highly promising. However, it is important that similar studies on the long-term performance and durability of SSBs are undertaken to further promote the commercial development of the product. The implementation of the product can contribute to the development of a more sustainable and ‘green’ economy.

5. Acknowledgements

The first author would like to thank the Irish Research Council for Science, Engineering and Technology (IRCSET) EMBARK Funding Initiative, who are funding this research project.
High resolution modelling and observation of wind-driven surface currents in Galway Bay

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Abstract
In the present research, a wind forecast model is coupled with a three-dimensional numerical model of Galway Bay, a semi-enclosed estuary on the west coast of Ireland, to investigate the effect of surface wind data resolution on model accuracy. High resolution and low resolution wind fields are specified to the model and the computed surface currents are compared with high resolution surface current measurements obtained from two high frequency SeaSonde-type Coastal Ocean Dynamics Applications Radars (CODAR).

1. Introduction
Hydrodynamic circulation in estuaries is primarily driven by tides, river inflows and surface winds. While tidal and river data can be quite easily obtained for input to hydrodynamic models, sourcing accurate surface wind data is problematic. Firstly, the wind data used in hydrodynamic models is usually measured on land and can be quite different in magnitude and direction from offshore winds. Secondly, surface winds are spatially-varying but due to a lack of data it is common practice to specify a non-varying wind speed and direction across the full extents of a model domain. These problems can lead to inaccuracies in the surface currents computed by 3D hydrodynamic models.

2. Research Aims
The aims of this research are as follows:
1. Develop a 3D numerical model to simulate tidal flows in Galway Bay
2. Validate the model using measured ADCP data
3. Validate the modelled surface currents using CODAR-observed surface currents
4. Investigate the effect of wind input data resolution on the modelled surface currents

3. Research Methodology
The wind forecast models used for the research are Harmonie cy361.3, running on 2.5 and 0.5km spatial grids for the low resolution and high resolution models respectively. The low-resolution model runs over an Irish domain on 540x500 grid points with 60 vertical levels and a 60s timestep and is driven by ECMWF boundary conditions. The nested high-resolution model uses 300x300 grid points on 60 vertical levels and a 12s timestep. EFDC (Environmental Fluid Dynamics Code) is used for the hydrodynamic model. The Galway Bay model has ten vertical layers and is resolved spatially and temporally at 150m and 4 sec respectively. The hydrodynamic model is run for selected hindcast dates when wind fields were highly energetic. Spatially- and temporally-varying wind data is provided by offline coupling with the wind forecast models. Figure 1 shows comparisons of modelled and measured depth-averaged currents.

6. Conclusion
The model shows good correlation with measured current meter and tide gauge data. Comparison with CODAR data has just begun, as has the investigation into the effects of wind forcing on the surface currents. It is hoped that modelled surface currents show good correlation with CODAR observed currents and the resolution of the surface wind data is shown to be improve model accuracy.
Improved Information Management in the Operational Phase: Driving Building Performance Optimisation through Information

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Abstract

Modern buildings are hugely complicated facilities, designed to satisfy a vast array of legislative, environmental and organisational requirements efficiently, whilst providing a comfortable environment for occupants. Research suggests that many of these buildings do not operate as intended and an information gap exists in the operational phase which prevents the achievement of optimal building performance.

This information gap manifests itself in three key ways. Building performance is not measured adequately, building operators do not have the range of tools required to provide a holistic view of building performance and little effort is made to integrate the data contained in various building related information silos into meaningful performance information.

This work defines ideal building performance and provides an information framework to equip building stakeholders with the decision support systems required to drive performance optimisation. It utilises key concepts from the information management sphere, including building information modelling and linked data.

1. Introduction

Currently, performance optimisation is an intuitive process, lacking the informational toolkits necessary to provide quantitative feedback on performance enhancements. This research investigates methods of providing holistic, relevant information to the key performance stakeholder.

It integrates this methodology with an exploration of the role of performance specialist, identifying key requirements for the position. The provision of a performance dashboard, providing the performance specialist with a holistic view of building operation will drive performance efficiencies.

NUIG envisaged the New Engineering Building (NEB) as an exemplar campus building, providing a living laboratory to engineering students. The building contains a host of suitable information sources and is the primary case-study for this research program. The NEB provides thermal energy to the Kingfisher sports complex and this building will serve as a secondary demonstrator. The DERI building provides an existing Linked Data architecture and will also be used as a primary test bed.

Figure 1 describes the data flows currently directed towards the Facilities Manager. Data comes from a range of sources in an unstructured format. The facilities manager reacts intuitively to events, lacking the time and toolset to optimise performance. Organisations lack the role of a performance specialist to develop and implement systems to improve performance.

Utilising Decision Support and Information Systems technology, common to other industries, it is possible to create a standardised framework around the provision of performance information. Figure 2 illustrates the proposed information transfer.
Determination of optimal applications of municipal biosolids to soils to optimize nutrient availability and minimize loss in surface runoff

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Abstract
Biosolids are the by-product of urban wastewater treatment and may be used as a fertiliser in agriculture. While Ireland can be seen as one of the leading countries in Europe in terms of landspreading of biosolids, very little is known of the phosphorus (P) availability of the biosolids to the soil or the potential for nutrient release in surface runoff following rainfall. The use of a novel agitator test in which an intact soil sample is placed in a glass beaker, overlain with a known volume of water and agitated to simulate overland flow, can be used to determine the release of P to surface runoff.

1. Introduction
In Ireland there are approximately 86,000 tonnes of biosolids produced per year, of which over 70% is presently disposed off via landspreading. Provided that the biosolids are treated to the approved standards, they can be landspread in agriculture, and offer an excellent source of phosphorus (P), nitrogen (N), and metals required for crop growth.

The Landfill Directive, 1999/31/EC (EC, 1999), requires that, by 2014, the disposal of biodegradable municipal waste via landfill is to be reduced to 35% of the 1995 value. As a direct result, landspreading of biosolids provides a sustainable and beneficial alternative to landfilling.

Guidelines governing their use are based on research carried out abroad and little information is based on their interaction with Irish soils. In addition, the guidelines do not consider the relationship between biosolids application rates, nutrient availability, and surface runoff of nutrients, suspended sediment (SS) and metals.

2. Materials and Methods
The soil used in this study was collected from a local farm in Co. Galway. Biosolids were collected from three wastewater treatment plants in Ireland. They were: lime stabilised biosolids, anaerobically digested (AD) biosolids, and centrifuged biosolids. They were tested for their nutrient and metal content.

The following treatments were carried out in triplicate (n=3) in the agitator test: grassland only; grassland receiving centrifuged, lime stabilised and anaerobically-digested biosolids. All treatments were applied at the optimum application rate for the soil under investigation.

The soil, 40 to 50 mm in depth, was first transferred from aluminium cores to glass Pyrex cylinders. The biosolids were then applied to the soil surface (t=0hr) and left sit for a period of 24 hr to allow the treatments to interact with the soil. After this 24 hr period, the samples were then saturated by the gradual addition of deionised water over a 24-hr period. This was conducted until slight ponding of the water was seen on the surface of the soil. After this 48-hr period, 500 ml of deionised water was gently added to the beakers. An agitator paddle was then lowered to mid-depth in the overlying water and rotated at 20 rpm for 30 hrs as an attempt to simulate overland flow.

Throughout the 30-hr period of the test, 2.5 ml water samples was removed at mid-depth of the overlying water at pre-determined time intervals and tested for dissolved reactive P (DRP). A 15 ml sample was removed from each beaker at the end of the test (at 30 hr) and stored until metal analysis was carried out.

3. Results
Initial testing has shown that the centrifuged biosolids released, at their peak, 2.43 mg DRP L⁻¹, which equated to a mass of P released in the overlying water of 148.464 mg m⁻² of grassed surface area, while the AD biosolids released 0.36 mg DRP L⁻¹ (22.2 mg m⁻²). The control results were far more conservative, releasing 0.14 mg DRP L⁻¹ (8.86 mg m⁻²).

4. Conclusions
For all types of biosolids analysed, P levels in the overlying water are in excess of the maximum allowable P concentration in surface water (20 – 30 μg P L⁻¹). Furthermore, owing to the centrifuged biosolids releasing eight times as much P as AD biosolids, biosolids may potentially need to be mixed with a chemical amendment capable to adsorbing P (alum, ferric chloride, etc.) before being landspread.

5. References
Axial Load Behaviour of a Driven Cast-in-Situ Pile in Sand

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Abstract
Driven cast-in-situ (DCIS) piles are used extensively in piling projects in the UK. Due to the lack of knowledge on the axial load behaviour of DCIS piles, a static load test was conducted on an instrumented DCIS pile in a uniform sand deposit at Shotton, Wales. Analysis of the test results showed that pile behaviour was predominantly end-bearing, with the base resistance accounting for approximately 81% of the total capacity at failure.

1. Introduction
Driven cast-in-situ (DCIS) piles are classified as a type of displacement pile [1]. The installation process involves driving an open-ended steel tube with an expendable driving shoe. Upon reaching the required depth of penetration, the reinforcement is inserted into the tube, followed by concreting via a skip. The tube is then withdrawn and the concrete is left to cure in-situ for a number of days. Despite the popularity of DCIS piles, there is a surprising lack of literature on their axial load behaviour. A static load test was performed on an instrumented DCIS pile in order to assess the axial load behaviour as part of an overall study to estimate pile capacity based on measurements during installation.

2. Ground Conditions
The test location was approximately 3 km northwest of the village of Shotton in Deeside, Wales. A cone penetration test (CPT) conducted at the test location prior to pile construction indicated three distinct layers – a 2 m thick layer of made ground, underlain by a loose to medium dense layer of fine sand. A significant increase in density was observed at a depth of 5 m, resulting in an average cone resistance $q_c$ of 20 MPa. The water table was located approximately 2 m below ground level (bgl).

3. DCIS Test Pile
The DCIS test pile was 5.75 m in length, with a nominal shaft diameter of 340 mm. In order to measure the shaft and base resistance during loading, the pile was instrumented with 16 no. vibrating-wire strain gauges at four separate levels (0.3 m, 2.5 m, 4.0 m and 5.5 m bgl), with an array of four gauges placed at each level in order to minimise the effect of bending on the measured strains during loading, as well for redundancy purposes. The pile was installed using a 5-tonne Junttan HHK5A hydraulic hammer, with a 380 mm diameter sacrificial steel driving shoe at the base of the installation tube.

4. Static Load Test
A maintained-load compression test was conducted on the pile in accordance with the Institution of Civil Engineers Specification for Piling and Embedded Retaining Walls [2] approximately 14 days after casting. The test pile was initially subjected to two loading cycles to maximum loads of 1000 kN and 1500 kN respectively, followed by a final cycle to 2400 kN. The measured load-displacement response at the pile head is shown in Figure 1. The failure load, defined nominally as the load at a displacement corresponding to 10% of the shaft diameter $D_s$, was 2147 kN.

![Figure 1 – Load-displacement response](image)

As the pile base was founded in a dense stratum, the axial load behaviour was predominantly end-bearing, with the base resistance accounting for 81% of the total pile capacity at failure. The magnitude of displacement required to mobilise both the shaft and base resistance was similar to that which would be expected of a full-displacement driven preformed pile in sand.

5. Conclusions
Based on the results of the load test, it is tentatively concluded that the axial load behaviour of a temporary-cased driven cast-in-situ pile in sand is similar to that of a full-displacement driven preformed pile.

6. Acknowledgements
The first author gratefully acknowledges the financial support provided by the COEI Fellowship and the University Foundation, NUI Galway.

7. References
Development of A Novel Data Assimilation Procedure for Hydrodynamic Forecasting in the Coastal Region
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Abstract
As we know that sea surface current information is important, not only because utilization of its resources, but also the demands for increasing development have directed both governments and individuals to investigate the basic mechanisms. We are carrying out research to develop a tidal current forecasting system in Galway Bay by using simulation and measurement. We have deployed two advanced CODAR SeaSonde High Frequency Radar Systems in Galway bay to receive the sea surface current vector map every half an hour; this data will be combined into the Environmental Fluid Dynamic Code (EFDC) through a detailed data assimilation[1] procedure to develop a numerical forecasting system. Further, the Tidal Basin at NUI Galway will be used to validate some parameters to improve the data assimilation routines in EFDC.

1. Introduction

1.1. EFDC
The Environmental Fluid Dynamic Code (EFDC) solves the three-dimensional, vertically hydrostatic, surface, turbulent averaged equations of motions for a variable density fluid. The module uses a stretched or sigma vertical coordinate and Cartesian or curvilinear, orthogonal horizontal coordinates. Dynamically coupled transport equations for turbulent kinetic energy, turbulent length scale, salinity and temperature are also solved.

1.2. CODAR
Coastal Ocean Dynamics Applications Radar (CODAR) describes a type of compact High Frequency (HF) Radar[2]. CODAR uses HF surface wave propagation to remotely measure ocean surface waves and currents. The ocean is a rough surface, with water waves of many different periods. When the radar signal hits ocean waves that are 3-50 meters long, that signal scatters in many directions. In this way, the surface can act like a large diffraction grating. The radar signal will return directly to its source only when the radar signal scatters off a wave that is exactly half the transmitted signal wavelength, and that wave is traveling in a radial path either directly away from or towards the radar. The scattered radar electromagnetic waves add coherently resulting in a strong return of energy at a very precise wavelength[3]. By looking at the same patch of water using radars located at two or more different viewing angles, the surface current radial velocity components can be summed to determine the total surface current velocity vector.

1.3. Tidal basin
The laboratory work will be conducted in a tidal tank at NUI Galway. The function of the tank is to produce tides and to generate water circulation that can represent the flow features of a prototype when appropriate scaling relationships are adopted. The tidal tank is constructed from reinforced PVC sheets having a size of 1 m by 1m each. The internal dimensions of the tank are 8.0 m by 5.0 m and the maximum depth is 1.0 m. The horizontal plan is divided into three sections: reservoir, manifold chamber and working area.

2. Objective of the research
The primary objective is to develop a new real-time marine forecasting system in Galway Bay, subsequently this system will be developed in a more generic manner so that it will be highly transportable.

3. References
Formal calibration methodology for a CFD model of a naturally ventilated room

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Abstract - Computational Fluid Dynamics (CFD) is a robust tool for modelling interactions within and between fluids and solids. This work focuses on a systematic methodology for the development of calibrated CFD models of naturally ventilated indoor environments. The calibration procedure is supported by on-site measurements obtained using a wireless sensor network. A valid CFD model of indoor environment helps estimate the boundary conditions that most influence indoor air temperatures and air speeds in naturally ventilated spaces.

Keywords - CFD, calibration, methodology, indoor environment, buildings, natural ventilation

I. INTRODUCTION

In recent years CFD has become a very popular tool for predicting the airflow in buildings. About 70% of ventilation performance studies published in year 2008 used CFD in their analysis [1]. Chen & Srebric [2] specified guidelines for the verification, validation and results reporting of CFD models of indoor environments. However, no systematic methods for the calibration of such models were determined. Thus there is a need for easily calibrated CFD models which provide good representation of the real environment. Being an effective tool for building design and optimisation, reliable CFD models would lead to cleaner, healthier and more efficiently controlled indoor environments.

II. RESEARCH GOALS

In this research a systematic methodology for the calibration of CFD models, for naturally ventilated environments in buildings, was developed. This methodology can be used to estimate the CFD boundary conditions that most influence model outputs and thus improve model accuracy and efficiency and lead to significant time savings when developing such models.

III. METHODOLOGY

Figure 1 shows the calibration methodology in a systematic manner. Firstly, different runs of the initial CFD model are performed; each with a finer mesh, and their results are compared to achieve grid independence. A grid independent solution implies the results do not change significantly with increasing numbers of mesh cells, i.e. the balance between accuracy and computation time is achieved.

Next, simulated air temperatures and speeds inside the room are validated against the on-site measurements. If the model meets the specified criteria, it may be called a true representation of the real environment. If the specified criteria are not met, parameter analysis is performed. Parameter analysis allows for the determination of the CFD model boundary conditions that most influence the model output results. The next step is the process of improving the agreement between experimental and simulated data by adjusting the most relevant parameters. This step is repeated as long as the CFD model meets the criteria of being a good representation of the real environment.

IV. DEMONSTRATOR

For the simulation of an indoor environment, a CFD model of one of the study rooms in the Nursing Library building at the National University of Ireland, Galway was developed. Data obtained from an on-site weather station and wireless sensors provided boundary conditions for the CFD model. A well-positioned wireless sensor network collected real-time data at multiple locations within the indoor environment to support a robust calibration of a CFD model.

REFERENCES

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Evaluation of the Effect of Radial Distortion on Pedestrian Detection in the Automotive Environment

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Abstract
The task of pedestrian detection from cameras mounted on a vehicle has become increasingly important to a number of automotive safety applications such as collision avoidance, parking assistance and autonomous driving. In typical automotive vision systems however, wide angle lenses introduce undesirable effects such as blur or radial distortion. The aim of this research was to evaluate the effects of these distortions on machine vision performance, using pedestrian detection as an important and widely-used machine vision algorithm for the automotive environment.

1. Introduction
Our approach was to consider the effects of radial distortion on a well-established pedestrian detection algorithm [1]. We carried out our research on test images selected from a publically available pedestrian detection database [2] in order to obtain representative data from typical automotive scenes. A distortion model was selected and the reference images were batch processed to create over 3,600 distorted images. The performance of the pedestrian detection algorithm was evaluated on each batch of images and correlated against the level of distortion applied to each batch. Fig. 1 shows the pedestrian detection algorithm operating on a distorted image.

2. Distortion Modeling
Radial distortion is the most evident geometric distortion in wide angle lenses [3]. There are several different mathematical models that have been developed to correct for radial distortion. The Fitzgibbon model [4] approximates the ideal image point \( p \) for any given image coordinate \( x \in \mathbb{R}^2 \) with distortion parameter \( \lambda \) and is given by:

\[
p = \frac{x}{1 + \lambda \| x \|^2}
\]  

(1)

This model has been shown to be as good an approximation to radial distortion as the more traditional Taylor expansion model [3] but requires only one distortion parameter (namely \( \lambda \)) in order to vary the amount of radial distortion.

3. Results
The results, plotted in Fig. 2 show that pedestrian detection performance drops with increasing radial distortion. The linear fit applied to the graph illustrates that there is a very strong correlation between the level of distortion and the performance of the algorithm.

References

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Simulation of Ethernet Based Automotive Communication Networks  
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Abstract  
Automotive electronics is a rapidly expanding area with an increasing number of driver assist and infotainment devices becoming standard in new vehicles. A review of the current landscape of networking standards within vehicles reveals a fragmented and proprietary state of affairs with several “standards” in current use by various vehicle manufacturers. Due to the costly nature of equipment and testing apparatus for these standards, there is a general desire within the automotive industry to use the 802.3 Ethernet standards for all in-vehicle communication between devices. Ethernet however does not provide real time guarantees for safety critical traffic and therefore precautions must be put in place to ensure that critical traffic reaches its destination on time. To investigate this issue, we have created a simulation network incorporating real world traffic which allows us to configure and test different scenarios rapidly, while allowing for realistic results.

1. Introduction  
Network simulation is often used to investigate network scenarios as it allows for multiple experiments to be carried out without the need for costly hardware. It also allows for rapid reconfiguration of devices. A disadvantage of this method of testing network scenarios is that simulations usually consist of network traffic generated by in build traffic generators within the simulation environment. Our approach allows for real network traffic to be introduced to the environment. This means that the simulation closely mirrors a real world environment, allowing for more accurate conclusions and results.

2. Simulation Architecture  
The ns-3 network simulator is being used to model a multi camera in-vehicle driver assistance system. ns-3 allows us to introduce real network traffic to a network simulation through the use of its Tap Bridge functionality. An illustration of a simulated network configuration is shown below.

Real video footage taken from in vehicle cameras is used across the network to accurately represent real scenarios. Video was encoded in real time to MJPEG format and streamed onto the network using the MPEG2 transport protocol. Packet losses are introduced to simulate corruption due to the noisy automotive environment.

3. Results  
An example of the result of packet losses can be seen below in Figure 3.

Inter-arrival times for frames were observed to be linear across a number of simulations involving different numbers of simultaneous video streams, as was measured bandwidth. This shows the robust and reliable nature of the designed test bed, making it a perfect system to allow for realistic tests to be carried out on potential next generation in vehicle networking architectures.

Acknowledgements  
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Energy Harvesting Techniques for Activity Monitoring Devices
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Abstract
Piezoelectric and electromagnetic generation are the two most common energy harvesting techniques. The aim of this paper is to present a comparison of the two techniques in terms of powering a wearable monitoring device. An electromagnetic generator and a piezoelectric system are proposed to power an activity monitoring device.

1. Introduction
Energy harvesting is a concept that has become more and more appreciated as battery power requirements have increased with the decrease in size and improved portability of electronic devices. Even though there have been several studies comparing different energy harvesting techniques, very little has been done to compare techniques for a given application.

2. Review of Energy Harvesting Techniques
Research in the field of energy harvesting has been reviewed in papers like [1] and [2]. Different materials and techniques have been suggested in order to improve the efficiency of generators, and electromagnetism has proven to be a preferred technique as the output power values appear to be higher, as shown in Fig 1. The drawback of electromagnetic generators is they have considerable dimensions.

Piezoelectricity has also been widely used. Authors like [3] and [4] have suggested different materials and power circuitry in order to maximise the power harvested by a piezoelectric component. Results of measured power vs. piezoelectric element size are compared with electromagnetic generators in Fig. 1.

3. Activity Monitoring Device Power Requirements
The application used is a wearable activity monitoring device, based on the Shimmer.[6] The Shimmer contains a 3-axis accelerometer and a Bluetooth module.[7] The main component, in respect to power consumption, is the Bluetooth module. As shown in the results of voltage measured over a 1Ω current sensing resistor the Shimmer power consumption alternates between 210mW peak and 0mW giving an average consumption of 60mW. These results can be seen in Fig. 2.

4. Generator Proposal
Research is on-going for designing an electromagnetic and a piezoelectric generator that will provide power for this wearable activity monitoring device.

5. References

Figure 1: Power vs size dependence of piezoelectric and electromagnetic generators

However, little work has been done in comparing these two techniques on the same applications since Kymissis et al. [5] proposed a comparison between a piezoelectric and electromagnetic generator mounted on a shoe in 1998. A self-powered system was built around the shoes that periodically transmitted a digital RFID as the wearer walked.
Comparison of Light-Load Improvement Techniques for Low Power Buck Converters

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Abstract

Recently a great deal of work has been done to improve the efficiency of DC-DC converters at light load. This has been driven by the desire to increase battery life in portable devices and to reduce standby power consumption in mains powered devices. Several methods to reduce power loss at light load including Pulse Frequency Modulation (PFM) and Diode Emulation (DE) are investigated. These methods however result in higher inductor current ripple (ΔI) as the inductor is designed for operation when output current (I_out) is at its maximum. Distributing inductors in parallel is shown to provide a means for increasing the effective inductance at light load thus reducing current ripple (ΔI).

1. Introduction

Light-load efficiency of DC-DC converters used in portable devices is an essential design consideration as battery life is critical. Converters used in these devices typically have an output current of less than 3 Amps. In DC-DC converters with an output current of between 3 and 10 Amps the majority of commercially available converters have no method to improve light-load efficiency. In the future light-load efficiency will be a major design consideration as requirements for low stand-by power will extend into many everyday products such as LCD displays, Hard Disk Drives, Network devices, Point of Load (PoL) supplies, Digital Signal Processing (DSP) Units and low power processors.

This work focuses on losses associated with the passive and active components in a buck DC-DC converter at light-load, and the corresponding performance of the circuit implementing the various light-load techniques. Distributing inductors in parallel provides the potential to switch out inductors at light load resulting in reduced current ripple (ΔI) as the effective inductance is increased. It is envisaged that the reduction in ripple current (ΔI) will result in reduced inductor AC and core loss.[1]

2. Light Load Techniques

Two different light load methods are compared to a standard DC-DC converter without any light load efficiency improvement method. The first method is Pulse Frequency Modulation (PFM). Many implementations of PFM exist but in its simplest form the switching frequency is lowered so that switching and gate drive losses are reduced, improving efficiency at light load. This method results in Electro Magnetic Interference (EMI) issues in noise sensitive applications.

The second method is Diode Emulation (DE), where the low side switch in a buck converter is switched off when the current flowing through the inductor reaches zero thus preventing reverse current through the inductor. It has been shown that entering DE mode results in higher efficiency at light load versus Continuous Conduction Mode (CCM) [2]. These light load methods will be implemented in two different topology variations, a single-phase buck converter and a single-phase buck converter with parallel inductors shown in figure 1.

![Fig. 1](image)

3. Summary

This work compares various light load techniques as well as a method to increase effective inductance at light-load. It is envisaged to extend this work to include loss calculations and measurements of the active switching components for the different techniques outlined.

4. References

Miniaturization Resonant Converter with Planar Magnetics
Applied in PV System

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Abstract

A continuous miniaturization of resonant converter incorporating planar magnetics is leading to higher performance, higher efficiency and decreasing costs which can be conveniently implemented with the independent solar panel in Photovoltaic (PV) system. We are focusing on the research of LLC resonant converter with synchronous rectifier and aim to develop the power conversion products implemented in renewable energy applications with higher power density. The LLC resonant converter with planar inductor and transformer integrated together can achieve the optimum design and an integrated planar transformer structure is presented.

1. Introduction

Power Electronics is an enabling technology for power conversion that can improve efficiency and reduce the cost of manufacture for applications ranging from renewables to aerospace to electric vehicles. Power and energy converters are at the heart of this movement. The implementation of resonant circuits on a large industrial scale has the same revolutionary potential that the change from linear regulators to switched converters achieved. The implementation of LLC resonant technology is picking up and the relevant research is ongoing worldwide [1], [2].

2. LLC resonant converter optimization design

The main topology of the half-bridge LLC resonant converter with synchronous rectifier output is shown in Figure 1.

![Figure 1. Half-bridge LLC resonant converter with synchronous rectifier](image)

The salient resonant components including \( L_r \), \( C_r \), and \( L_m \) should be designed for high efficiency, high power density, and meet the holdup time and no-load condition requirements as well as zero-voltage-switching (ZVS) operation over the full load range. Based on the detailed analysis, several optimization guilds are listed as follows.

- The power loss and ZVS are mainly related to \( L_m \).
- The minimum input voltage, which depends on the holdup time, raises the requirements of the maximum voltage gain.
- The peak current of the resonant tank and the voltage gain with no-load operation condition relates to the ratio between \( L_m \) and \( L_r \).

3. Planar magnetics

The reduction in the size of magnetic devices is essential for further overall miniaturization of power conversion systems. Planar magnetics fabrication and assembly processes have several advantages over conventional magnetics including low profile, high power densities and predictable parasitic. This latter advantage may be exploited in the design of LLC resonant transformers, whereby the leakage inductance can be controlled to provide a suitable value of resonant inductance, \( L_r \). An illustrative planar transformer is shown in Figure 2.

![Figure 2. Planar transformer for LLC resonant converter](image)

4. Conclusions

A new methodology for designing LLC resonant converters has been presented in this paper. Based on the detailed studies, it has been shown that planar magnetics can play an influential role in the future miniaturization of these converters. The final paper will validate the work described here with full working prototypes.

5. References


Modelling and Performance Analysis of an Adaptive State-transition Approach for Power Saving in Bluetooth

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Abstract
The kernel idea of a state-transition is that the Bluetooth Basic Rate / Enhance Data Rate (BR/EDR) controllers can reduce unnecessary polling operations and enter an idle/sleep state for power saving. Firstly, three different polling intervals that can be small, medium or large are set as idle/sleep states in the peer BR/EDR controllers. Each controller runs a common algorithm to choose among the three idle/sleep states and adaptively transfers the link state from active to idle. Furthermore, given the proposed approach's state-transition rules, a system model was established based on the Hidden Markov Model (HMM). Finally, the analysis demonstrates significant power saving and relatively low average end-to-end packet delay for this state-transition approach.

1. Introduction
Bluetooth [1] is a popular short-range wireless communications system, which transports real-time audio signals by Synchronous Connection-oriented (SCO) links and transports packet-switched, data traffic by Asynchronous Connection-oriented (ACL) links. Currently, Bluetooth is being applied to more and more ACL applications for variable rate data transmission, e.g., Wireless Sensor Networks (WSNs).

However, the problem of high power consumption of the underlying Bluetooth polling system has been highlighted for many of the broad range of ACL applications. The Bluetooth Basic Rate/Enhance Data Rate (BR/EDR) controller operates on a master/slave concept and adopts time division multiplexing (TDM). When there is no active traffic from the higher layers, the master sends a POLL packet to the slave who shall send back a NULL immediately as acknowledgement. The POLL-NULL pairs which are often unnecessary can be reduced by the link state-transition to an idle/sleep state in Bluetooth.

2. The kernel idea of a reduced polling operation approach
The new approach uses a set of three different polling intervals in the Bluetooth BR/EDR controllers, whereby the controllers can adaptively choose the intervals and link state transfers from active to idle based on a common algorithm.

3. A set of states and a common state-transition algorithm
The basic concept is to introduce four related states: an active state, and "small", "medium" and "large" interval states. A Finite State Machine (FSM) diagram is used to re-present the state-transition algorithm.

4. System modelling
The system model of the proposed state-transition approach is a classic Hidden Markov Model (HMM) [2]. The system model can be used to estimate state-transition paths, to calculate the average power, to analyze the state-transition rules and to design a broadly applicable common algorithm for the controllers.

5. Performance analysis
This approach can be implemented autonomously on the controllers and significantly improve Bluetooth power efficiency by reducing the polling operations. A set of default parameters can be used, and it could easily be added to Bluetooth as a feature. If necessary, additional configuration options can be supported through additional HCI and/or LMP commands.

6. Simulation evaluation and Conclusion
The simulation results showed that although the power consumption of the proposed approach is slightly more than adopting Sniff mode for a typical configuration, it has very low average end-to-end packet delay and is easier and more flexible for setting the parameters. The state-transition approach adjusts the states according to the traffic levels. The state setting can be optimized for a specific Bluetooth scenario.

7. References
Practical Application of FMEA Methodology in Electronic Manufacturing

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Abstract

Failure Mode and Effect Analysis (FMEA) is a proactive tool used to identify, evaluate and prioritise potential weakness or failure modes in a given system. While an expected tool utilized across multi-disciplinary fields from aerospace to automotive to pharmaceutical, when scrutinised in detail the FMEA as a process has a number of weakness. This research work aims to dissect the FMEA process, review the perceived weaknesses, and present alternative improvements were applicable as applied to the Electronic Manufacturing Industry.

1. Introduction

As with any methodology, familiarity leads to scrutiny. The more a particular method is utilised, the more questions are asked and inevitably the more weaknesses are found. The FMEA is no different. From its early stages of development with NASA, the FMEA has evolved into an industry accepted methodology used across varied fields from pharmaceutical, to militarily to automotive. It is this widespread use which has exposed the FMEA to various questions and critics.

In his 1993 article Gilchrist [1] presented a critical review of the FMEA and in particular the use of the RPN to rank failures. He points out that using the product of the three attributes, severity, occurrence and detection to calculate a ranking score (or RPN) for a given failure mode is inaccurate due to the non-linear method of scoring the occurrence element of the equation and the linear method of scoring the detection element. Further more, Gilchrist criticises the fact that the FMEA and corresponding RPN views a failure mode as a singular event as opposed to the potential of a singular failure mode causing multiple failures at the customer. To this end he defines an alternative, and in his view, a more accurate FMEA model which he expresses as the expected cost (EC).

Ben-Daya and Abdul Raouf [2] while acknowledging Gilchrist’s observations and proposal, suggested that the expected cost model was itself flawed. Yes it addressed a number of issues with the conventional RPN, but it fails to consider what Ben-Daya and Abdul Raouf consider to be one of the major drawbacks of the RPN, the weightings associated with severity, occurrence and detection. They suggest that the occurrence factor determines the likelihood of a defect escaping to the customer and as such should be awarded a higher weighting. Their proposed solution is to rate occurrence using a larger interval.

A review of the RPN scale by Sankar and Prabhu [3] highlight some fundamental problems which further expose the RPN ranking system as a flawed system. The conventional approach assumes a linear, evenly distributed scale. Sankar and Prabhu explore the scale of possibilities suggested by the RPN scale of 1 – 1000. Rational thinking would lead you to believe that the closer you get to an RPN value of 1000, the greater the risk factor. Sankar and Prabhu prove this not to be case. An analysis of the scale shows that of the various resulting outcomes from the RPN equation, there are only 120 unique outcomes possible, certain outcomes can be repeated up to 24 times and the mean value attainable is 166.

2. Results / Next Steps

Having reviewed and considered the literature available on FMEAs, it is the conclusion of the author that there is a gap in the current available research material. In terms of the FMEA process, there has been comprehensive analysis carried out the mechanisms which contribute to the generation of the RPN score. However, while this may satisfy theoretical curiosity is certainly does not appease practical use of the FMEA. While in theory, presenting a Pareto chart of RPNs in decreasing order will guide the user in assigning resources to corrective actions, the reality is somewhat different. A simple Pareto chart does not consider resource constraints, costs associated with mitigation or the varied gains which may be associated with certain correct actions. The author will utilise and incorporate Decision Making tools as well as Change Management principals to develop a proposal which will significantly enhance the effectiveness of FMEA when applied to the Electronic Manufacturing Industry.

3. References

A Synchronized Time based Intelligent WiFi Access Point
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Abstract
With the migration of voice communications to IP based networks, particularly on mobile and wireless internet devices, a growing number of mobile VoIP applications such as Viber, Skype mobile, and Google Talk, are now becoming commonplace. This research aims to investigate the Quality of Service (QoS) benefits of applying synchronized time to wireless networks. There exists a major engineering problem in that, due to synchronization issues, Mouth-to-Ear (M2E) delay cannot be accurately calculated for multimedia applications that run over wireless networks as these are asymmetric in nature. Real-time applications such as VoIP are very sensitive to delay and QoS can be much improved if the M2E delay in a VoIP session is known. We are developing an Intelligent Access Point (IAP) that will calculate M2E delay in both directions for each active VoIP session in a BSS, in order to prioritize VoIP sessions with lower QoS based on M2E delays.

1. Background
802.11e is an extension of the 802.11 WiFi standard that was developed to provide Quality of Service (QoS). It categorizes traffic into four categories with Voice traffic being the highest priority followed by Video, Best Effort and Background. Our AP will further prioritize traffic within the voice category, by tuning 802.11e EDCA parameters for individual clients. For our experiments, we will implement the Network Time Protocol (NTP) on nodes at both ends of a VoIP session to provide synchronization in order to calculate the M2E delay for that session.

2. Methodology
Our experiments will involve running multiple VoIP sessions over a wireless network, each connecting to a wired client. Once the sessions have been initiated, there are a number of different delay values that must be calculated for each session. Our AP will calculate M2E delays in each direction for each individual session Fig. 1(a). This information can be computed by analyzing RTCP Sender Reports (SR) and Receiver Reports (RR) at the Access Point. These RTCP reports contain an NTP timestamp (TS), which allows accurate computation of delays when all nodes are synchronized with NTP.

A script file running on the AP will use these delay values along with log information provided by TCPdump on the AP Fig 2, to generate a full picture of delays for all active sessions.

3. Test-bed Setup
RTCP packets are captured on an AP running DD-WRT firmware by TCPDump, before being transferred to an external MySQL server via and Ethernet connection over SSH. Delay calculations are then calculated using a C script which then computes E-Model R-Values, based on which 802.11 beacon frames are generated informing client NICs of updated EDCA parameter values. The X-Lite softphone is used as it fully implements the IETF RTCP RFC 1889, and all VoIP calls are routed through an Asterisk PBX server for scalability.

4. References
Enhancing HbbTV via Time Synchronisation

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Abstract

The future of TV is the convergence of all TV delivery systems into a unique TV set. New Hybrid Broadcast and Broadband TV (HbbTV) points the way forward by offering users the possibilities provided by the integration of all media delivery systems, Digital Video Broadcasting (DVB) and Internet Protocol TV (IPTV). Thus users are able to access the multimedia content of their choice in a unique electronic device, regardless of the platform, in a unique electronic device.

We propose to increase the services provided to users by emerging synchronised content related multimedia delivered through multisource TV platforms in a unique HbbTV device.

1. Introduction

Traditionally users access multimedia using different electronic consumer sets. Users use a personal computer or tablet to access any web media such as YouTube or Internet Radio and use a TV set to watch broadcast TV.

HbbTV provides a standard integration electronic TV device to facilitate users the new TV experience, lean backwards model, which means users access any media from the TV while sitting in a sofa, whereas traditional Internet uses the lean forward model using a PC to access Internet content.

We propose to use the HbbTV capability of uniting all TV platforms to create new user services such as fully personalised sports watching experience. To watch any sports event via IPTV and being able to choose any audio channel from Internet Radio. [1][2]

2. DVB

Traditional TV content is delivered to users via DVB, satellite (DVB-S2), cable (DVB-C2) and terrestrial (DVB-T2). All systems are broadcast delivering all content to all users. DVB systems use MPEG-2 Transport Streams (MP2T) [3] for the media delivery and DVB Systems Information (DVB-SI). [4]

3. IPTV

IPTV delivers TV content over a private managed IP network and differs from the traditional broadcast systems using multicast in that it only delivers the required channel to the user. Both IPTV and DVB systems use MP2T [3] and in conjunction with MPEG-2 Program Specific Information (MP2T PSI) also utilise DVB SI [4].

The main difference between DVB broadcast systems and DVB-IPTV [5] is the recommended use of media delivery via Real-Time Protocol (RTP) over User Datagram Protocol (UDP) for extra robustness.

4. WebTV

WebTV differs from IPTV in that the media content is streamed using Internet, a public non-managed network, therefore it uses different Transport and Application Protocols.

RTP traffic is often penalised by Internet providers and blocked by firewalls and therefore other protocols are used, such as Hypertext Transfer Protocol (HTTP) over Transmission Control Protocol (TCP) or Real-Time Messaging Protocol (RMP2T), for media delivery.

5. HbbTV new services

HbbTV can offer new services to users by synchronising multiple content related streams provided by different media platforms. One example is to give users the choice of watching a sports event via an IPTV channel and selecting the commentary from any Internet Radio available channel.

Sports differs from other media content because there is a highly emotional aspect involved. Therefore users do care if, e.g., in a France-Republic of Ireland match, at the World Cup, Irish people living abroad would watch the game via Sky Sports where comments are given by Thierry Henry. I believe all Irish fans would choose the audio from www.rte.ie for impartial, enlightened synchronised audio comments. HbbTV provides the multimedia platform to this new service.

5. Acknowledgements

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6. References

A Software Radio Digital down Converter

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Abstract—Digital down converting has become one of the nucleus technologies of software radio. This paper describes a method of designing digital down converter based on the technology of FPGA, and has tested the result by simulation. This will avoid using professional digital down converter, make the hardware circuit simpler and increase the flexibility of system.

I. INTRODUCTION

The typical digital down converter has three parts as shown in Figure 1: digital mixer, numerically controlled oscillator-NCO, extraction filter. The orthogonal signal from NCO is put into the digital mixer to mix with A/D sample signal. The mixed signal is output to the extraction filter to remove the times frequency component and out of band signal, and have extraction at the same time. The extraction filter is combined with CIC filter, HB filter and FIR filter by cascade connection.

II. DDC COMPONENTS DESIGN

A. The NCO design based on FPGA

In order to avoid applying the memory with high capacity, we use the CORDIC (Coordinate Rotation Digital Computer) algorithm to create sine/cosine samples. The basic idea is to approach the required ultimate rotation angle through a series of successive descending; operation base angle related reciprocating deflection.

B. CIC filter design based on FPGA

The so called Cascaded Integrator Comb—CIC filter has the impulse response in (1).

\[ h(n) = \begin{cases} 1, & 0 \leq n \leq D - 1 \\ 0, & \text{others} \end{cases} \]

(1)

This paper applied the CIC filter by 5 level, 8 times CIC extraction filter and Verilog language. The simulation result in Quartus II is shown in Figure 3.

C. Half Band Filter design based on FPGA

In this paper, we applied a 19 levels half band filter in the Quartus II. The simulation result is shown in Figure 4. The input signal is CIC filter output signal, sample rate is 10M. We can see the output signal sample frequency is 5M after the HB filter.

D. FIR filter design based on FPGA

The main purpose of the FIR filter is shaping filter to the whole channel. It could also be used as matched filter if necessary. In this paper, we design FIR filter by Window Function.

III. SYSTEM SIMULATION TEST

In the system simulation, we input a simple sine signal, sample rate is 80M, input FCW is 0x01000 (π/16), and the NCO output is 2.5M sine and cosine signal. The sample rate is still 80M after the mixer. After 8 times CIC and 2 times HB (totally 16 times) extraction, sample rate is 5M, and the original signal remain unchanged. After FIR shape filter, a low sample rate signal is output to the DSP. The simulation waveform diagram is shown in Figure 5.

IV. CONCLUSION

The designed DDC system could achieve basic down converter function without professional DDC chips and is suitable for necessary occasions.

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Factors Affecting Carbon Emissions for Road Construction on Peat

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Abstract

In addition to the usual drivers of cost and timely programme delivery, embodied energy (EE) and embodied carbon (EC) have emerged as major considerations in all aspects (including geotechnical aspects) of large construction projects. Where construction involves the modification or removal of peat, these EE/EC calculations become more challenging as allowances should be made for the impact on the carbon stored within the peat and the gases potentially released from peat.

Research is presently underway to consider the EE/EC associated with piling, soil-mixing and excavate-and-replace—options that can facilitate road/motorway construction on peat. This poster summarises a literature review carried out to identify specifically the ‘peat-related’ factors that will impact upon EE/EC calculations on construction of a road/motorway on peat.

1. Introduction

Peatlands cover approximately 20% of Ireland’s land area [1]. Avoiding sites with unfavourable foundation soils is becoming more difficult as areas are now more populated and have more infrastructure than historically. Significant motorway projects in Ireland in the first decade of the 21st century such as the M6 has required geotechnical engineers to give careful consideration to how to deal with the large volumes of peat encountered along the routes. Challenges posed by peat include high moisture content, compressibility and creep, and low shear strength. To counteract these problems ground improvement techniques such as soil-mixing, piling and excavate-and-replace methods are used.

2. Factors affecting carbon emissions

The methods mentioned above all have effects on the carbon stored in peat. Peat has been sequestering carbon for thousands of years, and it is not surprising that healthy peatlands store approximately 183kgCO₂/m³ of peat in Ireland [1][2]. Besides depending on peat characteristics, the estimation of EC as a consequence of a particular method of road construction depends on a wide range of factors and construction activities. These include the following: materials, transport, machinery, peat drainage, peat stability, restoration of peatlands, vegetation/forest, and the effect of climate change. When the preceding factors are taken into account in EC summations, the choice of method to use for ground improvement must be reconsidered.

For instance excavate-and-replace seems greener than other methods because of the low carbon intensity of the fill needed to replace the excavated peat, while in soil-mixing and piling, binder and pile production are environmentally costly and energy intensive. However excavated peat from excavate-and-replace will lose 100% of its carbon as CO₂ if dried and burnt, or at least some of its carbon if placed in peat disposal areas.

A possible solution is to plant a forest on these areas. Trees will then start sequestering carbon and offset the carbon released from the drained peat as shown in Figure 1.

5. Conclusions

The poster describes a potential methodology for assessing and comparing the EC of various ground improvement techniques used in road construction on peat by taking all the above peat-related factors into account. It is hoped that in the near future soil-mixing and piling will be given equal consideration to the traditional method of excavate-and-replace.

8. References

Design and Development of a methodology to support the automation of Energy Action Generation in accordance with ISO 50001 Standard

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$^2$Informatics Research Unit for Sustainable Engineering, College of Engineering and Informatics–Civil Engineering Department, National University of Ireland, Galway.

Abstract

Heating Ventilation and Air Conditioning (HVAC) consumes the largest proportion of energy in most commercial buildings. HVAC can be responsible for up to 80% of a facilities energy bill, due to poor design, operation and management. Air transportation is often associated with high energy consumption and greenhouse gas emissions. Not only the aircrafts, but the airport Buildings are responsible for a considerable amount of energy needs and CO2 emissions: typical electricity consumption being 100 -300 GWh / year, a huge amount of this being HVAC related. Enerit ISO 50001 state-of-the-art software has been created to provide a systematic management framework, where energy actions are triggered by other people (as a result of audits, meetings, suggestions etc), which has the potential to save up to 40% on HVAC related energy costs alone. Enerit ISO 50001 software automates all aspects of the ISO 50001 standard (PDCA Methodology).

2. Methodology

This research will focus on the development of a methodology for the automation of energy action generation for HVAC systems using Enerit ISO 50001 software. The HVAC specific energy actions will assist energy managers at different stages of their activities. This work is being carried out as part of the CASCADE “ICT for Energy Efficient Airports” collaborative project under the EU Seventh Framework Programme (FP7).

1. Introduction

Enerit focus on the development of software in accordance with the ISO 50001 energy standard. The Enerit tool is a highly focused product that helps organisations to systematically manage energy by converting people’s actions into dynamic integrated action plans for your team to work together in driving down energy costs. Within CASCADE, the focus of the research will be on the progress beyond the state-of-the-art Enerit ISO 50001 in the following areas:

1. By allowing these triggers of peoples actions to be machines (e.g. via FDD algorithms from machine sensors or other measured data, etc.)

This will ensure that people’s actions that are necessary to repair adjust and maintain machines will be controlled in the same persistent way as other actions. These actions will then be targeted at the right people through algorithms and decision tools within Enerit ISO 50001 Energy Management Software.
Optimisation of a horizontal flow biofilm reactor for the removal of methane at low temperatures

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Abstract

In this research three pilot-scale Horizontal Flow Biofilm Reactors (HFBR) were used to treat methane (CH₄) contaminated air. The study was conducted over two phases (Phase 1, lasting 90 days and Phase 2, lasting 45 days) at temperatures typical of ambient air and wastewater temperatures in Northern Europe (10°C). The reactors were simultaneously dosed with CH₄ contaminated air and a synthetic wastewater (SWW). The influent loading rates to the reactors were 8.6 g CH₄/m³/hr (4.3 g CH₄/m² TPSA/hr; where TPSA is Top Plan Surface Area). Despite the low operating temperatures, an overall average removal of 4.63 g CH₄/m³/day was observed during Phase 2. The maximum removal efficiency (RE) for the trial was 88%.

1. Introduction

The EU has committed to reducing CH₄ emissions under the legally-binding Kyoto Protocol. Biological treatment methods are being employed more frequently due to their inherent advantages, including (i) neutralisation of the pollutant, (ii) low capital and maintenance costs and (iii) good overall performance ¹.

In this study, a Horizontal Flow Biofilm Reactor (HFBR) was applied to the treatment of an air mixture containing methane (CH₄). The study was carried out at 10°C, which is typical of onsite temperatures in Northern Europe. The HFBR has previously been shown to be cost-effective, sustainable and easy to construct and maintain; with excellent potential as a wastewater treatment technology ².

2. Materials & Methods

The HFBR units comprised a stack of 60 horizontal plastic sheets positioned one above the other, enclosed in an airtight reactor. The working volume of each reactor was 20 L. The air mixture was introduced at the top of each reactor, and flowed horizontally across each sheet before moving to the sheet below and flowing along that sheet in the opposite direction. The air mixture flowed concurrently with a synthetic wastewater (SWW), which added nutrients to the biofilm. The HFBRs were housed in a purpose-built temperature-controlled. CH₄ gas, supplied from a cylinder was mixed with compressed air to form an air mixture with the desired concentrations. Flowmeters and pressure regulators allowed flow rates and gas mix proportions to be controlled and varied. A gas chromatograph was used to measure CH₄ and carbon dioxide (CO₂) concentrations.

3. Results

Phase 1 CH₄ Removal

After inoculation with a methanotrophic seed material, the reactors were continuously fed with ordinary SWW for 90 days. After a 14 day start up phase, pseudo steady state removals were observed; thereafter effluent CH₄ concentrations remained reasonably constant. CH₄ removals averaged 28.5%, 34.3% and 33.9% for HFBRs 1, 2 and 3 respectively.

Phase 2 CH₄ Removal

After the initial phase, the SWW was varied for each reactor. In all cases significant improvements in reactor performance were observed. CH₄ removals averaged 58%, 50% and 55% for HFBRs 1, 2 and 3 respectively. For the final 30 days of this trial, removal rates in HFBR 1 were consistently higher than 75%.

Carbon Dioxide (CO₂) Production

CO₂ production rates can give valuable information on biomass yields due to methane oxidation and also defines the reduction in global warming potential of the treated effluent. From effluent analyses about 0.255 moles of CO₂ exited HFBR 1, about 0.199 moles of CO₂ exited HFBR 2 and about 0.145 moles of CO₂ exited HFBR 3 every day. The global warming potential of the oxidised effluent was reduced 5 fold via conversion to CO₂.

4. Discussion and Conclusions

Three pilot-scale reactors were loaded with an average of 8.6 g CH₄/m³/hr. The reactors reached a steady state CH₄ removal rate of 32% when municipal-strength, SWW was applied. Various combinations of carbon and nitrogen in the SWW were then examined (Phase 2), resulting in significant increases in the REs. Average RE increased up to 55% and then to 75% towards the end of phase 2, with a maximum RE of 88% observed, despite the low operating temperatures. CO₂ production was also measured, giving a more complete insight into methanotrophic activity in the CH₄ reactors. The maximum observed elimination capacity (EC) was 7.6 g CH₄/m³/hr.

5. References

Calibration of a Detailed Building Energy Simulation (BES) Model to Measured Data using an Analytical Optimisation Approach

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Abstract
This paper outlines a methodology for the calibration of detailed building energy simulation (BES) models using an analytical optimisation approach. The approach combines evidence-based model development with statistical Monte-Carlo based optimisation techniques. The first stages of the proposed calibration methodology are applied to a 700m² naturally-ventilated library building using short-term monitored BMS and sensor data. The paper concludes with a discussion of how this methodology differs from existing approaches and the benefits it offers over traditional calibration techniques.

1. Introduction
Whole building energy models provide a means of understanding building operation as well as optimising performance. Simulation tools, such as EnergyPlus, represent continuous, stochastic processes in buildings by discrete time-step, deterministic model estimations. The built environment is complex and influenced by a large number of independent and interdependent variables. Thus, it is difficult to achieve an accurate representation of real-world building operation in a model. By ‘calibrating’ the model to measured data, we aim to achieve more accurate and reliable representation of the building. A review of current literature on this topic has revealed that there is no generally accepted method by which building energy models should be calibrated [1].

2. Methodology
This paper will attempt to validate an analytical optimisation approach to calibrate a detailed EnergyPlus model of a naturally ventilated building. In order to avoid an over-reliance on analyst knowledge and judgement, this methodology follows a clear evidence-based structure and proven statistical methods. This can be broken down into the following steps:
1. Data Gathering / Building Audit.
2. Evidence-based BES model development.
3. Bounded Grid Search
4. Refined Grid Search (Optional)
5. Uncertainty Analysis

This methodology is intended solely for the advancement of calibration research and is not suggested for commercial adoption in its current form due to the significant levels of time and resources required.

An initial Building Energy Simulation (BES) model of the building is developed. The analyst collects data pertaining to the building construction, systems and operating schedules over time and uses this information to evolve the BES model. Version control software tracks model evolution along with the relevant evidence where available. This process continues until all readily available sources of building information have been exhausted.

Best-guess estimates and probability density functions are applied to the input parameters based on the hierarchy of source information.

A Monte-Carlo simulation process generates a set of random parameter vector trials. Finally, EnergyPlus performs a batch simulation of the above trials and a goodness-of-fit analysis reveals the most promising set of solutions that satisfy the objective function.

3. References

4. Acknowledgements
This research is funded by a College of Engineering & Informatics Fellowship at the National University of Ireland, Galway
A Systematic Methodology to Underpin A BLC Oriented CC Tool Utilising BIM Technology

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Abstract
Continuous commissioning is widely regarded as the preferred method to achieve optimized energy performance in buildings. At present it is not common practice to continuously monitor how buildings perform. When data is not collected and analysed regularly it is impossible to achieve optimum performance. If CC was combined with a high level building energy simulation it would allow for dynamic energy management and optimized building energy performance.

1. Introduction
Globally buildings consume more than 40% of primary energy and are responsible for in excess of 30% CO₂ emissions. Policies have been introduced nationally and internationally that include the EPBD in Europe and EISA in the USA in order to increase the energy efficiency of buildings and reduce the contribution of building operation to the total energy demand. Various rating systems are being utilised (BREEAM, LEED) to classify building performance dependent on the energy consumption and carbon emissions of buildings.

2. Continuous Commissioning (CC)
Currently building commissioning is predominantly a once-off activity that occurs during the construction and during initial operation phase of the Building Life Cycle (BLC). Building performance during operation does not normally reflect the original design expectation [1]. Continuous Commissioning (CC) is being promoted worldwide as the preferred method of building commissioning as it is a far more dynamic and reactive commissioning strategy. The individual operation methodology for a building is specified in the O&M manual. Currently, CC is deployed from the construction phase onwards. As the design phase is omitted from the CC process, achieving the design performance from a building can be difficult. This is mainly due to information loss from the design that is not carried through the entire BLC.

3. Building Energy Simulation (BES)
Building Energy Simulation (BES) tools are used in order to evaluate how a building would operate theoretically under given conditions. These tools can be used to either analyse current performance or to estimate how a building will operate post construction using controlled estimated model inputs. In order for the BES models to be a reliable source of information, either pre or post-build, they need to be calibrated using either real or simulated data. In practice whole building energy simulation is seldom used across the BLC especially during operation [2]. The tools that are available for simulation can vary a great deal in complexity and the amount of quality data available from a building can be variable. The available data is usually scarce and especially so in older buildings. These factors combine to allow for very varied level of simulation quality. This can make it difficult to accurately predict future performance or verify that performance goals are met.

4. CC and BES
If CC were incorporating over the whole building life-cycle using best practice building energy simulation models and Building Information Modelling (BIM) methods and technologies then by the incorporation of CC over the BLC, design information will be documented and carried through all phases of the buildings life cycle. The methodology will allow for greater transparency in design information and allow the expected building operation to be maintained at all stages of the BLC. By incorporating a more detailed BES model at the design phase rather than rating methodologies, which are currently common place, it will be possible to use BES models in both the design and as a means of carrying the building design information through the entire BLC. These BES models can then be incorporated as part of the Building Information Model (BIM). By having a BIM which is utilised at all stages of the BLC it will allow the building manager to have access to all information in relation to the expected building performance and identify deviances from the expected building behaviour and to optimise the building performance.

8. References
Abstract

Building Energy Management Systems (BEMS) record large amounts of data from sensors in a building. This data is generally used to control the HVAC (heating, ventilation, and air conditioning) system and then archived and eventually deleted. By visualising this data, it can become a valuable resource for monitoring the energy performance of the building. The aim of this research is to develop a system to generate this visualisation by mapping between live and archived BEMS data and the Building Information Model (BIM). Such a mapping facilitates the extraction of both the BIM and BEMS data into a web browser-based visualisation. The resulting model displays both live and archived data for monitoring the current state of the building and viewing its performance over time.

1. Introduction

As energy costs increase the ability to identify wastage or possible problems becomes ever more important. By visualising the likes of temperature variation throughout a building at any time, hot or cold spots can be identified easily and the energy loads from the HVAC system investigated. With a visualisation linked up to the live and archived data, any abnormalities can become more quickly apparent.

2. Building Energy Management System

A BEMS monitors and controls the building’s performance and HVAC system in realtime. It is a software solution which takes sensor readings from throughout the building (temperature, CO2 etc.) and controls HVAC equipment to match desired set values for each area in the building.

This data is generally archived in large files but analysis of the archive to study the building’s performance can be slow due to the quantity of data, range of sources and software limitations.

3. Building Information Modelling (BIM)

Building Information Modelling is a concept being adapted in recent years by the construction industry. A BIM is a digital model of a building which stores information about the building through its design, construction and more recently, operation. It is a central model to which all involved parties contribute and collaborate with. At its core, a BIM has a full 3D model of the building.

3.1. Adding BEMS reference to the BIM

This research seeks to embed BEMS references into the BIM. This will give them both a geometric position in the building and a reference to their corresponding data in the BEMS archive. One standard element in a BIM is a zone, a reference to a 3D space. This project uses zones to identify “air pockets” in the building, which will be relevant to BEMS data such as temperature or CO2 from a specific sensor. These zones will be named using a set naming convention to identify what data in the BEMS archive they are relating to.

4. Generation of the Visualisation

Through embedding the BEMS data into the BIM, the system developed in this research will be able to extract the core 3D model from the BIM as well as generate semi-transparent air pockets whose colour can be changed to visualise variations of the BEMS data.

4.1. Generation of Air Pocket Blocks

As air pockets are stored as zones in the BIM, these are saved in the standard BIM output file (.ifc). The system developed searches through the file for the zones and extracts their geometry and reference. The system then creates separate Collada files for each air pocket. Collada is a standard file format for 3D models and can be used by WebGL in the visualisation. The system will create links between the available BEMS data, e.g. temperature sensor and tagged air pockets.

5. Visualisation using HTML5

By using modern web technologies that are made available with HTML5, the final visualisation will be easily accessible using any HTML5-ready web browser. It will utilise WebGL, which is available within the Canvas element, for rendering the 3D model of the building. Javascript controls are added to allow interaction with the model, enabling the user to switch areas of the building or visualised data on/off and navigate the model. Essentially this makes live BEMS data available anytime, anywhere in a highly visualised and intuitive manner.

6. Case Study: Engineering Building, NUIG

As a case study for this application, the new Engineering Building in NUI Galway will be used. A BEMS is installed in this building and a BIM exists from the design stages of the project. The data from the BEMS is being archived in an online database and will be linked up to the visualisation.
A pilot scale study to examine the treatment of piggery wastewaters using woodchip biofilters

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Abstract
The Irish nitrates directive limits the amount of pig manure that can be landspread per year; therefore treatment warrants consideration. In this study, six pilot scale woodchip biofilters were set up to treat (i) the separated liquid fraction of raw pig manure (SR) and (ii) digestate after anaerobic digestion of pig manure (SAD). Three replicates per treatment were analysed over 228 days. On average, the SR biofilters were successful in removing 50% dry matter (DM), 72% chemical oxygen demand (COD), 89% total nitrogen (TN) and 91% total phosphorus (TP). Removals of 59% DM, 82% COD, 89% TN and 82% TP were observed for the SAD biofilters. The woodchip biofilter is a simple, effective, sustainable method of removing a large proportion of DM, COD, TN and TP present in the liquid fraction of SR and SAD.

1. Introduction
The Irish Nitrates Action Plan [1] restricts the amount of land area suitable for the landspreading of pig manure. Pig manure contains high concentrations of nutrients with the potential to cause environmental pollution to receiving waters.

The objective of this study was to investigate the use of indigenous woodchips as a biofilter media for the treatment of the separated liquid fraction of (i) raw pig manure (SR) and (ii) pig manure after anaerobic digestion (SAD).

2. Materials and methods
Six identical pilot scale woodchip biofilters were established to treat the SR and SAD. Each biofilter had dimensions of 1.5 m (W) × 1.5 (W) × 1.5 m (H), comprising a 1 m aerobic layer above a 0.5 m anoxic layer of lodgepole pine woodchips. SR and SAD were obtained using a decanter centrifuge. 3 replicate woodchip biofilters were used to treat both the SR and SAD at a hydraulic loading rate of 10 L/m²/day. The influent was applied four times daily through a manifold distribution system. Samples were taken weekly and analysed within 24 hours of collection. The effluent from the filters was tested for dry matter (DM), chemical oxygen demand (COD), biochemical oxygen demand (BOD), nitrogen (total N, NH₄⁺-N, NO₂⁻-N and NO₃⁻-N), phosphorus (total P and PO₄³⁻-P) and pH. The biofilters were operated for 228 days.

3. Results

Table 1. SR - Average influent, effluent and % removals.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Dry Matter</th>
<th>COD, BOD, TN, TP</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent (mg/l)</td>
<td>3521 ± 1099</td>
<td>1992 ± 942</td>
<td>7.05 ± 0.14</td>
</tr>
<tr>
<td>Effluent (mg/l)</td>
<td>3873 ± 1272</td>
<td>545 ± 229</td>
<td>6.28 ± 0.45</td>
</tr>
<tr>
<td>% Removal</td>
<td>50%</td>
<td>72%</td>
<td>73%</td>
</tr>
</tbody>
</table>

Table 2. SAD - Average influent, effluent and % removals.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Dry Matter</th>
<th>COD, BOD, TN, TP</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent (mg/l)</td>
<td>9401 ± 2036</td>
<td>10145 ± 2531</td>
<td>8.26 ± 0.16</td>
</tr>
<tr>
<td>Effluent (mg/l)</td>
<td>4977 ± 1236</td>
<td>1134 ± 330</td>
<td>6.84 ± 0.60</td>
</tr>
<tr>
<td>% Removal</td>
<td>47%</td>
<td>89%</td>
<td>74%</td>
</tr>
</tbody>
</table>

4. Conclusions
The SR biofilters were successful in removing 50% DM, 72% COD, 89% TN and 91% TP (Table 1). Removals of 59% DM, 82% COD, 89% TN and 82% TP were observed for the SAD biofilters (Table 2). The woodchip biofilter is a simple, effective, sustainable method with respect to removals of a large proportion of DM, COD, TN and TP present in the liquid fraction of SR and SAD. However, further polishing is needed to bring the final effluent to a water quality suitable for discharge.

5. Acknowledgements
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6. References
ICT for Energy Efficient Airports

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Abstract - CASCADE will develop facility-specific measurement-based energy action plan for airport energy managers underpinned by systematic Fault Detection Diagnosis (FDD) Methods. CASCADE will develop a framework and methodology to underpin the execution of customised ICT solutions building upon existing ICT infrastructure. A measurement framework and minimal data set will be established that control and benchmark equipment performance, optimise user behaviour, and match client specifications.


I. PROJECT OBJECTIVE

CASCADE aims to develop airport specific ICT energy management solution underpinned by systematic Fault Detection and Diagnosis (FDD). FDD can identify faults in complex facilities. It uses dynamic machine-learning algorithms to track possible performance degradation and inadequate behaviour of mechanical and electrical systems leading to an excessive energy consumption. NUIG will pioneer FDD based ICT energy management methodology that integrates several innovating commercial and under development solutions including and ISO 50001 energy management software, advanced data visualisation, and building performance simulation. CASCADE will develop a systematic user-centred standards based Energy Action System through the integration of a range of ICT provided by project partners and its interoperaton with existing BMS/BAS ICT technologies.

CASCADE targets a 20% reduction of energy consumption and CO₂ emission. It will implement innovative energy management technologies in real facilities at Rome Fiumicino and Milano Malpensa Airports.

II. SCIENTIFIC OBJECTIVES

A. CASCADE will develop a systematic user/centred standards based Energy Management Action System with explicit validation actions that measure the effectiveness of the CASCADE scientific approach. The CASCADE Energy Management System will be realised through the formal integration of a range of ICT tools being provided by the CASCADE partners and interoperation with a range of BMS/BAS ICT technologies. The scientific objective centres about developing an unambiguous understanding of the necessary standardised energy management actions that underpin best practice airport operational management and specifying, implementing, deploying and validating the CASCADE Energy Management Action System in the form of an integrated software/hardware toolkit capable of interoperation with industrial scale BMS/BAS at number of selected pilot airport sites. A series of standards based validation actions will be detailed that aim to measure the effectives of the CASCADE Energy Management Action System utilising recognised metrics that include comfort, energy consumption, CO₂ emissions and ROI.

B. Validation utilising recognised energy management standards (EN16001/ISO5001) is a key concept underpinning the CASCADE Energy Management Action System. The second scientific objective in CASCADE is to develop:

1) Benchmark metrics for best practice airport operational management;
2) Minimum measurement infrastructure that will underpin the measurement/quantification of those benchmark metrics;
3) FDD algorithms to support transformation of field data into FDD information underpinning systematic energy management control actions;
4) Field certification guidelines of energy consuming devices and renewable energy technologies utilised in airport operational management;
5) Systematic validation procedures that measure the effectiveness of the CASCADE Energy Management Action System;
6) The definition of standardized interfaces between raw data incoming from building ICT systems and data processing software, scientific numerical computing environments (Matlab, Numpy, R) and thermal simulation software (TRNSYS, IDA ICE, Modellica)

III. RATIONALE

Current Building Management Systems (BMS) are not designed with a focus on minimizing energy consumption or the optimisation of energy systems. The vast amount of data generated by a BMS doesn’t often translates into valuable information leading to validated energy actions, or an enhanced systems operation. CASCADE will develop a proof point where advances in data analysis and manipulation will serve the goal of energy reduction. CASCADE will develop a methodology to execute ICT customised solutions upon existing ICT infrastructure. CASCADE will enable transformation of FDD into actionable information by developing an energy action plan that links Actions-Actors-ISO Standards through a web based management portal.
Performance and optimisation of a novel biofilm wastewater treatment technology – the Air Suction Flow – Biofilm reactor (ASF-BR)

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Abstract
A novel wastewater treatment technology, the Air Suction Flow - Biofilm Reactor (ASF-BR), has been developed for the removal of organic carbon, nitrogen, and phosphorus from high strength wastewaters. During Phases 1 and 2 (166 days and 264 days respectively) the pilot-scale unit treated synthetic high strength wastewater. During Phase 3 (152 days) of the study the pilot-scale unit was used to treat landfill leachate. During Phases 1 and 2 removal rates averaging 97.8% filtered chemical oxygen demand (CODf), 88.5% filtered total nitrogen (TNf) and 98.4% ammonium nitrogen (NH₄-N) and 97.2% CODf, 88.5% TNf and 98.5% NH₄-N respectively were achieved. During Phase 3 removal rates averaged 73.5% CODf, 35% TNf and 94.9% NH₄-N were achieved. The results indicates the ASF-BR offers a low energy alternative to existing technologies and enables the control of odorous emissions produced during the wastewater treatment process.

1. Introduction
The rapid global increase in both population and consumer demand for various products has led to a growing requirement for industrial and agricultural facilities to increase output. This has in turn caused environmental problems such as overexploitation and pollution of water resources1. High strength industrial wastewater containing excessive concentrations of contaminants pose a significant risk of pollution to the receiving water body. Biofilm based technologies can offer robust solutions and can (i) be energy efficient, (ii) recover better from shock loads, and (iii) have reduced sludge production when compared to activated sludge systems 2. The air suction flow biofilm reactor (ASF-BR) is a new technology developed and patented at NUI Galway and may provide an alternative to existing technologies. The aim of this study is to develop and demonstrate a laboratory scale ASF-BR that can biologically treat high strength wastewater at a low cost and help control the emission of odorous and greenhouse gases produced during the wastewater treatment processes.

2. Materials & Methods
A laboratory scale ASF-BR was constructed and operated in a temperature controlled (11°C) room, at the Environmental Engineering Laboratory, NUI, Galway. The unit comprised two enclosed cylindrical airtight steel reactors (R1 and R2), each measuring 350 mm in diameter and 450 mm in height and containing plastic media supporting biofilm growth. Movement of wastewater through the system was controlled by a series of valves and an air vacuum pump. During Phases 1 and 2, 11.8 l/day and 10.2 l/day of SWW were treated respectively. Phase 3 had a loading rate of 1.1 l landfill leachate/d. During Phase 2 the energy requirement was reduced by 60% by decreasing the frequency of the water movements between the two reactors, thus optimising the aeration cycle. Influent and effluent samples from the unit were taken on a daily basis and tested twice weekly for suspended solids, COD and nitrogen (TN, NH₄-N, nitrite-nitrogen (NO₂-N) and nitrate-nitrogen (NO₃-N). Tests were carried out in accordance with the Standard Methods for the Examination of Water and Wastewater3.

3. Results
Table 1 shows the average removal rates for COD, TN and NH₄-N during steady state conditions.

Table 1: Percentage removals for various parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Phase 1 % Removals</th>
<th>Phase 2 % Removals</th>
<th>Phase 3 % Removals</th>
</tr>
</thead>
<tbody>
<tr>
<td>CODf</td>
<td>85.9</td>
<td>69.4</td>
<td>72.9</td>
</tr>
<tr>
<td>CODf</td>
<td>97.8</td>
<td>97.2</td>
<td>73.5</td>
</tr>
<tr>
<td>TNf</td>
<td>75.5</td>
<td>70.9</td>
<td>35</td>
</tr>
<tr>
<td>TNf</td>
<td>88.5</td>
<td>88.5</td>
<td>35</td>
</tr>
<tr>
<td>NH₄-N</td>
<td>98.4</td>
<td>98.5</td>
<td>94.9</td>
</tr>
</tbody>
</table>

4. Discussion and Conclusions
In this study a novel wastewater treatment process, the Air Suction Flow - Biofilm Reactor has been presented. Results have shown the ASF-BR to be comparable or exceed alternative systems treating similar wastewaters – while having lower operating costs. The unit offers the additional benefit of being able to control the odorous emissions produced during the treatment process. Large pilot-scale on-site reactors have been commissioned and are currently being trialed.

5. Acknowledgements
The authors gratefully acknowledge funding and support provided by Enterprise Ireland for this research project.

6. References
Simulation Based Intelligent Control and Decision Support for Energy Efficiency in Buildings

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Abstract— This research work aims to develop Artificial Neural Network (ANN) based approach to support the efficient control of HVAC systems, pointing to reduce the overall energy consumption and peak demand while maintaining indoor environmental conditions within specified parameters of comfort and air quality. The work will focus on buildings with significant dynamic usage characteristics and high restrictions in comfort conditions including sport facilities and airports. Results could be easily extended to other types of buildings. Sport facilities represent about 8% of the building stock but their energy consumption accounts for 10% of the building sector. Sports are an energy intensive sector and savings may count for up to 20% in energy consumption and CO2 reduction. Expected Results: Optimal start/stop schedules, Predictive control during functioning hours, Flexibility to incorporate new modules and characteristics into the system, Distributed and hierarchical control and extended scope will include ANN based fault detection and diagnosis.

I. RATIONALE

Sport facilities represent about 8% of the building stock but their energy consumption accounts for 10% of the building sector. Sports are an energy intensive sector and savings may count for up to 20% in energy consumption and CO2 reduction. With HVAC systems being responsible for up to 20% of the overall energy consumption, energy efficiency actions in HVAC systems of sport facilities and airports are expected to have a great impact on reducing energy consumption and CO2 emissions.

II. METHODOLOGY

The proposed methodology (see Figure) will use already available BMS archive data from each type of facility, in combination with design specifications, to create a physical model of the zone to be controlled which will be implemented in a modeling tool like Energy Plus, Modelica or Matlab. With the BMS data an ANN will be trained to emulate the behavior of the highly complex HVAC systems beyond the capabilities of the physical model. Afterwards both models, the physical zone model and the HVAC system ANN based model, will be coupled using the software tool developed by the Lawrence Berkeley Laboratory (LBL) called Building Control Virtual Test Bed (BCVTB). From this coupling training data will be generated for the control system.

The new proposed control system will be based on an ANN based controller will consist of an ANN based model agent and an optimisation algorithm. The ANN based model agent is trained to replicate the HVAC system functioning and is used to predict its future behaviours due to variations of conditions in the zone or the application of different control strategies. The optimization algorithm uses the results from the ANN based model agent to calculate, within a certain future time horizon, the optimal control signal to be applied to the system.

III. EXPECTED RESULTS

1. Optimal start/stop schedules: Identify and predict the optimal “working” hours of the systems providing services (e.g. heating, cooling) only when needed. HVAC components such as boilers, air handling units and cooling coils are largely responsible for providing the heating and cooling requirements. Here we will experiment with recurrent ANN to introduce “memory” to the system;

2. Predictive control during functioning hours based on historical data already existing in the BMS: In this part, the work will focus on preventing the fluctuations in the indoor environmental conditions due to variations in occupancy or external weather that may produce energy loss and diminish the comfort. In this case a Model Based Predictive Controller in which the model is a combination of ANN models and Physical models will be tested with different training techniques and optimisation algorithms.

3. Flexibility to incorporate and test new modules and characteristics into the system such as renewable energies systems (RES), electrical power and heat co-generation and new operational scenarios.: The developed methodology must take into account that RES and co-generation systems are being widely used for retrofitting facilities aimed at improving the facility's environmental footprint;

4. Distributed and hierarchical control: From the actuators inside the system to the interaction between different facilities to improve efficiency not only at the building level but at communities/district level and also facilitate maintenance as a direct result of the modular approach.
Carbon footprint of greenways: lessons in the design of environmentally friendly cycle routes

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Abstract
Government transport policy has led to the design of a National Cycle Network (NCN) as one measure to encourage a modal shift to cycling. While a modal shift to cycling has clear potential to reduce carbon emissions in the transport sector the climate cost of constructing new cycling routes, particularly greenways, has not been previously considered. This research, using a case study, calculates the carbon emissions associated with greenway construction. The case study greenway was found to embody 60400 kgCO₂e/km. The carbon savings of shifting a Passenger Kilometre Travelled (PKT) from driving a car to cycling were found, in Ireland, to average 0.134 kgCO₂e/PKT. Therefore, in the example presented, a shift of 102 commuters per year are required to offset the carbon footprint of one 10 km asphalt greenway.

1. Literature Review
In Ireland, 1.1 million people (58% of the commuting population) drive a car to work daily while only 36,000 people (2% of the commuting population) cycle [1]. This is despite the fact that 30% of commutes are less than 5 km – a reasonable cycling distance [2]. To encourage a modal shift in cycling to 10% of commuter trips, the Irish government has introduced a range of measures including the establishment of a National Cycle Network (NCN). The NCN will comprise a range of cycle route types including: (i) on-road, (ii) cycle lanes, and (iii) greenways (traffic-free cycle trails) [3]. Due to the large carbon emissions associated with car usage, a modal shift to low carbon or carbon free transport, such as cycling, is desirable. However, the climate cost of constructing new cycling routes, particularly greenways, has not been previously considered.

Embodied carbon is measured in carbon dioxide equivalents (CO₂-e), which includes carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O)[4]. Ireland’s greenhouse gas emissions in 2010 were 61.64 MtCO₂e and 11.77 Mt CO₂-e or 19.1% of these emissions were a result of the transport sector [5]. Emissions of the average Irish car are 0.145 kgCO₂-e/PKT [6]. Cycling is not quite a zero emissions mode of transport and recent research has shown that emissions as a result of cycling are approximately 0.011 kgCO₂-e/PKT. [7].

The preferred greenway surfacing is asphalt and the path in poor soils is generally laid down in three layers: surface layer, the base/sub-base layer and the capping layer with depths of 60 mm, 150 mm and up to 600 mm respectively [8]. This method has been used in greenways such as the Great Western Greenway in County Mayo, Ireland, where poor soils were frequently encountered.

2. Methodology
The carbon savings of a modal shift to cycling were calculated by subtracting the carbon footprint of a trip by bicycle from that of a trip by car. The carbon footprint (or carbon cost) of a typical greenway was estimated by calculating the embodied carbon of each material, the transport of material to site and the machinery used in construction.

3. Results

<table>
<thead>
<tr>
<th>Embodied Carbon (kgCO₂e/km)</th>
<th>Carbon savings</th>
<th>Carbon costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car trip</td>
<td>0.145</td>
<td>Materials</td>
</tr>
<tr>
<td>Bicycle trip</td>
<td>0.011</td>
<td>Transport</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Machinery</td>
</tr>
<tr>
<td>Total</td>
<td>0.134</td>
<td>Total</td>
</tr>
</tbody>
</table>

Therefore 450,746 PKT must be shifted from the car to the bicycle to balance the carbon costs and savings. This is the equivalent of 102 commuters per year for 20 years to offset one 10 km greenway.

4. Conclusion
These results show the need for the incorporation of low-carbon, local and recycled materials the construction in cycling routes. The methodology and results will be used in a wider matrix for the design of environmentally friendly cycling routes.

Acknowledgements
This research was funded by the National Sustainable Transport Office at the Department of Transport, Tourism and Sport.

References
Real time control of small scale wastewater treatment systems

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Abstract

Small wastewater treatment plants can be susceptible to infrequent supervision, increased energy costs, shock wastewater loads, while simultaneously required to meet stringent wastewater discharge limits. This study examines the potential of real time control of wastewater treatment systems that will allow desired effluent standards to be met while simultaneously improving energy efficiency. A pilot test centre was constructed and tested to develop a robust intelligent treatment control programme that monitors influent concentrations, and subsequently adjusts the treatment cycle to improve energy efficiency as well as significantly reducing breaches of discharge limits.

1. Introduction

There is an increasing requirement on local authorities, utilities and industry to meet stringent wastewater discharge limits while also improving the energy efficiency of the water and wastewater treatment plants they operate. Recent EPA reports show that nearly 50% of wastewater treatment plants are not meeting required standards\(^1\). Many of these plants do not have permanent operators on site and thus when problems occur they may not be identified for some time. This study examines the potential of real time control of wastewater treatment systems that will allow desired effluent standards to be met while simultaneously improving energy efficiency. Real time control of wastewater treatment has to date mainly been investigated at lab-scale\(^2,3\). Only limited work has been conducted on real-time control of small-scale and how such control can be used to achieve discharge limits. Small scale systems present a number of particular challenges such as (i) lack of permanent operators, (ii) shock wastewater loads resulting in periodic effluent quality spikes causing breaches of discharge limits.

2. Materials & Methods

A pilot scale test centre was developed with three, 4 population equivalent (PE) sequencing batch reactor (SBR) wastewater treatment units. Each unit is loaded with domestic wastewater from a small housing estate, and monitored and controlled under identical conditions. This study will initially be conducted over two phases.

**Phase 1:** Initially these units will be monitored using a variety of robust sensors. Parameters such as pH, oxidation reduction potential (ORP), dissolved oxygen (DO) and conductivity will be monitored and related to effluent discharges; particularly for nitrogen and phosphorous. The energy consumed by each unit will be recorded. Similar studies will also be carried out on laboratory reactors and on municipal wastewater reactors.

**Phase 2:** The data gathered from Phase 1 will be used to create a robust intelligent PLC programme. This programme will monitor influent concentrations in real time using robust probes. Subsequently the programme will adjust the treatment cycle accordingly, improving energy efficiency as well as significantly reducing breaches of discharge limits. A schematic of this strategy is shown in Figure 1.

![Figure 1: Schematic of a sequence batch reactor with real time control strategy](image)

3. Discussion

A pilot scale test centre with three, 4PE SBR units has been developed. These units will be monitored and adjusted to develop a new wastewater treatment PLC programme. This programme will be optimised to analyse influent data and subsequently adjust the treatment of the wastewater. The results of this study will be a robust, optimised treatment unit designed to reduce breaches of discharge limits, particularly in treatment plants where full time supervision is not available.

4. Acknowledgements

This research is jointly funded by IRCSET Partnership Scheme and Molloy Precast Products Ltd.

5. References


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Abstract

Current Irish Building Energy Rating (BER) assessment procedures currently calculate the operational performance of buildings and allocate grades accordingly. However, adopting this methodology fails to incorporate the embodied energy (EE) or embodied carbon (EC) emissions associated with a building over an assumed lifespan. Carbon footprint analysis encompassing all life cycle aspects of a building properly quantifies the greenhouse gas (GHG) emissions associated with residential housing and, consequently, the entire construction industry.

This research presents the findings of an environmental life cycle assessment (LCA) of Irish residential buildings with varying operational efficiency. The EE and EC of case study buildings are calculated and contributions to total energy and carbon usage over a building’s lifespan analyzed.

1. Introduction

With more attention focused on global environmental issues, reduction of construction industry energy usage and associated GHG emissions is imperative. Studies have shown the building industry to be responsible for 40% of all energy used in society [1] and 50% of global GHG emissions [2]. With Ireland committed to the Kyoto Protocol, pollution within the entire construction sector requires attention. Therefore, sustainability in residential construction is essential. BER assessments only assess operational attributes of homes and incorrectly discount embodied features. Through LCA, a true environmental impact of constructing residential homes is demonstrated and GHG emission mitigation strategies can be developed to tackle pollution at source.

2. Methodology

Employing ‘cradle-to-gate’ process-based (PB) analysis with intensities from the ICE database [3], EE and EC values were calculated for measurable installed building materials. Bills of quantities, drawings and BERs were obtained for each building.

3. Results

Results of the LCA carried out on the case study buildings demonstrate the contribution of both operational and embodied features. The operational energy (OE) and operational carbon (OC) contribute highest to the studied buildings total energy and carbon usage. OE and OC contribution varies from 73-84% and 66-77% respectively. These values are slightly higher than previous analyzed studies [4, 5].

EE and EC values also contribute significantly to the total energy and carbon usage. Total EE and EC contributions, inclusive of reoccurring values, vary in the range 16-27% and 23-34% of total energy and carbon usage respectively. Despite being unaccounted for in current assessment procedures, EE and EC values are proportionally higher for homes with lower BERs.

4. Conclusions

Research results demonstrate the breakdown in life cycle energy and carbon in some Irish residential buildings. OE and OC contribution varies from 73-84% and 66-77% of total life cycle energy and carbon use respectively. Total EE and EC calculated values range from 16-27% and 23-34% respectively. The EE and EC contribution is proportionately higher for buildings with lower BER ratings.

Future ‘zero carbon’ homes will increase the EE and EC contribution of homes and so, EE and EC of building materials will gain more intense observation and scrutiny.

5. References

Hydro-environmental modeling of tidal power

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Abstract
The world’s reliance on fossil fuels needs to be reduced with the introduction of sustainable energies. The EU MAREN project hopes to bring together countries of the Atlantic area to expand the marine renewable energy sector. Environmental impacts are one of the issues that need to be analysed and addressed for marine energy to be a viable source of energy. Numerical modelling can be used to look into this issue and model the effects of sediment and solute transport.

1. Introduction
The EU is part of the Kyoto Protocol and is committed to reducing their greenhouse emissions by 8% below the 1990 levels. Ireland has a target of 13% above their 1990 levels. Marine energy is one of the areas which could be exploited by the island of Ireland for the use of electricity(Roche, Minister for the Environment et al. 2007)
The countries of the EU interregional Atlantic areas have come together under the EU funded MAREN project to optimize the energy potential of the Atlantic. The main aim of the MAREN project is to optimize the energy extraction process of marine renewable energy and do so with the least amount of hydro-environmental impacts. Numerical investigation into the analysis of tidal current energy extraction and its impacts on the environment are the main aims of this research project.

2. Advantages of tidal power
Tidal energy extraction has a few advantages over the other forms of marine energy extraction processes. The predictable nature of tides is the main advantage of this type of energy extraction. The density of water is greater than air, allows greater amounts of energy to be captured from tides with same size device used for wind energy extraction.(Hammons 1993)

3. Environmental impacts
There are a number of different environmental impacts that can be possible with the marine energy extraction. The following issues can be affected by extraction devices: Habitat and ecology, water quality, birds, fish, sediment transport, landscape and visual, ports and navigation, biodiversity, protected areas and flooding(Commision 2007)

4. Research to date
Numerical modeling techniques have been developed to identify areas for the deployment of tidal current energy extraction devices. The method of tidal ellipses was employed to identify these areas, using methods of harmonic analysis and ellipses parameters to calculate the max velocity, eccentricity, phase and inclination. The use of the actuator disk theorem to represent the turbine rotor of a tidal stream device was modeled for representation of a field of turbines in the Shannon estuary. The change in the flow field and the effects of the environmental parameters were modeled using this theory. Nested modeling has also been carried out with the implementation of a one-way nested model in the Shannon estuary. The one way nested model has been expanded to allow the nested domain to be orientated at different angles to complement the orientation of the coastline. This allowed an increase in accuracy without an increase in computational costs.

5. Conclusion and future work
Future work involves the development of a two-way nested model to allow information from the high resolution model to be passed to the low resolution model. In conclusion tidal power can become one of the leading sustainable energy’s in Ireland by tackling issues such as hydro-environmental impacts and optimizing energy extraction, with the use of advanced numerical modeling.

7. References
Structural modelling of offshore wave energy converters

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Abstract
Ocean Wave Energy is the latest natural resource to be exploited as a renewable source of energy, while also coinciding with the aim of reducing our reliance on non-renewable energy sources. The main objective of the project is to develop a method of optimising the structural shape of a WEC for a given sea condition. Analytical methods, numerical simulations using computational fluid dynamics and experimental procedures have been used to determine the pressure distribution, the hydrodynamic forces and the dynamic response of a given converter in order to undertake this task.

1. Introduction
The concept of harnessing ocean wave energy is by no means a new idea. However, the topic only gained international interest in the 1970’s with the publication of Stephen Salter’s groundbreaking paper on his Wave Energy Duck. Since then thousands of patents have issued for wave energy converters (WECs), incorporating a variety of methods. However, as of yet, no ‘winning’ WEC design has being established.

The energy in ocean waves is the most dense of the renewable energies and is available up to 90% of the time, compared to wind energy which is available 20-30%. Furthermore, the wave energy density off the west coast of Ireland is one of the largest in the world.

2. Project Objectives
1. Develop an analytical approach for calculating the wave excitation forces on vertically axisymmetric floating bodies in deep water.
2. Develop a methodology for developing an optimised deep water wave numerical wave tank and explore wave-structure interaction using computational fluid dynamics (CFD).
3. Develop a methodology of optimising the structural shape of a WEC for a given design sea or ocean region.
4. Explore methods for the structural health monitoring of offshore WECs[1].
5. Perform physical experiments in order to verify the results of the study.

3. Analytical solution
An analytical solution for determining the wave excitation forces on a floating truncated cylinder in water of infinite depth has been derived[2].

The derivation uses the wave-water problem and eigen-function expansions to obtain the velocity potentials. The velocity potential is then integrated over the structural surface to calculate the excitation forces. The analytical solution is arrived at by taking an asymptotic approximation of $k_0b < 1$ and $a/b$ is $O(1)$.

4. Computational fluid dynamics
CFD is used to analyse the various arbitrary geometries in both the frequency and time domains.

A commercial finite volume method is used to analyse wave-structure interaction in the time-domain. In order to insure the properties of the incident wave are accurate, a methodology for creating an accurate and optimum numerical wave tank model was developed[3].

A boundary element method software is used to calculate the various hydrodynamic coefficients and excitation forces on the floating structure being analysed, in the frequency-domain.

Furthermore, a method, which combines the CFD analysis and analytic techniques, was developed in order to examine the dynamic response of an arbitrary shaped structure with an irregular incident wave.

5. Future Work
An algorithm and methodology procedure for optimising the structural shape of WEC, depending on the sea or ocean region in which it is to be deployed, is currently being developed. Furthermore, physical experiments are to be performed in the in-house wave flume and a numerical model of the flume using the CFD methodology[3] is to be created. Subsequently, wave-structure interaction will be experimentally performed and modelled in order to validate the study. Initially, the wave excitation and hydrodynamic forces and dynamic response of a truncated vertical cylinder and a half-immersed sphere are to be analysed.

6. Acknowledgements
The first author acknowledges the information provided by the Marine Institute, computational facilities provided ICHEC and financial support provided by NUIG under the College of Engineering and Informatics Postgraduate Scholarship.

8. References
Abstract
This presentation details the research and development project focused on the design and implementation of a control system to autonomously pilot tethered parafoils. The specifics of a prototype AWE system under development at the University of Limerick are detailed, including a winching mechanism and airborne control system. A mathematical analysis and simulation model of the system are also introduced.

1. Introduction
Airborne wind energy (AWE) is an emerging development within the renewable energy sector. AWE systems are experimental electro-mechanical systems which convert wind energy present at high altitudes to electrical energy. The objective is to gain access to the wind resource at higher altitudes than can be reached by current wind energy technology. The motivation is simple; at higher altitudes the wind speeds are stronger and more consistent. AWE designs have moved away from the traditional wind energy approach of employing large static towers to elevate electro-mechanical systems into the stronger winds. The approach of AWE developments is to use self-lifting airborne bodies to access the winds at higher altitudes. These airborne systems aim replace the heavy structural and civil works with “smart” controlled airborne systems. Figure 1 below illustrates the typical layout an AWE system. An experimental prototype and simulated model of such an AWE system are under development as part of this research project. Internationally many new start-up companies and research groups are investigating a wide range of approaches to utilising high altitude wind.

2. Research Objectives
• Development of a suitable simulator to aid the analysis and design of a prototype.
• Develop a prototype airborne wind energy system with focus on the parafoil control pod as the critical element of the system.
• Bench testing and shake down tests of prototype prior to flight testing.
• Flight testing of control pod under fixed tether initially using both open (human in loop) and closed loop control.
• Flight testing of system with tether actuation and power take off.
• Post flight data analysis of tests.
• Refinement of simulator based on flight test results.

3. Simulation model
A simulated model of the prototype AWE system has been developed with Simulink. This enables simulated test runs of the system which are used to define the physical parameters of the prototype and provide an insight to the system dynamics.

3.1 Simulation methodology
The modelled aerodynamic forces developed by the foil are fed as a resultant force to the winch model, which causes the winch model to compute the resulting rotational speed, voltage and current. The electrical mechanical torque and frictional forces developed on the winch are then fed into the foil force balance equations, resulting in a coupled system which takes into account the dynamic interactions from “wind to wire”.

4. Prototype Development
The prototype under development for flight testing consists of a ram air inflated parafoil, controlled by a control pod, tethered to a ground winch station as illustrated in figure 1. The system is controlled by PCs and real time controllers running LabVIEW.

Major system components:
• Kite Control Pod: The kite control pod contains the sensors & control mechanism which flies the kite while maximising stability and power production. This pod is battery powered with wireless communications to ground.
• Ground station: The ground control station is a key subsystem of the airborne wind energy project. The winch acts as the anchor point for the airborne system and it is here that the mechanical energy from the airborne system is converted to electrical energy.

5. Acknowledgement
This research is funded by the Irish Research Council for Science, Engineering and Technology (IRCSET) with Bord Gáis as Enterprise Partner.
Building with our waste: Incinerator Ash as a Construction Material in Ireland

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Abstract:
This research considers the potential of Irish municipal Incinerator Bottom Ash (IBA) serving as a useful construction aggregate. In this research, IBA is studied from three separate aspects: mechanical characteristics, environmental safety and economic viability. Knowledge of these properties is essential if the material is to be put to use in construction. A successful outcome will result in IBA which would otherwise be landfilled being applied to constructive applications thus improving the nature of waste management in Ireland.

Introduction:
Municipal waste management in Ireland is facing major change with the arrival of Waste to Energy (WtE) incineration facilities. Our first facility in Meath commenced operation in 2011 while others are proposed in Dublin and Cork. These plants will significantly reduce our dependence on landfill with the combined benefits of producing electricity and hot water from our waste.

Although incineration considerably reduces the waste bulk, it does not eliminate it. For every tonne of waste burnt 240 kg of ash will remain on the grate in the form of Incinerator Bottom Ash (IBA). The Meath facility produce 50,000 tonnes of IBA per year. Currently this IBA is disposed of by landfill. The Irish WtE operators have cited a lack of scientific data of Irish IBA as the main reason for not using it beneficially.

This research investigates Irish IBA’s suitability as an environmentally safe and reliable construction material. If successful, landfill of IBA will be eliminated. This will drastically improve the WtE system for sustainably managing our waste.

What is Incinerator Bottom Ash (IBA)?
IBA is an aggregate like material which consists of glass, ceramics, metal, and fine ash components. IBA aggregate has been used as construction fill in Denmark since 1903. Since then it has been used across the globe in applications ranging from cement production to aggregate in bituminous mixes, but mainly as an unbound road foundation material.

This Research:
A statistically representative sample of Irish waste was established. This was incinerated at 850 °C. Mechanical and environmental quality tests were then conducted on the resultant ash.

Mechanical Characteristics:
To meet industry standards IBA must have the strength demanded of it to support and distribute its design loads as well as the durability to sustain long term usage. A range of critical properties such as; gradation, shear strength, durability, toughness, compaction and swelling were assessed in the laboratory. Test results indicate that it is highly compactable and has significant strength with CBR values of 50 %. However it is of a very fine gradation and concerns have arisen regarding swelling and durability. A grading system whereby much of the fine material is removed is thought necessary if it is to be used as an unbound aggregate.

Environmental Safety:
The main concern surrounding the use of IBA in an unbound form is the fear that it will leach toxic heavy metals when it is placed against the natural soil. A leachate testing and analysis programme using Atomic Absorption Spectrometry has been implemented. The IBA was compared to Danish compliance limits. It was identified that weathering is necessary in order to attain acceptable results.

Economic Analysis:
IBA usage provides a number of financial advantages. It saves a considerable landfill cost and it does not require the same intensity of quarry processes as crushed rock. Against this it does require more quality control, the extent of which will not be known until the materials consistency over a year of production is examined.

Conclusion:
If Irish IBA aggregate can be used, we will reduce our landfill and rock extraction volumes, while making our infrastructure more sustainable. This will cause waste to be viewed as a raw material rather than an inconvenience.
Dwelling Energy Measurement Procedure

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Abstract

Abstract – This study presents a building energy measurement procedure utilising Zigbee wireless sensor networks. It is presented as an alternative to the Dwelling Energy Assessment Procedure (DEAP) yielding the actual energy performance of the building; taking into account not only the design and materials used, but also the standards of workmanship and maintenance applied.

1. Introduction

In Ireland, the Dwelling Energy Assessment Procedure (DEAP) is encapsulated in Irish law as the required method to assess the energy performance of a residential building. It is also stated in legislation that every building for sale or lease is required to have a building energy rating (BER). The rating is based on static conditions, building design and materials criteria. However, parameters such as workmanship and maintenance are not considered, even though they have a significant impact on thermal performance.

2. Dwelling Energy Measurement

The advent of Wireless Sensor Networks (WSN’s) allows the measurement of distributed temperature and heat flow throughout a dwelling. Providing an asset rating such as that provided by DEAP but incorporating both actual built local conditions and occupant behavior. Therefore, allowing an improved assessment using local performance parameters.

This study has developed the Dwelling Energy Measurement Procedure (DEMP) through the use of WSN’s to show an improved method of BER using local energy measurement techniques. The overall aim of DEMP is to highlight the current energy performance of existing buildings to the occupant’s. In order to produce more sustainable dwellings using a figure of merit scheme based on actual energy performance.

2. DEMP

The DEMP output is calculated from local accumulated temperature data. The results are specific absolute values based on the thermal performance of the dwelling being assessed. The information provided by DEMP is useful to the end user as it provides them with a factual rating of their home based on local performance parameters. The main advantage of DEMP is its universal application. It can be used as a tool to provide a measured asset rating or it can be installed as an individual or community building energy monitoring system or ‘smart grid’ to provide end user feedback. An illustration of the DEMP ‘smart grid’, can be seen below in Fig.1.

![Fig.1. DEMP ‘smart grid’ community scheme](image)

3. Procedure

In this study, a number of different residential buildings were identified as case studies for the investigation. Buildings were selected based on variations in design and as-build criteria.

A Zigbee network was placed in each building measuring its local thermal conditions and periodically reporting the data back to a central hub for storage and analysis. At present, we are currently in the final stages of modelling and analysis of results accumulated from a wide range of experiments under controlled conditions. The results are being analysed to determine the actual thermal performance of the building and to determine useful metrics for a figure of merit.

![Fig.2. D.E.M.P Information Flow Illustration](image)

4. References

Microbial Ecology of Aircraft Potable Water
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Abstract
For the purposes of this study, 274 water samples were collected from the aircraft potable water chain: aircraft galleys, water service vehicle and central water point at an airport and analysed for their microbial content. Bacterial levels declined noticeably immediately post sanitation, however multiple fluctuations occurred between sanitising intervals. A total of 8 bacterial classes were identified. Future work will establish whether the isolated bacteria species have been implicated in infections and to assess the risk level to passengers and flight crew. The possibility that the tank material surface may support the growth of biofilm will be investigated.

1. Introduction
Commercial aircraft are equipped with one or more potable water tanks which are topped up rather than being emptied completely and refilled. Water can support and host pathogenic and non-pathogenic microorganisms making it a vector for transmittable diseases [1]. Aircraft drinking water originates from municipal water sources. These are subject to a European Council Directive to ensure that drinking water does not contain any concentration of micro-organisms, parasites or substances which create a potential human health risk and that it meets the minimum requirements of microbiological, chemical and radioactive limits [2].

2. Aims and Objectives
The aim of this study was to examine the microbial ecology of potable water in aircraft tanks on the premise that microbial persister cells exist in the form of biofilm despite the tanks’ construction from new composite materials for the prevention of biofilm formation.

The objectives of this study were to conduct a microbial and chemical analysis of aircraft water samples collected from commercial aircraft within a yearly representative time period, and isolate and identify bacteria that comprise the Total Viable Count (TVC).

3. Methods
A total of 274 water samples were collected over a 210 day period from water taps in aircraft galleys using standard procedures for water sampling: ISO 5667-21:2010(E) and ISO 5667-5:2006. Water samples were also collected from the airport central water collection point: a mainline tap connected to the County Council municipal water supply, and from the airport water transport vehicle (bowser). Microbiological, physical and chemical analysis was carried out on the water samples, which included TVC based on ISO 6222:1999; Coliforms, E-coli, and Enterococci, pH, Total and Free Chlorine, Bioluminescence, and temperature. Subsequent isolated bacteria underwent Gram staining, oxidase and catalase testing. Identifications were made by employing the biochemical test VITEK and the Analytical Profile Index (API) 20NE (BioMérieux), and the 16S ribosomal DNA (rDNA)-based identification system MicroSeq500 (Applied Biosystems).

4. Results
The results from water samples obtained from aircraft used for short haul flight sectors differed somewhat from those from long haul designated flight sectors. Strong TVC growth occurred in the first 2 weeks after the water system had been sanitised. Accrued TVC values for each sampling point exhibited cyclical variations in bacterial values at every subsequent sampling. These growth patterns appeared to be independent from flight sectors and physical and chemical analysis results.

A total of 80 species were positively identified from water samples taken from aircraft galleys, bowser tank and water collection point. The identified bacteria belong to 8 classes: γ-Proteobacteria; β-Proteobacteria; α-Proteobacteria; Bacilli; Actinobacteria; Flavobacteria; Sphingobacteria and Cytophagia Two of the classes comprise Gram-positive bacteria whereas the remainder consist of Gram-negative bacteria.

5. Conclusions and Future Work
The theory of biofilm sloughing off and producing sudden high levels of bacteria in the tank water will be tested. Future work on the aircraft water tank material consisting of characterisation of free surface energy and in vitro biofilm cultivation will give a better understanding of bacteria growing in the water tank and possible adhesion to its surface. Risk assessment will be carried out including antibiotic susceptibility testing in order to establish whether the isolated bacteria may possess higher antibiotic resistance levels.

6. References
An environmental sustainability assessment of policies to increase the sustainability of medium to large sized settlements in Ireland.

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Abstract

Current policies to mitigate GHG emissions are proving ineffective. Energy efficiency measures have a key role to play: while technological development is crucial, significant gains may be made through the wider adoption of existing proven technologies through better planning and behaviour change.

1. Introduction

A major challenge facing the world is the need to enhance sustainability urgently as we face the inter-related challenges of climate change, dependence on fossil fuels, food shortages and growing population [1]. Given the slow movement towards a more sustainable system, more radical and systematic policies are needed. There is an increasing interest in research into how current understanding of environmental impacts and their drivers, together with knowledge of smarter technology and management options, may be integrated into holistic policies that deliver the needed behavioural changes. While technological development is crucial, significant gains may be made through the wider adoption of existing proven technologies through improved planning and behaviour change, on the basis that if such technologies be used to their full effect there would be a large reduction in human impact on the environment and dependency on fossil fuels [2]. It is however unclear to policy makers which technologies should be prioritised, and this creates a major barrier to GHG emissions reduction. There is need for quantitative evidence to guide policy prioritisation and implementation.

2. Method

A literature search identified six broad policy arenas in settlement sustainability enhancement: transport, food, housing and urban form, energy, waste and water. Within these arenas published cases describing implementation of relevant policies were identified. A total of 40 policies were identified for further analysis. Candidate policies were tested through SEMPRe, to calculate the percentage change in sustainability, this percentage change was recorded as a measure of the success of proposed policy initiatives if implemented in that settlement.

An existing database of over 300 economic, social and environmental attributes of 79 Irish settlements, located in three regional clusters in central and western Ireland provided a baseline against which the effects of new policies could be modeled.

Following on from this a metric (SEMPRe) was developed to quantify the percentage increase in per capita sustainability for a settlement, which might be expected following the implementation of policies, using published analyses and direct Irish experience [3].

3. Results

The analysis showed that policies were found to differ widely in terms of sustainability improvements and new insights emerged as to which policies are most effective in increasing sustainability in medium to large sized settlements. There was no single policy which achieves a sustainability increase of greater than 10%. Therefore it was necessary to bundle policies into quantitative change scenarios in order to achieve the desired sustainability improvement.

4. Discussion

Our results provide a better evaluation of what and who should be targeted in terms of policy development therefore assisting planners in overcoming the first mover issue. The inter-settlement variation in feasibility scores provides a justification for policy selection and avoids cherry picking of policies to support the viewpoints of the decision maker.

5. References

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The Development of a Decision Support Model for New Technology Based Firms

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Abstract
This research is primarily focused on the development of a decision support model and risk assessment framework for New Technology Based Firms (NTBF). While the scope of the research is limited to Ireland, the author believes that the model under development has the potential to aid not just founders of Irish NTBFs but also the wider community of NTBF policy makers and the researchers. The project is jointly funded by IRCSET and Central Solutions Ltd.

1. Introduction
Launching an NTBF is an inherently difficult and risky undertaking. Along with general new business development activities (funding development, market development and organisational development) the founders of an NTBF must also grapple with an uncertain product or service development process. No surprise then that NTBFs suffer from a very high attrition rate. Indeed a recent study of 11,259 NTBFs in the USA over a five year period by Song1, found an NTBF survival rate of just 36% after four years and a 22% survival rate after five years.

2. Aims of the Project
Best practice models of NTBF development and associated decision support systems hold out the promise of increasing the survival rates of such enterprises, improving the effectiveness of investment capital they attract and reducing risks for the founding entrepreneur(s).

However entrepreneurship research (See Bygrave2, 2008) which underpins many existing development models and decision support tools, suffers from a number of key weaknesses including:-

• Weak relevance to practitioners
• Poor empirical longitudinal base
• Bias towards venture capital datasets
• Lack of integrated approach that makes connections between related fields of study

The motivation for this research therefore lies in the belief that existing NTBF development processes and decision support tools are largely derived to meet the publication needs of researchers or the assessment needs of potential external investors and that there is a need for a model primarily focussed on addressing the needs of entrepreneurs wishing to navigate their business through the fuzzy front end of firm development.

The premise of the research is that rather than the linear process often portrayed, the NTBF development process is a loosely bound series of events, activities and feedback loops that gradually evolve into a more focused and structured firm over an extended period of time. During this “fuzzy front end”, opportunities are uncovered, assessed and decisions made that have a lasting and fundamental impact on the longer term direction and likelihood of success of the firm. The flexibility and creative environment offered by operating in this dynamic and unpredictable fuzzy front end offers the firm multiple growth opportunities and the potential to achieve stellar performance. However, it is this very same lack of structure and a clear roadmap that makes decision making so difficult for the entrepreneur.

3. Methodology
Much of the NTBF development process is obscured from the view of external observers or inaccessible using traditional cross-sectional research techniques. Furthermore founders of such firms often have an incentive to hide the internal deliberations, key events and underlying context of decision making within the firm, as they attempt to maximise the firm attractiveness to outside investors and hide the firm’s vulnerabilities from prospective customers and development partners.

Hence NTBF researchers must be equipped with methodologies and tools to enable them to look within the firm and fully understand the internal context and dynamics of establishment and growth processes. This research project leverages a novel synthesis of ethnography, grounded theory methods and more traditional data collection techniques to overcome these research challenges.

4. References
Dominant Operational Performance Measures for SMEs
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Abstract
The focus of the research is to determine if there exists a set of dynamically available dominant, operational, ex-post performance measures for owner-managed SMEs (small and medium enterprises). There is a predominance of performance measurement literature that focuses solely on corporate strategy with little or no literature speaking to advance operational performance. This research focuses on SMEs and the identification and application of performance measures for the daily operational decision making of an SME owner-manager. The majority of the research developments in relation to manufacturing have examined idealised corporate strategy models that bear little relation to the resource constraints and constrained problems that are experienced in SMEs. Few of these developments are inter-changeable among large enterprises and fewer still are suitable for SMEs.

1. Introduction
The concepts determined were developed through a review of literature and a methodology that involved significant practitioner input through case studies, a survey, a workshop and direct action research within an SME. SMEs spend the majority of their time dealing with operational concerns revolving around availability of time, money and people. SME owner managers require a method to adequately monitor and control operational concerns before they focus time and money on dealing with strategy.

2. Objectives
This research focuses on three objectives that will contribute to SME management capability; they centre on dominant operational performance measures that SMEs can use to advance their business. The objectives include the identification of a set of dominant performance measures, the application of dominant performance measures and the validation of those measures in a more global context. These objectives must be fulfilled in order for the owner manager of an SME to introduce performance measurement in a manner that will promote the opportunity for better management without the introduction of time constraints.

3. Research
The research outlined facilitated identification, application and validation of six top-level ex-post dominant performance measures of common concern for SME owner managers. The contribution of the research is those 6 measures confirmed by owner managers and an implementation through software in an operational SME environment. The primary concern for any SME owner manager is “fire fighting” with limited resources and multiple time conflicts. These dominant operational performance measures are designed to help reduce “fire fighting” through immediate information availability enhancing the opportunity for improved decision making. It will provide an opportunity for owner managers to spend less time on operational issues and to focus more on the strategic direction of the SME.

3. References
A Typology Framework for Virtual Teams

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Abstract

This research reviews the literature on virtual teams with the aim to identify a common set of criteria to study the typology of virtual teams. Using these criteria/attributes a typology framework for researching virtual teams will be proposed. Following this a comprehensive large scale survey will verify the model and attempt to determine common typologies for virtual teams.

1. Introduction

In the modern work environment the need for organisations and people to work on a global level has increased. Today the team as a grouping of co-located people working for a common purpose is no longer the norm. Instead people find that team work occurs across many time zones, locations and organisations. This type of team work has led to the development of the term virtual team.

The role of typology in scientific development is to help organize and make sense of complex phenomena. Typology is especially useful in new areas of inquiry that are little explored and characterized by a variety of diverse but related phenomena (Bell & Kozlowski 2002). Apart from the work of Bell and Kozlowski in 2002, Foil and O’Connor in 2005 to Dixon and Pantelli and Schweitzer & Duxbury both in 2010, there is little research on the patterns/structure of ‘real world’ virtual teams. The aim of this paper is to explore research into virtual teams in order to develop a typology framework that will assist future research to classify the phenomena of virtual teams into distinct types.

2. Approach

This research will

• Examine past research on typology of virtual teams
• Based on a literature review, identify the most pervasive characteristics of virtual teams
• Conduct a detailed survey using the characteristics to gather data on the structure of virtual teams.
• Perform detailed analysis of the survey data to categorise virtual team types and formulate a typology framework for virtual teams.

The research is at the initial stage. A thorough review of the literature is being conducted in order to define a questionnaire that will comprehensively explore virtual team typology.

3. Preliminary analysis plan

The data from the research questionnaire will be analysed as follows

Step 1. Each individual questionnaire will be analysed to determine the virtual team typology.

Step 2. Each questionnaire will then be mapped onto a virtual team typology template developed from the literature review.

Step 3. The mappings will be analysed to determine if there are common patterns or grouping.

Step 4. If patterns are identified these will be classified, and key characteristics for each classification will be developed.

References


Abstract
When companies innovate they often focus their attentions on exploiting their existing markets. There is nothing wrong with this strategy—as long as the ‘rules’ don’t change. What happens when a new technology/product is developed that potentially threatens your existing market share? Do you ignore the potential threat and continue to invest in your own technology? Do you recognize the threat as a potential opportunity? Established companies are vulnerable to disruptive technologies especially if they rely on a single product or technology. This paper looks at this issue of exploring innovation space and in particular the search and selection approaches which firms deploy in order to extend the range beyond their immediate search and selection environments. Strategies companies can utilise to explore their search and selection spaces are identified. These strategies are then tested on a sample of innovating companies in Ireland to examine the extent to which such routines exist and are deployed.

1. Introduction
It is widely accepted that organizations require both exploration and exploitation type activities to be successful innovators over extended periods of time. Exploration activity that leads to radical innovation can propel small companies into a position of industry dominance and can result in the failure of those incumbents that do not recognise the potential of very new technologies. There are practices companies can utilise to enhance their search and selection capabilities in the radical search and selection spaces. These practices include using lead users, using idea generators, and using alternative measurement for radical innovation.

2. Methodology
An extensive review of the literature identified 12 search practices and 14 selection practices a company could use to enhance their radical capabilities. A survey methodology was employed to examine the extent to which such practices exist and are deployed within Ireland.

3. Results
Factor analysis resulted in the discovery of 5 underlying search factors and 4 underlying selection factors.

Search Factors
Market Awareness
Idea Management
Customer engagement
Open innovation environment
Internal Networking

Selection Factors
Fostering and supporting radical innovation.
Prototyping as a selection tool
Strategic and operational flexibility
Differentiating between radical and incremental

4. Conclusions
From this research a number of important conclusions can be drawn. Firstly large dominant companies are leading the way in terms of radical innovation. Secondly a large gap exists between the usage of practices for radical innovation and the perceived importance of the practices for radical innovation. Innovation practitioners are aware of the existence of best practice but are failing to utilise them. Further to this point this study has highlighted that there is a gap between the practices of firms who have a record of successfully introducing radical innovations and those that do not. Comparing the usage of the innovator companies with the usage of the non-innovator companies demonstrated that the innovators use all the practices to a larger degree than non-innovators. Thirdly there appears to be underlying factors relating to radical innovation search and selection. These practices clearly work. Many markets are extremely competitive and companies, when following their current trajectories, often need to ‘sprint’ in order to keep pace with their competitors. If a company shifts its focus from the current trajectory and takes a few steps in an alternative direction i.e. reframes the search and selection space then they may find the market place less crowded and filled with potentially radical opportunities.
Comparative Analysis of 3D Parametric Surface Modeling and Freeform Mesh Modeling as Tools for Investigating Student Learning

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Abstract
This paper investigates the effectiveness with which similar outputs can be produced from two 3D CAD packages that employ different modeling approaches. The modeling approaches in question are parametric NURBS (Non-Uniform Rational B-Spline) surface modeling and polygonal freeform modeling. The former refers to the creation of organic geometry using 2D sketches and building standalone faces between sketches, the latter refers to taking an existing geometric shape and “sculpting” it into a desired form with manipulation of faces and edges. The advantages and dis-advantages of parametric and freeform modeling of organic, complex shapes are numerous and disputable. Parametric surface modeling is advantageous in creating well defined functional geometry but is not considered to easily allow for design iteration. Freeform mesh modeling alternatively allows a more flexible approach in design but commonly results in unusable geometry from a manufacturing or rapid prototyping perspective. The central aim of this study is to evaluate the two modeling approaches.

1. Introduction
Students in the study participated in 2 design tasks, the first to create a design using the parametric approach (using SolidWorks) and the second task using the freeform mesh modeling approach (with AutoDesk Inventor Fusion). Each task involved the creation of similar real world objects that employ organic form. Both design tasks required the students to produce digital 3D models to visually represent their concepts. A separate 3D modeling software package was used for each task. The concept of organic surface creation was new to each participant, all of whom had 3D graphical experience exclusively in solid geometric modeling. Through the paradigm of Project Based Learning, a scaffolded approach encouraging student exploration and experimentation was employed across the study.

2. Methods
The study was conducted using a group of Product Design students during their third year of a four year undergraduate degree programme. Participation in the study was voluntary and anonymous. Ethics approval was acquired. Seventeen students completed all parts of the study. The briefs, for both tasks, were designed to have a similar level of difficulty and complexity in the requested outcome. The deliverables were set so either brief could have been attempted in either of the chosen software packages. The study was conducted over four weeks and consisted of four, four hour computer laboratory sessions (one session per week). Each task took two laboratory sessions to complete. All seventeen students attended the four sessions. The first of the two sessions in each task consisted of instruction on using the surfacing tools in each applicable software package. Students were allowed four hours (one full session) to work on each design, applying the knowledge gathered in the first session of each task.

3. Results
On analysing the grades achieved by each student on both tasks, it was apparent that the majority of students performed significantly better overall on Task 1 than Task 2. Only two students of the seventeen performed better overall on the second task. The group as a whole scored at least 20% better under each of the grading criteria on Task 1 than Task 2.

4. Conclusions
The parametric nature of SolidWorks did allow students to change geometry created numerous steps back, but on many occasions caused inveterate errors when changes were made retrospectively. The ability to use the history tree (in the parametric approach) to make slight changes to reference sketches was deemed useful and helpful by fourteen students. From conducting the study it cannot be conclusively argued that one approach to modeling is better than the other for producing 3D digital concept mock-ups. Statistically students performed better overall at Task 1 (parametric modeling) than Task 2 (freeform modeling). However, almost all students commented that Task 2 was more enjoyable. This suggests that it is a more enjoyable approach to alter existing geometry than it is to create geometry face by face.

5. References
In-line Variability Management Project for Irish Manufacturing Industry

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Abstract
The abstract provides a summary of the in-line variability management project being carried out for companies in the portfolio of Irish Centre for Manufacturing Research (ICMR). The project scope and targets along with the concepts utilized so far are explained in detail.

1. Introduction
Variability is one of the key drivers of cycle time in manufacturing industries. Variability can be defined by the deviation from a norm or target value. Frequently cited in literature variability always degrades the performance. Consequently, improvements on variability will improve the performance. Among some of the popular performance metrics, throughput rate and cycle time can be considered as examples. With this project ICMR aims to deliver improvements to performance of its portfolio of companies, some of which are namely; Intel, Seagate, Pfizer, Analog. The output of the project will enable these key players better manage and reduce the variability in their systems improving their competitiveness.

The remainder of this manuscript is organized in alignment with the project objectives.

2. Metric
Management of variability will not be possible unless it is measured. This quantification needs to be done appropriately considering the dynamics of the manufacturing systems in order to allow addressing the sources of variability.

The literature suggests the coefficient of variation (CV) as a primary metric in measuring variability. CV is the ratio between standard deviation (s) and mean (m) of a set of observations. In our context, we can regard these observations as the performance measure, e.g., cycle time, used by a company.

While the use of CV is common, it encompasses problems in application. First, CV does not have a unit; hence use of CV alone does not allow an immediate understanding towards the sources of variations observed. Its use can be undermined due to mode of operations such as batching. Machines with batch operations will have more intermittent output by nature; and CV can be amplified when this is the case flagging these machines as the source of variability. Therefore, an important part of the project is concerned with a metric for variability that can be used to determine the sources of variability.

3. Sources of variability
Among the most frequently cited sources of variability we can list; arrival, process and departure variability occurring throughout the production steps. One can consider these as aggregate sources since they reflect the overall impact of operations. To illustrate, arrival variability can be generated from variations in transfer times, machine loading operations, times waited to form full batches.

Due to complexity of the manufacturing systems, in particular semiconductor manufacturing, there can be numerous sources of variability in the system. These can include poor operational decisions ranging from WIP policies, material releases into system to lean factors regarding staff behavior which highlights that a systems approach is needed to manage variability. Regarding process and departure variability, machine availability, product diversity, maintenance operations and most importantly unplanned events such as break-downs can be shown as the significant factors.

The next section provides an overview of the preliminary steps in managing and reducing the variability.

4. Preliminary Steps
While experience alone may not be enough to manage and control variability, theory is most valuable when it manages to incorporate the experience which is already available. The success will be the outcome of a collaborative effort from the definition of the project goals to implementation of the actions around these goals.

To begin with, the sources of the variability may be different across different companies and industries. We suggest our companies to develop an interaction map around the performance. This will not only expose the potential sources, but also provides a good starting point. Subsequently, it is important to get expert opinion and mine already available system data to extract the trade-off between the sources and performance.

5. Future
After determination of the significant contributors to variability; common statistical methods, such as, regression, can be used to understand the variations and develop further into a metric and a model for variability. While a metric is necessary to flag variation, a variation model dependent on the sources and direction towards optimization to eliminate variability is required.
Genetic Programming-based Product Cycle Time Prediction using Dynamic System Characteristics
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Abstract
This manuscript provides a predictive method to estimate lot cycle times in manufacturing. The analysis incorporates dynamic system state information and develops explicit cycle time functions distinguishing it from previous studies using genetic programming (GP). The application can be utilized to provide a feedback in planning and scheduling operations attempting to improve the factory cycle time and throughput.

1. Introduction
Lots (individual products) flow through a system going under consecutive process steps. The time that it takes lots to be finished goods is referred to as cycle time (CT). This study attempts to predict CTs in order to assist planning operations. Figure 1 illustrates the advantage it delivers. By having a predictive tool for CT model with acceptable accuracy and representative of dynamic system state, planning can be made more effectively.

2. Predictive models with GP
In order to develop convenient predictive CT models genetic programming (GP) is used. GP is an evolutionary algorithm which is capable of constructing mathematical functions of data (training data) to find the underlying relationship. These functions are dependent on system parameters and basic arithmetic operations. In this manner, it is application is similar to regression. The application is performed as follows:
1. Randomly create a population of functions;
2. Evaluate each function on training data, assign fitness (quality) to each function.
3. Apply evolution;
   a. Select 2 functions
   b. Exchange random parts of these two to form new ones, then get fitness.
   c. Repeat a&b until population limit is reached
4. Replace the old population with the new population from 3.
5. Repeat 3&4 until a stopping criterion.

3. Dynamic system state information
The CTs which are only derived from static information, e.g. number of machines, may fail to provide accuracy since system state will vary in time. For this reason, 3 dynamic variables are considered.

The first variable is the WIP (work-in-process) levels in the system and the second is effective process time (EPT). The WIP dynamically changes as lots enter to/leave the system. It is an indicator of the system loading levels. The WIP is considered in two folds; total WIP and distribution of the WIP across the system (cWIP) in the queues of machines. The latter provides more granular information. The second variable, EPT used in conjunction with the WIP variables. EPT is defined as the time seen by the lot from a machine point of view. Hence it includes all the operations that a lot experiences. These can be setups, transportation, processing, waiting and so on. The recent EPT observations from the system are averaged to have an idea on the velocity of the lots in the system.

3. Results
The experiments are performed on a 4-station production line (Figure 1) for validation. The performance is investigated across different experimental settings (Table 1). The data is collected from models built in Plant Simulation discrete event simulation at steady-state. The results are provided in Table 2 in terms of mean absolute deviation.

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π is fitness (t, training, v validation), s is function length, c, number of functions evaluated
INFORMATION TECHNOLOGY

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Multi Modal Emotion Recognition for Decision Support Applications

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Abstract
This research aims to provide a technique for the two-stream processing of text and speech for emotion detection in decision support applications. Through processing the text and speech in isolation, two separate probabilistic measures of the true emotion being conveyed can be ascertained. These two measures can then be weighted together to determine a more accurate reading of emotion than a single stream could provide. Once our multi modal framework is in place, it is planned to train the system to a stage that we can run test data through it. Once we have achieved a significant level of confidence in our trained system it is our final intention to implement a real time prototype decision making application, and monitor the added benefit of a multi-modal emotion recognition plug-in.

1. Introduction
Collaborative Virtual Environments are distributed virtual reality systems with multi user access. There are many potential applications of these groupware systems ranging from learning environments to remote conferencing and also decision making applications. In making decisions and in discussing research which evidences the indisputable external influences in arriving at such decisions it is imperative that we discuss the somatic-marker hypothesis. This hypothesis as formulated by Antonio Damasio (1991), proposes a theory by which ones underlying emotional state can be a key factor in the biasing and guidance of the behavior of individuals, in particularly when it comes to making decisions [1]. It has not been until the last ten years that fields like psychology has recognized the inextricable link between emotions and decisions, which is why this research aims to utilize the phenomena as a context in which to test the usefulness of our multi modal recognition system.

2. Previous Work
Researchers in acoustic and linguistic analysis have studied extensively the identification of emotional characteristics by parameterizing acoustics. Fernandez for example proposes a framework for emotional recognition in speech through the four primary components of speech: intonation, loudness, rhythm and voice quality [2]. Ververidis identifies the most appropriate acoustic features for emotional speech classification by using a selection method to discover a set of 10 acoustic features that provide best classification [3]. Gupta et al. provides a multi modal system based on audio and speech input for the purpose of call center monitoring [4]. We can use resources such as these as a benchmark upon which to improve upon in terms of the level of accuracy of our algorithms.

3. Proposed Work
The proposed work will involve designing an appropriate framework which will parse input from both a text stream and a corresponding audio stream (Fig 1). It is intended to utilize the ‘Wordnet Affect’ database on our parsed text, which is essentially a dictionary with ‘affective’ tags for words and their emotional weighting. Audio will need to be parsed and refined to a small number of parameters. How these parameters are implemented in our algorithms will determine our contribution to research in terms of our accuracy vs. the accuracy of similar algorithms. The classification stages involves the training of a neural network which, once complete, we shall fed our test data through.

Fig 1. Structure of proposed multi modal recognition system

A large data bank of data has been sourced, namely the Belfast Naturalistic Emotion Database which includes 127 speakers and 298 audiovisual clips of individual conveying emotion [5]. From this data source, text and audio can be extracted and used as training data.

4. References
In this research paper, the authors investigate bias in traditional media through the lens of social media. They propose a simple model for empirical measurement of media bias by leveraging citizen journalism.

### 1. Introduction

With the emergence of Web 2.0 there has been a tremendous increase in the usage of social Web applications which have considerably changed the nature of how media operate. This has given birth to an alternative paradigm of social media for journalism on the Web. This paradigm has caused people to shift from traditional media (newspapers, television etc.) to social media sites like Twitter to find news. In fact social media have given birth to the concept of citizen journalism with ordinary citizens now playing an active role in news dissemination and discussion. It has been observed that mass media remain largely controversial in nature due to being controlled by “the elite few”. On the other hand social media provide a forum for the masses to express their concerns and opinions. A few examples are shown in Table 1.

<table>
<thead>
<tr>
<th>Date</th>
<th>Tweet</th>
</tr>
</thead>
<tbody>
<tr>
<td>26th Jan.</td>
<td>What is wrong with the TV channels?! No news about #egyt!!! #Jan25 #Arab #Media</td>
</tr>
<tr>
<td>27th Jan.</td>
<td>A call to everyone in Egypt: Boycott all national governmental newspapers (Al Ahram, Al Akhbar, Al Gomhoreya). Spread it. #Jan25</td>
</tr>
<tr>
<td>28th Jan.</td>
<td>RT @BrianKeene: disparity in US media Egypt coverage: CNN=peaceful protests. FOX=violent protests. MSNBC= Charlie Sheen banged porn star.</td>
</tr>
</tbody>
</table>

Despite the hype surrounding social media as an alternative paradigm for journalism there has not been much investigation into how social media differ from traditional media in news reporting. Our hypothesis is based on the notion that the alternative journalism paradigm of social media can serve as a test bed for the measurement of bias in the traditional media platforms. Using publicly available data on media sources, we conducted a study of bias in traditional media. We also propose a simple method (built on top of topic models) to measure the bias in traditional media through the use of social media.

### 2. Quantitative Analysis of Coverage for a Major Event

How do traditional media outlets and social media differ in the coverage of an event? To answer this question we conducted a study of the coverage patterns of the two sources (i.e., NYT times articles and tweets) during the Egyptian uprising in January, 2011.

For our experiments, data were gathered using the TREC 2011 microblog track and we gathered all tweets from 23rd January, 2011 to 28th January, 2011. This data significantly covers the time period of the Egyptian revolution which was an event heavily tweeted by the masses and social media activists alike. We simultaneously collected all the New York Times articles regarding the Egyptian revolution for the same period. The time period was chosen on account of the high level of media bias exhibited at the start of the Egyptian revolution. Figure 1 shows the jaccard similarity scores for entity sets in the two media (social and traditional). As evident from the figure, the bias is quite high in terms of entity coverage and it remains below the 0.5 threshold.
Utilizing Social Breadcrumbs for a Balanced Approach to Personalized Search

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Abstract
The World Wide Web has turned from an online information repository into an online gathering point for the masses, and this evolution is now referred to as the Social Web. This change enables users to leave traces of their social experiences which we refer to as social breadcrumbs (simply, footprints on Social Web). Recently the research community is attempting to make use of these social breadcrumbs to enhance Web search engines, and in particular with respect to Web search personalization. We propose a similar utilization of Social Web data for effective Web search personalization. However, we argue for a balance in Web search personalization by using social breadcrumbs of search engine users to fit some search engine results to their personal preferences. This paper presents an early (first year) PhD proposition that calls for a balance in Web search personalization.

1. Introduction
The World Wide Web has undergone a dramatic change in the past few years due to the increasing number of user participations made possible through social media platforms such as wikis, blogs, forums, social networking and social tagging sites. The emergence of the Social Web has also brought a fundamental transition in the way people interact on the Web leading to a new paradigm of search. People now utilize both search engines and social networks to the purpose of information-seeking [3]. This new paradigm of search is referred to as social search [2]. Social search is in a phase of infancy, and there is some ambiguity with respect to its exact definition. Furthermore, the Social Web has given birth to the phenomenon of information discovery thereby leading to more recent systems for information seeking that are known in the literature as recommendation systems. My PhD thesis is situated in this research context, as I will explain in next sections.

2. Problem Statement
In this paper we argue for a balance in the utilization of Social Web data for improving the effectiveness of search engines and recommendation systems of today. Existing approaches that make use of social media data for Web search and recommendation systems are fundamentally built upon the following two ideas: (1) making use of Web page social annotations (available on sites like Delicious, CiteULike, Flickr) for improved ranking of Web pages, and (2) making use of social media data to identify trending topics (e.g. news items) for improved ranking/recommendation of Web items centered on the trending topics. We argue that each of these approaches when taken in isolation has some drawbacks, including:

- Social annotations of Web pages (folksonomies) are useful for only a minor portion of the Web and mostly covers news articles. Moreover, due to the case (i.e., openness) of social tagging services, social annotations are highly prone to social spammers.
- Trending topics on social media are mostly composed of news articles and leveraging this data has a greater chance of improving news search thereby ignoring Web search in general.

3. Research Methodology
On the other hand there is another community of researchers pursuing a study of social networks from a traditional network perspective; these researchers are investigating problems such as community detection, influence analysis, information diffusion and propagation [2]. Currently, there is a wide gap between the research approaches taken up by these two communities. We intend to merge together the ideas from these two promising fields so as to define an integrated personalized search model to enhance search results. Towards this end we propose to take into account additional dimensions (bias, text content, search type) that can have an influence on the personalized (biased to the user) Web search results. This personalized search takes into account the social graph of the user performing the search. Furthermore, personalized search may not be satisfying the user every time as he/she may want a general and global perspective as well (and hence we propose the notion of balanced personalized search). Consider a scenario of a single user issuing a factual query, and a news query intending to seek a non-personalized search result for the factual query while a personalized one for the news query.

4. References
Traces of Social Media Activism from Malaysia and Pakistan
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Abstract
Recent uprisings in North Africa and Middle East saw the role of social media as an online activism medium used frequently by activists. Social media activism is an evolving phenomenon and is viewed by many as the main gathering point in recent protests (e.g., Arab Spring, Occupy Wall Street). Recently, the research community has begun to investigate the intricate interplay between activism and social media. This paper presents a preliminary study in this direction by making use of public Twitter data. We analyse the regional characteristics of online activists of two regions, Malaysia and Pakistan. Unlike previous approaches, we perform a content analysis of activists’ tweeting habits. For this, we identify the popular topics in both the regions along with the frequency with which these topics are discussed by the activists according to their tweeting habits. Further, we analyse the diversity of the content being shared by an activist with respect to their tweeting habits from both the regions. Our results show differences in tweeting habits across the two regions for a period of 45 days (Dec. 1st, 2011 to Jan. 15th, 2012).

1. Introduction
In this paper we address two main questions:
- What behavioral differences are exhibited by social media activists of different regions?
- Is there any commonality between the topics shared by social media activists of different regions? What is the pattern in which social media activists of various regions share the top topics?

To address these questions, we performed an analysis of well-known Twitter activists from Malaysia and Pakistan. These activists were manually sampled by the authors from those respective countries: a total of 70 Malaysian Twitter activists and 118 Pakistani Twitter activists were collected which comprised of a total of 183,028 tweets. Table shows some basic statistics about the Twitter activists of both the countries. As shown in the table, there is a wide disparity in the tweeting activity of journalists from the two countries with Pakistani Twitter activists being highly active.

<table>
<thead>
<tr>
<th>Country</th>
<th>Mean tweets per activist</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaysia</td>
<td>204</td>
<td>219</td>
</tr>
<tr>
<td>Pakistan</td>
<td>621</td>
<td>2405</td>
</tr>
</tbody>
</table>

2. Experimental Methodology
Application of Twitter-LDA on the tweets’ dataset yields the topics of interest of Twitter activists and the words associated with these topics. We then perform tweet clustering with respect to discovered topics along the dimensions of statuses, mentions, retweets, mention endorsements and retweet endorsements.

We perform two types of studies on the tweets of the activists. The first one which we refer to as a popular topics’ study investigates the top topics in statuses, mentions, retweets, mention endorsements and retweet endorsements. The second one which we refer to as a user behaviour study investigates the diversity of topics in activist’s statuses, mentions, retweets, mention endorsements and retweet endorsements.

3. Experimental Results
The Figures below show the ratio of Malaysian and Pakistani activists that share common topics in the various tweet type combinations respectively. As clear from Figures, Malaysians exhibit greater diversity in their tweeting habits.
Searching an Expert in Semi-Structured Documents over Web

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Abstract
A query such as “who is an expert in a given topic?” submitted to Web search engines does not provide satisfactory answers to the users to date (in terms of precision and recall). Although some work has been undertaken for defining enterprise level expert search systems. A satisfactory investigation over World Wide Web (WWW) users (not limited to enterprise) is less than adequate. This contribution presents an early (first year) Ph.D. proposition that calls for proper investigation of public domain expert search over the WWW.

1. Introduction
The WWW has grown from a few hundreds of millions of Web pages to many billions of Web pages. Without any search assistance it would be difficult to find relevant information from such a large volume of data repository. A Web search engine is a system over the Web that addresses the informational need of a diverse user base during the last decade. In addition, queries for finding people have increased by 10% over the period of the last four years. However, Web search engines do not respond well to the queries of ever demanding users such as who is an expert in a given topic? An expert can be defined as an entity that provides knowledge value gain to the person who is searching for an expert. An expert can either be a person with appropriate skills and knowledge or an organizational unit such as enterprise, research center, group, etc or both. Searching for an expert can be a challenging task for the user given his/her limited resources (such as previous knowledge on the subject or regional reachability preference). In addition, standard information retrieval techniques cannot satisfy users’ expectations [1]. Therefore, to meet the users’ expectations, a new field has caught the attention of researchers called expert search [1]. In contrast with traditional document retrieval where documents are shown as result, an expert search system enables users in identifying experts over the given topic (mentioned or hinted in the query). Due to the importance of this research challenge, TREC [2] setup a track between the period 2005 to 2008 exclusive for enterprise level expert search.

2. Problem Description
Recent research literature focuses on enterprise level expert search; some works have used the Web as an additional evidence for the enterprise level expert search. In addition, there have been some recent Ph.D. dissertations focusing on the enterprise level expert search. However, to the best of our knowledge there is no proper research investigation done on expert search system for the public domain (i.e., publicly available content over the WWW) Web documents (simply, public expert search system). Therefore, we plan to investigate this as a topic of interest in our work. A public expert search system, as opposed to an enterprise expert search system, is a facility for the common WWW user for finding experts from the publicly available documents.

3. Research Direction
In this section we proceed by identifying a few general questions, the proper answer of which will help us proceed with our proposed area of research.

3.1. General lines of investigation
- Can topics be discovered from documents?
- How can queries be mapped to identified topics of documents?
- Can known methods for retrieval be adopted?
- Which entity can be stated as an expert?
- How can expert finding be personalized?
- How can we take advantage of external evidence?
- What could be the effective (comfortable) interface for the users for finding experts?
- How can one correctly evaluate such approaches?

4. Current Progress
We began our work by addressing the question of topic discovery from documents. Initially, we took academic Web sites as our data set assuming to serve the type of user who is looking for an expert from academics. We downloaded websites of different schools using a web crawler. Then, we extracted collocations of words from the title and body part of the html pages. In order to remove meaningless collocations, we took the intersection of collocations with Wikipedia articles' titles with the intuition that Wikipedia articles have good coverage of meaningful topics. Results to date look promising.

8. References
Emergence of Cooperations in General Two-Strategy Evolutionary
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Abstract
This research proposed a mathematic model which can present for all two-strategy games. Based on the model, experiments of two strategy games in spatial graph have been observed. A map of the result has been plotted which may help us to understand the difference between different type of games, and predict the result of the evolution under certain setting of the game.

1. Research question
Evolutionary games usually being researched under different graphs, such as spatial graph [1][2][3][4], and small-world graph [5]. Even in the same graph's setting, players may still perform quite different behaviour under different game settings [6]. As we know, the most important research problem of the evolutionary games is the emergence of cooperation, however, the effect of different graph's setting will be hard to conclude if the games show different feature during the evolution in different games setting. It is good to have a uniform model to form the different games.

2. Payoff function and Normalisation
For N×two player or liner N-player games, the payoff of a player picking each strategy can be present as a liner function of its neighbour's strategy, which is the payoff function.

In the invasion, we defined two critical points I and E. The projection of I and E on X axis is I' and E', on Y axis is I'' and E''. Point I is the invade point of strategy S1, which means a S1 strategy player who play against less than I' other S1 player, cannot invade any S2 player. Point E is the escape point of strategy S2, which means that a S2 strategy player who play against more than E' S1 player, can never been invade, and it also can invade the S1 player's cluster. It is easy to see that decreasing I' and/or increasing E' could make S1 more easily to invade S2.

By applying basic transformation on the payoff function, we could normalize the payoff matrix of all two-strategy games to a normal form like:

\[
\begin{bmatrix}
1 & 0 \\
\beta & \alpha
\end{bmatrix}
\]

The normalised payoff function is:

\[
\begin{align*}
P_{S1} &= x \\
P_{S2} &= \alpha + (\beta - \alpha)x
\end{align*}
\]

\[
\begin{align*}
I' &= \alpha \\
E' &= 1 - \alpha (0 < \alpha < 1, 1 < \beta < 2)
\end{align*}
\]

3. Experiment Results
The experiments are run on an 80*80 lattice grid spatial graph, each player play game with his neighbors in the Moore neighborhood. At the beginning of each generation, each player takes the strategy of its best payoff neighbor in the past generation. All the strategies are update synchronized.

The game starts with an initial generation which has been set as one defector in an 80*80 cooperator grid. The emergence of evolution patterns is like below:

7. Conclusion
The experiments show the emergence of the patterns of non-randomly initialized evolutionary games. According the map, the emergence of cooperates of two-strategy games are predictable. However, the most important thing is that we know all the two-strategy games can be presents in one math model. It helps us to understand how and why the emergence of cooperator is not continues, and it also helps to understanding the difference between different two strategy games, such as prisoner's dilemma, snow drift game.

8. References
Evaluating the Cost of Individual Data Centre Services
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³Discipline of Civil Engineering, College of Engineering & Informatics, NUI Galway
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Abstract
The role of data centres has evolved in recent years. They have become significant energy consumers as a result with cloud computing trends further adding to the need for more power. As adoption of PUE [1] levels out globally, more granular metrics will be required to provide integrated, timely, meaningful and accurate indications of a data centre’s energy efficiency. Additionally, consumers are becoming more aware of data centre energy issues and will continue to request more accountability from their data service providers or the organizations availing of those services. Energy efficiency metrics which meet this trend, clarifying data centre costs for the consumer, will become prevalent.

1. Introduction
In the light of increasingly widespread requirements to report energy efficiency, data centre operators will face a number of specific challenges which they will have to overcome to remain competitive.

In a majority of jurisdictions there is no legal requirement to report energy metrics but data centre operators are increasingly adopting the practice based on recommendations published by industry leaders such as the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) [2], the Green Grid [3] and others. With governmental commitments on CO2 emissions and climate change, PUE reporting may well form the basis for widespread legislative requirements in the future, obliging data centre operators to not only monitor the metrics required for calculation of their energy efficiency but also publish their results.

One key requirement will be to ensure that energy metrics assess energy consumption in the context of the service which is being processed (e.g. web mail, search, storage, social networking). As such, the energy cost of each particular service should be made available to the consumer in real-time. We now propose a new metric (DCsPI) which would provide a more meaningful representation [4] of energy efficiency to all data centre stakeholders. The core contribution of the metric is that it applies directly to the service being used by consumers – as and when they use it.

2. DCsPI
DCsPI (Data Centre Service Power Index) is an indication of the power consumed by all the IT equipment involved in processing a particular service required by a consumer e.g. how much power did the IT equipment involved in processing all the calls to a cloud-based email application in a certain time period consume? DCsPI is defined as follows;

\[ \text{DCsPI} = \left( \sum \left( \frac{E_{ip}}{n} \right) \right) \times \left( \frac{60}{t} \right) \times \text{PUE} \]

where:

- \( E_{ip} \) = Power consumed (kW) by equipment \( E_i \)
- \( n \) = number of individual pieces of IT equipment involved in processing the service
- \( t \) = time period to be calculated (minutes)
- PUE = Power Usage Effectiveness

3. Conclusions
We have proposed a new metric which provides data centre service consumers with a clear indication of the energy demands of that service. Crucially, the metric is relevant to the consumer’s context i.e. it reports on the services being used in real-time. With increased awareness of data centre energy usage, consumers may well choose to deploy the services that demonstrate the highest efficiency standards, adding to the governmental requirements and institutional recommendations which are prevalent in the industry today.

4. References
Term Volatility in Twitter Tweet Data

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Abstract
This thesis investigates term volatility in Twitter data. Twitter provides the ability to post short “tweets” including mentions to other users and hashtags that link external events or topics. Over time the meaning associated with a particular term may evolve and diverge as new events and information are posted. Query difficulty is an issue that is important given the presence of this term ambiguity. The aim of this research is to alleviate the problem of query difficulty by removing this ambiguity with an analysis of term volatility.

1. Introduction
Twitter is an immensely popular platform with global tweet counts in the range of 200 million tweets per day [1]. This provides a valuable source of real time streaming information on events and topics. Mining this information reveals categories and trending topics. Interpreting this information at a term level can lead to ambiguities. Term co-occurrence and correlation can provide a deeper insight into events as they evolve while staying focused on individual terms. Terms can be regular text as well as “@” user mentions and “#” hashtags. Co-occurrence of hashtags is a good starting point when beginning analysis as they provide indications of the content topic and related events. As an example, querying for the phrase Michael Jackson provides a perfect example of potential ambiguity. Such a query may return results related to many different events including his death, trials or famous records. Using co-occurrences allows us to build distinct events while retaining a link to an overarching theme. This analysis will then be used to assess query difficulty.

2. Data Collection
TREC 2011 microblog track [2] provides a collection of 16 million tweets from the TREC 2011 conference. The time span of the tweets in this corpus is January 23rd and February 8th, 2011. This two week span will serve as a starting point with which to conduct an analysis. Following this initial step another collection of tweets that spans a broader time frame may be required that better demonstrates the volatility of terms over time.

Twitter provides a developer API that grants access to three kinds of tweet stream. These streams vary in terms of the access level granted and download rate limit and include the REST, Stream and Search API. Once initial co-occurrence and correlations have been built from the TREC dataset, specific terms of interest from this analysis may be used as seed values to build up a more detailed corpus using the Search API. The Stream API may also provide a useful source of random tweet data.

3. Data Analysis
Indexing this collection of tweets is the first step in an assessment of term volatility. This process involves building a TF-IDF index [3] of all terms in a tweet. Hashtags and “@” mentions are also indexed in parallel with regular tweet terms. The Apache Lucene(TM) project provides an indexing and search library which has be used to build this index. Ranking terms by frequency is necessary to assess importance, following this term co-occurrences and correlation may be calculated. These measures will provide an indication of volatility in the data and when analyzed over time, offer a snapshot of the trending topics within the time span.

4. Scale Issues
The issue of scale is a factor limiting the depth of analysis permissible on a data collection of this size. The Tweet data is 10GB with an index that is just under 5GB. Fortunately services are available, such as Amazon Elastic Compute Cloud, that can break down and spread the task of analysis over multiple computing nodes using a technique known as map reduce. This process breaks large tasks into subcomponents (map) that can be executed separately and on different nodes and recombined later (reduce).

5. Conclusion
The goal of this research is to analyze term co-occurrence and correlation in the Twitter data set and to generate useful data on term volatility. An assessment of this volatility over time will reveal important term trends in the data. Ambiguities associated with certain terms due to multiple different co-occurrence pairs can then be identified. A method for the estimation of query difficulty will then be built on top of volatility results by identifying ambiguities in documents in relation to particular search query.

6. References
Analysis of Agent Networks with Social Context

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Abstract

The aim of this research is to introduce and analyze the impact of a model of social relationships on a network of interacting agents. We wish to explore the dynamics of such a network in the context of a computer game environment.

1. Introduction

In the real world, interaction between individuals is based on the relationships they have with one another. These relationships affect our dealings with others, whose outcomes in turn impact the state of our relationships. The study of social relations is an important field within the domain of sociolinguistics, where much research has gone into identifying and quantifying the components of a relationship. Over the past 50 years, researchers have used established classifications of a relationship to study its impact on the language of interaction [1] [2] [3], while in recent years, researchers have sought to improve the quality and believability of virtual agents through the application of social context [4] [5].

While this measure of a social relationship allows for the study of one-to-one interactions between individuals, in order to understand the workings of a large social system, one must look at the connectedness of all individuals within the system. This system of social individuals can be represented on a social network, a scale-free graph where each node represents a person, connected to others through edges that store some measure of social distance. Through analysis of these graphs, communities and friendship networks can be identified and the dynamics of the system can be studied. Commonly, such networks use a scalar distance measure along its edges to quantify the closeness or connectedness of two nodes, and from this information about the connection can be inferred.

2. Proposal

This research seeks to build upon the study of social relationships and their use in the creation of virtual agents, by applying the social relationship variables of sociolinguistics to a social network, so that systems of socially aware agents may be simulated. The measure used is based on the model of Ochs et al. [6], which quantifies the relationship as a four-dimensional vector of liking, familiarity, solidarity and dominance. Each of this measure’s dimensions quantifies a different component of a social relationship, allowing for a richer representation of a relationship to be stored on the graph’s edges, which more fully captures the state of a relationship than a scalar closeness value. From this, more meaningful data can be extracted, and agents can use this information to affect interactions with each other. These interactions will in turn impact the state of the relationship, and the graph will evolve over time. The overall goal of this research is to apply this network of social agents within the setting of a computer game, using it to control groups and towns of Non-Player Characters (NPC), where each agent is socially aware and interacts with those around it, to support a dynamic environment in which player interaction impacts the social state of a virtual world.

3. Current Work

To date, a set of graph topologies have been implemented with tuples associated with each edge representing the relationship between the nodes. The Prisoner’s Dilemma, a well-known abstract game, has been adopted for the current interaction model. Other established models are in place such as trust models and choice and refusal models. An initial set of experiments have been undertaken to test the correctness of the models and to explore the effect of the increased expressiveness of the relationships between nodes. Future work will involve identifying real-world and computer game scenarios in which agents will interact, and analyzing the dynamics of the graph as these scenarios are simulated for agents with and without social relationships.

4. References

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Effect of Conformational Defects on the Racing Performance of Thoroughbred National Hunt Horses

Emily Barrett, Dept. of Life Sciences, University of Limerick, Emily.M.Barrett@ul.ie

Abstract
This study sought to investigate the effect of a variety of defects on racing performance in a large sample of 5,282 Thoroughbred (TB) National Hunt (NH) horses. Horses with defects were significantly less likely to race and had significantly more non-finished races than horses without defects. Horses with prejudicial defects were less likely to race and had significantly fewer career starts, wins and places than horses without prejudicial defects (P < 0.01). Horses with laryngeal paralysis were significantly less likely to race, had significantly fewer career wins and places and significantly more non-finished races than horses without laryngeal paralysis. Horses that were sold had significantly more career starts, wins and places than horses that were not sold or that were withdrawn from the sale (P < 0.05) and horses that were in the higher price brackets at the sales had significantly more career starts, wins and places than horses in the lower price brackets (P < 0.001).

1. Introduction
Thoroughbred breeding and racing are significant industries in Ireland and the UK, with approximately twenty thousand foals born each year. Not all of the foals bred will make it to the racetrack, approximately one quarter will never race and of those that do almost half never win a race. Conformational and other abnormalities can affect the soundness of a horse and can impede its performance to varying degrees. There is a dearth of information, regarding the effect, if any, of these abnormalities on athletic performance.

2. Materials and Methods
Information regarding the defects was gathered from the Pre-Purchase Veterinary Examination Certificates of 5,282 TB NH horses from Tattersall’s Ireland Derby and August Sales, Goffs Ireland June Sale and Doncaster Bloodstock Spring Sale, from 2002-2004. Racing results were gathered from www.racingpost.co.uk with a cut-off date of 31/12/09. This allowed at least four years racing.

3. Results
Horses with defects were significantly less likely to race and had significantly more non-finished races than horses without defects. Horses with prejudicial defects were less likely to race and had significantly fewer career starts, wins and places than horses without prejudicial defects (P < 0.01). Horses with laryngeal paralysis were significantly less likely to race, had significantly fewer career wins and places and significantly more non-finished races than horses without laryngeal paralysis, see Table 1 below. Horses with warts had significantly fewer career starts, wins, places and earnings per year raced than horses without warts. Horses with splints were less likely to have raced by age four than horses without splints and horses with curbs had significantly more non-finished races per year raced than horses without curbs. Horses that were sold had significantly fewer career starts, wins, places and earnings per year raced than horses that were not sold or that were withdrawn from the sale (P < 0.05) and horses that were in the higher price brackets at the sales had significantly more career starts, wins and places than horses in the lower price brackets (P < 0.001).

4. Conclusion
The results indicate that defects play a significant role in racing performance and indicate that more selective breeding to reduce the incidence of these abnormalities in the national hunt population may improve overall racing performance.

Table 1. Summary of defects for horses (compared to horses without those defects)

<table>
<thead>
<tr>
<th>Defect</th>
<th>Raced by 4</th>
<th>Raced by 5</th>
<th>Career Starts</th>
<th>Career Wins</th>
<th>Career Places</th>
<th>Earnings/Year Raced</th>
<th>Non-Finishes/Year Raced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prejudicial Defect</td>
<td>**</td>
<td>*</td>
<td>-</td>
<td>**</td>
<td>**</td>
<td>-</td>
<td>*</td>
</tr>
<tr>
<td>Respiratory Noise, No Paralysis</td>
<td>**</td>
<td>*</td>
<td>-</td>
<td>**</td>
<td>**</td>
<td>-</td>
<td>*</td>
</tr>
<tr>
<td>Laryngeal Paralysis</td>
<td>**</td>
<td>*</td>
<td>-</td>
<td>**</td>
<td>**</td>
<td>-</td>
<td>*</td>
</tr>
<tr>
<td>Unilateral Splints</td>
<td>**</td>
<td>-</td>
<td>-</td>
<td>**</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>Multilateral Splints</td>
<td>-</td>
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<td>-</td>
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<tr>
<td>Unilateral Curbs</td>
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<td>-</td>
</tr>
<tr>
<td>Bilateral Curbs</td>
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<td>-</td>
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<td>-</td>
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<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sarcoids</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Warts</td>
<td>-</td>
<td>*</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Sig. * = p<0.05, ** = p<0.01, *** = p<0.001
Enzymatic Hydrolysis of Heat-denatured Whey Proteins
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Abstract
The effects of heat-induced denaturation and the subsequent aggregation behaviour of whey protein isolate (WPI) solutions on the rate of enzymatic hydrolysis, bio-activity and physicochemical properties were determined. The denaturation and aggregation of whey proteins presents a conformational structure beneficial to certain enzymatic activities.

1. Introduction
Whey is gaining recognition as a source of biofunctional food ingredients benefitting human wellbeing. According to the three-stage model of denaturation (Fig. 1) proteins un-fold and aggregate upon thermally-induced denaturation in a step-wise pattern.

Fig. 1 Denaturation model of β-lactoglobulin where; (A): native β-lg, (B): unfolded and (C): aggregated.

The enzymatic hydrolysis of heat-denatured whey proteins can yield hydrolysates with unique techno- and bio-functional properties distinct from the control hydrolysate (without heat-treatment). Heat-induced protein aggregation followed by enzymatic hydrolysis may lead to the release of novel peptide sequences.

2. Methods
WPI solutions (100 g L−1 protein w/w) were subjected to different heat-treatments ranging from 50 to 80 °C. Denaturation of whey proteins was monitored by SDS-PAGE and reversed-phase and size exclusion HPLC. Particle size, viscosity, solubility and surface hydrophobicity analyses were performed on the heat-treated solutions and associated hydrolysates. Heat- and non-heat treated WPI solutions were hydrolysed to a target degree of hydrolysis (DH) of 5 % using a commercially sourced enzyme preparation with high proteolytic activity in whey. The resulting hydrolysates were characterised at the amino acid level.

3. Results
Table 1 Physicochemical properties of heat-treated whey protein isolate solutions.

<table>
<thead>
<tr>
<th>Test sample</th>
<th>Particle size (μm)</th>
<th>Solubility (%)</th>
<th>Viscosity (mPa s)</th>
<th>Hydrophobicity (μg SDA 500 μg−1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WPI Control</td>
<td>15.9</td>
<td>6.5</td>
<td>90</td>
<td>15.5</td>
</tr>
<tr>
<td>WPI 70°C x 15 min</td>
<td>53.3</td>
<td>1.4*</td>
<td>71</td>
<td>20.4</td>
</tr>
<tr>
<td>WPI 75°C x 15 min</td>
<td>38.9</td>
<td>1.8*</td>
<td>43</td>
<td>214.9</td>
</tr>
<tr>
<td>WPI 80°C x 15 min</td>
<td>40.2</td>
<td>2.8*</td>
<td>31</td>
<td>247.1</td>
</tr>
</tbody>
</table>

Table 2 Physicochemical properties of hydrolysates of control and heat-treated whey protein isolate solutions.

<table>
<thead>
<tr>
<th>Test sample</th>
<th>Particle size (μm)</th>
<th>Solubility (%)</th>
<th>Viscosity (mPa s)</th>
<th>Hydrophobicity (μg SDA 500 μg−1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WPI Control</td>
<td>13.5</td>
<td>0.7</td>
<td>92</td>
<td>13.9</td>
</tr>
<tr>
<td>WPI 70°C x 15 min</td>
<td>25.8</td>
<td>1.2</td>
<td>78</td>
<td>17.2</td>
</tr>
<tr>
<td>WPI 75°C x 15 min</td>
<td>20.2</td>
<td>1.1</td>
<td>50</td>
<td>105.8*</td>
</tr>
<tr>
<td>WPI 80°C x 15 min</td>
<td>21.8</td>
<td>1.2</td>
<td>42</td>
<td>113.1*</td>
</tr>
</tbody>
</table>

4. Discussion and Future work
Non-heat-treated WPI took significantly longer (P < 0.01) than heat-treated WPI to reach a DH of 5 % (Fig. 2). Significant thermal treatment related differences in particle size distribution, solubility, viscosity, and surface hydrophobicity for the non-hydrolysed and the hydrolysed WPI samples were observed (Tables 1 & 2). These results demonstrate the potential role of thermally-induced protein aggregation on the hydrolysis per se and the functional properties of the 5 %DH hydrolysates of WPI. Future work will utilise enriched whey protein fractions to help deconstruct the mechanism(s) by which thermal treatment alters hydrolytic susceptibility and the techno- and bio-functional properties of hydrolysates.
Diversity of desulfurising bacteria in the mycorrhizosphere
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1. Introduction
In 80-90% of all plants, growth is dependent on symbiotic associations with arbuscular mycorrhizal fungi (AMF) and their microbial colonisers. These associations facilitate the biogeochemical cycling and mobilisation of essential nutrients. Sulfur is an example of an element which in soil is up to 95% organically bound, and of this 30-70% is directly carbon bound as sulfonate sulfur, the dominant organo-S source in soils (Zhao et al. 2003). Fungi, while unable to directly desulfonate, are involved in the lignolytic degradation of sulfonated humic material which releases mono- or oligomeric sulfonates that can be catalysed by specific bacteria to inorganic, plant available, sulfur (Kertesz et al. 2007). This study analyses the diversity of bacteria associated with AM hyphae involved in the mineralisation and bioavailability of sulfonates in soil.

2. Methodology
The grass roots were obtained from an uncultivated field site in Castletroy, Co. Limerick, Ireland. The rhizospheric soil was extracted and stored on ice. Using a light microscope at x100 magnification, 2 g of AM hyphae were picked from roots exhibiting a dense hyphal network. The hyphal associated bacteria were extracted following a modified technique for the separation of hyphae from soil (Tommerup 1992), comparative extraction methods were included (Scheublin et al. 2010, Faegri et al. 1977). MPN analysis was undertaken on R2A and the MPN/g of soil/hyphae was recorded. Following this enumeration step, the morphologically distinct bacterial colonies were separated out into pure cultures on R2A and a minimal media agar with toluenesulfonate as the sole sulfur source (MM2TS). Bacteria that grew well on MM2TS were transferred in triplicate into microtitre plates containing liquid MM2TS and, as a control, a sulfur free minimal media (MM2SF). Optical density was measured at 590 nm to establish the relative bacterial growth of the isolates.

The bacterial diversity of the hyphae and bulk soil was analysed using Denaturing Gradient Gel Electrophoresis (DGGE) of the bacterial 16S rRNA gene (Muyzer et al. 1993). DGGE was carried out in a 30-70% denaturant gradient. The gel was run at 60°C for 16.5 h at 63 V.

3. Results and Discussion
The relative magnitude of the microbial communities colonising the AM hyphae and bulk soil were compared by MPN analysis of the R2A cultivation plates, yielding 10⁶ CFU/g of hyphae and 10⁵ CFU/g of bulk soil. Each of the extraction methods employed resulted in a CFU count of at least an order of magnitude greater in the hyphae samples relative to the corresponding bulk soil samples. Optical density measurements at 590 nm of 58 bacterial isolates incubated in MM2TS and MM2SF identified 53 isolates with higher relative growth in MM2TS (P ≤ 0.05). Of these 53 isolates, 47 were cultured from AM hyphae and 6 from bulk soil. Furthermore, community analysis based on DGGE band number indicated greater diversity in the 16S rRNA gene in the hyphal microbial community (25 bands) in comparison to the bulk soil microbial community (13 bands).

The results suggest that AM hyphae are host to a larger, more diverse community of bacteria partially involved in the mineralisation and bio-availability of sulfonate sulfur. The findings place an emphasis on the relationship existing between the AM hyphae and their microbial population that requires further investigation.

Fig 1: A representation population of the bacterial isolates incubated in triplicate in microtitre plates with toluenesulfonate (TS) and without sulfur (SF). The optical density at 590 nm was measured after a 10 d period.

5. References
Effects of Emulsification and Microencapsulation on the Oxidative Stability of camelina and sunflower oils

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Abstract

Oil in water (O/W) emulsions containing sodium caseinate and dried glucose syrup were prepared using various concentrations of oil (camelina or sunflower). Emulsions were subsequently spray-dried to yield powders containing 71.7-85.6 % oil. Oxidative stability of the bulk oils was improved by emulsification and further improved by microencapsulation (spray drying).

1. Introduction

Lipid oxidation can be a significant problem in most edible oils, especially polyunsaturated oils. Formation of lipid oxidation products can have flavour, odour, rancidity, nutritional and shelf-life implications.

Numerous health benefits have been attributed to ω-3 fatty acid consumption, largely related to heart health. Due to their beneficial health properties, ω-3 fatty acids have excellent potential as functional food ingredients, once the issue of their low oxidative stability can be overcome. Camelina oil is a rich source of the ω-3 fatty acid α-linolenic acid (C18:3 ω-3, 30-40%).

2. Materials and methods

Sensitive oils → (1) camelina oil (33.8% α-linolenic acid) (2) sunflower oil (59.97% linoleic acid). Emulsifier → sodium caseinate (NaCas). Wall material → dried glucose syrup (DGS) DE 38. Primary lipid oxidation products: Lipid hydroperoxide test (Shantha & Decker, 1994). Secondary lipid oxidation products: p-Anisidine value test (IUPAC, 1979).

3. Results & discussion

Oil droplet size of the O/W emulsions was not affected by spray drying (reconstituted powders were also tested).

Powders with higher fat content and lower DGS content, had lower microencapsulation efficiency and higher free fat content (P<0.05). The bulk sunflower oil, sunflower O/W emulsions and spray dried powders had lower oxidation products than those containing camelina oil, throughout storage at 15 °C (P<0.05). This is likely due to camelina oil having a higher content of unsaturated fatty acids, particularly α-linolenic acid. Emulsification and microencapsulation of the oils improved their oxidative stability, in particular for camelina oil.

4. Conclusion

Emulsification and microencapsulation improved the oxidative stability of camelina and sunflower oils. Microencapsulated omega-3 rich powders (spray dried emulsions) were created, and were easily reconstituted in water and showed no signs of deterioration during storage at 15°C. The microencapsulated omega-3 rich powders provided the same functional properties as emulsions, but could be utilised in many different food systems (for example spreads, yoghurt, mayonnaise, salad dressing, milk, bakery products or orange juice).

5. References

RACK1 Promotes the Regulation of Focal Adhesion Kinase (FAK) Activity in Neuronal Cells.

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Abstract
This project involves investigating the role of the scaffolding protein RACK1 in regulating the activity of Focal Adhesion Kinase (FAK) in neuronal cells. The mechanism by which FAK is regulated in neurons is unknown but FAK activity is elevated during the invasion of many brain cancers. Our working hypothesis is that RACK1 provides other signalling proteins for FAK activation in migrating neurones by positioning them in close proximity to their substrate FAK. The results show the interaction between RACK1, FAK and other important signalling proteins using immunoprecipitation and immunofluorescence techniques. The importance of the FAK-RACK1 interaction for neuronal migration is also outlined.

1. Introduction
Cell migration is a fundamental process required for embryonic development and the components of cell migration are functionally conserved in evolution. The migration process during brain development and functioning of the CNS requires the ability to sense the extracellular environment and respond to particular cues. This involves a series of integrated and tightly regulated cell signaling pathways and includes Growth factor receptors, Integrins and a series of non-receptor tyrosine kinases such as Focal Adhesion Kinase (FAK). The mechanism by which FAK is regulated in neurons is unknown but FAK activity is elevated during the invasion of gliomas, glioblastomas and astrocytomas. We have reported that FAK phosphorylation is regulated by the scaffolding protein RACK1 (1). FAK binds RACK1 directly and we have mapped the interaction site to Y52 in WD repeat 2 of RACK1 (2). When the interaction between RACK1 and FAK is disrupted, cells are deficient in cell adhesion and migration.

2. Hypothesis
Our working hypothesis is that RACK1 is required to precisely integrate a wide array of signalling events leading to FAK activation during cell migration in the nervous system. We predict that RACK1 provides both spatial organization and specificity of signalling proteins for FAK activation in migrating neurones by positioning them in close proximity to their substrate FAK.

3. Results
We immunoprecipitated RACK1 and FAK from both hippocampal homogenates derived from 3-4 week old male Sprague Dawley rats and differentiated rat pheochromocytoma PC-12 cells. We determined that RACK1 and FAK co-immunoprecipitate and immunofluorescence studies demonstrated that RACK1 and FAK co-localise in the neurite terminals. PC-12 cells transfected with RACK1 Y52F were less adherent and displayed a significantly decreased rate of neurite outgrowth in response to NGF over time when compared to untransfected cells. This suggests a role for the RACK1/FAK interaction in neurite path determination. We have determined that the p85 subunit of PI3K and Fyn are in complex with RACK1 and FAK. We hypothesise that these interacting proteins are involved in the regulation of FAK in neurite outgrowth and are being brought to FAK by RACK1.

4. Conclusion
Our data suggests that RACK1 promotes the regulation of FAK activity in migrating neurons by recruiting the scaffolding proteins Fyn and p85 to their substrate FAK. This work will help establish a clearer understanding of the mechanisms underlying cell migration in neuronal cells.

8. References
The effect of reducing the concentration of sperm cells during liquid storage of bull semen

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Abstract

The hypothesis was that reducing the sperm concentration would prolong the lifespan of liquid bull semen stored for up to 5 days. Sperm stored at higher concentrations exhibited reduced viability and greater levels of oxidative stress than sperm stored at lower concentrations. There was no effect of storage concentration on progressive linear motion (PLM) or on mitochondrial activity of viable sperm. This indicates that a reduction in sperm number may facilitate the storage of liquid bull semen for longer.

Introduction

The Irish dairy industry is rapidly expanding and therefore, the demand for semen from a small number of elite bulls is increasing. The use of liquid semen enables sperm number per insemination dose to be reduced (thus maximising the number of doses per ejaculate) compared to conventional frozen semen without affecting pregnancy rates. Currently in Ireland, liquid bull semen contains 5 x 10⁶ sperm per 0.25 mL dose and is not used after 2.5 days post collection due to concerns over the fertility of ageing sperm. The hypothesis of this study was that 5 x 10⁶ sperm per dose is counterproductive in terms of oxidative stress and glucose consumption within the diluent. Therefore, reducing the sperm number per dose would allow for liquid semen to be stored successfully for a longer duration.

Materials and Methods

Semen was collected from dairy bulls at a commercial AI centre (5 collections with 3-4 bulls per collection). Each ejaculate was diluted in Caprogen diluent to final concentrations of 5 (T5), 4 (T4), 3 (T3), 2 (T2) and 1 (T1) x 10⁶ sperm per 0.25 mL straw. Straws were stored at ambient temperature and assessed in vitro daily for 6 days (Day 0.25 = 6 h post collection on day of collection). PLM was assessed using standard procedures. Sperm viability, oxidative stress and mitochondrial activity were examined using the fluorescent probes propidium iodide (PI), CM-H₂DCFDA and rhodamine 123 (R123), respectively, and analysed using flow cytometry. For glucose analysis samples were centrifuged at 8000g at 4°C and the supernatant was removed, frozen at -20°C and analysed later using a commercial glucose kit. Briefly, samples were diluted 1:2 with distilled water, added to 1 mL of glucose oxidase/peroxidase reagent and incubated at 45°C for 20 min. Absorbance was measured using a spectrophotometer with glucose concentrations determined by a standard curve. Data were examined for normality, transformed where appropriate and analysed using repeated measures in SPSS (version 20.0). The model included the main effects of day, treatment and day x treatment interactions. Results are presented as mean ± s.e.m.

Results and Discussion

PLM declined with duration of storage from 95.1 ± 0.68% to 73.8 ± 0.99% for all treatments from Day 0 to 5, respectively (P < 0.001). There was an effect of day and treatment on viability (P < 0.001) with the highest % live in T1 and the lowest in T5 each day (Day 0: 92.4 ± 0.68 and 66.3 ± 2.79% for T1 and T5, respectively, vs. Day 5: 80.7 ± 2.32 and 56.1 ± 3.23% for T1 and T5, respectively. CM-H₂DCFDA positive events increased in all treatments each day (Figure 1; P < 0.001). There was an effect of treatment (P < 0.001) with T1 having significantly lower oxidative stress in comparison with all other treatments. Live sperm positive for R123 ranged between 91.9 and 94.8% and were not affected by treatment (P > 0.05). Glucose concentration in Caprogen declined with duration of storage (P < 0.001), being lowest in T5 and highest in T1 on Day 5 (831.3 ± 22.25 and 964.4 ± 21.61 μg/mL, respectively).

Figure 1: The percentage of live bull sperm positive for oxidative stress. Vertical bars represent ± s.e.m; n = 9.

Conclusions

Reducing the sperm number per dose reduces the level of oxidative stress and may be beneficial to the prolonged storage of liquid bull semen.

Acknowledgments

We gratefully acknowledge support from IRCSET and Enterprise Ireland. Semen was kindly donated by the National Cattle Breeding Centre, Enfield, Co. Meath.

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To assess the sustainability of rehabilitated industrial residues by uses of soil organisms.

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Abstract

In rehabilitated industrial residue areas the main restoration objective is to develop a sustainable natural ecosystem and to eliminate or amend undesirable properties such as pH extremes. A key factor to a successful self-sustainable ecosystem is a continuous nutrient cycling system and an active soil community system. There is limited information on soil biological activity in decomposition and nutrient cycling in relation to rehabilitated industrial residues. In the present study litterbags were used to monitor spatial and temporal variation in decomposition rates in a restoration chronosequence (0-12 years). In addition, physical and chemical soil analysis was carried out to characterise soil properties. Tullgren extraction was used to determine arthropod assemblages and soil enzyme activity was also analysed. Preliminary results have shown promising signs of a self-regulating ecosystem with evidence of plant litter decomposition and the natural establishment of large invertebrates such as earthworms. This research has potential to determine the success of the rehabilitation process in an industrial residue and can be used to monitor the recovery of other disturbed and degraded sites.

1. Introduction

Approximately 30 millions tonnes of bauxite residue is produced annually world-wide [1]. This residue must be disposed of in an environmental friendly manner, and also in the most cost efficient way for the mining companies. The most effective practise is to layer and amend the residue to a semi-natural rehabilitated soil, which is the technique used in Aughinish Alumina, Askeaton, Co. Limerick. There is limited research into the sustainability of the ecosystem as a whole and the soil communities. The aim of this study is to assess the long-term sustainability of the rehabilitated soil by looking at the ecosystem key processes [2]

2. Experimental design

An effective ecosystem is one that obtains all the key function to allow it to gain long term success. The key functions are; organic matter turnover, decomposition nutrient cycling and mineralization. The project investigates these key processes in relation to four sites of different rehabilitated ages: 12 years, 10 years, 1 Year and 0 years (raw bauxite residue). Soil parameters such as pH, conductivity, soil moisture, temperature, organic matter, nitrogen, and phosphorous and other trace elements were assessed each season for one year. The decomposition rate was analysed using the litterbag method [3]. Litterbags with a mesh size of lcmxlcmm were placed above and below ground. The invertebrate assemblages were extracted using the Tullgren method. Soil enzyme activity was also determined each season.

3. Results and Conclusions

The preliminary results have shown that the older sites (12 and 10 years) have higher decomposition rate, higher enzyme activity and are more enriched in organic matter and nutrients. The older sites also have a wide range of invertebrate species and more plant bio-diversity compared to the young sites. An interesting find was that the decomposition rate was quite high in the unamended site 4. This was due to invertebrates travelling to the litterbags from the surrounding areas- showing promising signs for ecosystem establishment. The results showed that the old rehabilitated sites are showing strong indicators of a self-regulating ecosystem that will need no further human interactions such as the addition of fertilisers. This assessment process can be used for other industrial residue to confirm the sustainability of a rehabilitated ecosystem.

4. References


A comparison of the insulinotropic and enterogastric response to ingestion of an equivalent quantity of maltodextran and whey protein

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Abstract

The insulinotropic effect of whey protein ingestion induces a rise in plasma insulin and lowering of blood glucose. It was hypothesized that the insulinotropic action of whey protein may, in part, be regulated via the secretion of the enterogastric hormones. This study reports on the post-prandial response of plasma glucose, insulin and GLP-1 to feeding maltodextran and an equivalent quantity of whey protein.

1. Introduction

In the absence of carbohydrate, the insulinotropic effect of whey protein ingestion induces a post-prandial rise in plasma insulin peaking at 30 min (1). This insulinotropic action of whey protein may, in part, be mediated by incretin hormones. Glucagon like peptide-1 (GLP-1) and glucose dependent insulinotropic polypeptide (GIP) are enterogastric hormones that stimulate insulin secretion from the pancreatic β-cell in a glucose dependent manner (2). An increase in enterogastric hormone (GLP-1, GIP, CCK, PYY, Ghrelin) secretion is related to satiety following protein ingestion (3). The inter-relationship between post-prandial enterogastric hormone release, glucose regulation and satiety is of relevance to the regulation of obesity, diabetes and the metabolic syndrome.

2. Objectives

To evaluate the time-course and magnitude of insulinotropic action and enterogastric hormone release following ingestion of whey protein compared to an equivalent amount of carbohydrate

To examine whether the enterogastric response is related to post-prandial satiety.

3. Methods

With ethical approval and informed consent four young, healthy adults (n=4, age 25(2.8)y, BMI 21.8(1.1)kg/m²) undertook a randomized ingestion of either protein (WHEY 0.33 g/kg, 10% w/v water) or maltodextran (MALT; 0.33 g/kg, 10% w/v water), each treatment separated by 5 days. Subjects fasted overnight (10 h) prior to participation. Serial blood samples were withdrawn prior to and post ingestion for a period of 2 h and batch analysed for glucose, insulin and total GLP-1. Visual analogue scale (VAS) questionnaires were used to rate subjective feeling of satisfaction, fullness, hunger and prospective food consumption (4). VAS was completed prior to ingestion and every 30 minutes during the post-prandial period. A composite score of the four responses was used to report the subjective satiety score for each treatment. Data are presented as mean (SEM; n=4). Area under the curve for plasma insulin, total GLP-1 or subjective satiety (Δ AUC0-120) was calculated by trapezoidal integration. Difference in the mean response was analyzed by paired Student’s t-test.

4. Results

Following ingestion of MALT, plasma insulin tracked the increase in blood glucose to a maximal concentration (Cmax) of 299(48) pM after 30 min. Ingestion of WHEY resulted in similar time-course but lower Cmax of 182(23) pM (p=0.09) that was independent of a change in plasma glucose. Analysed by ΔAUC0-120, the insulinotropic potency of WHEY was 76% of that induced by MALT (8506(1783) vs. 6512(1184) pM.2h; p=0.29).

Ingestion of MALT induced a transient increase in total GLP-1 in the first 30 min and a Cmax of 7.4(3) pM. The post-prandial response to WHEY was more prolonged (Cmax of 11.4(2) pM at 75 min) resulting in an 8-fold greater circulating total GLP-1 (AUC0-120 -64(40) vs. 527(90) pM.2h; p=0.014).

The post-prandial change in subjective satiety peaked at 30 min for both treatment after which the satiety response was greater following ingestion of WHEY. Satiety AUC was 920(629) vs. 1369(877) mm.2h (p=0.19) for MALT and WHEY respectively.

5. Outcomes

Ingestion of a milk protein (WHEY) induced a non-glucose dependent insulinotropic response that was approximately 75% of that induced by carbohydrate (MALT). Compared to MALT, the post-prandial enterogastric response (AUC0-120 total GLP-1) was 8 fold higher following ingestion of WHEY.

Subjective rating of satiety was ~50% greater following ingestion of WHEY. The greater increase in total GLP-1 may have contributed to the higher level of subjective satiety following ingestion of WHEY.

6. References

Why do Guinness bubbles sink?

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Abstract

Anyone who has ever tried Guinness or another stout beer knows that the bubbles in the glass appear to sink. This suggests that they are driven by a downward flow, the velocity of which exceeds the upward velocity of the bubble due to the Archimedean force. The existence of such a flow near the wall of the glass implies that there must be an upward flow somewhere in the interior. The mechanism of such a circulation is, however, unclear.

In this work, we demonstrate that the circulation in a glass of stout – or any other container with a bubbly liquid – is determined by the container’s shape. If it narrows downwards (as the stout glass does), the circulation is directed downwards near the wall and upwards in the interior. If the container widens downwards, the circulation is opposite to that described above.

1. Introduction

Bubbles in liquids normally float up due to the Archimedean force – yet those in so-called stout beers appear to go down. Such counter-intuitive phenomena rarely occur in our everyday life, challenging the curiosity of both scientists and lay people.

Interestingly, even though the effect of bubbles sinking in Guinness is widely known and that the bubbles/liquid interaction in stouts has been examined before [1], no explanation of this puzzling phenomenon has been put forward so far.

In this work, we shall first describe the properties of Guinness as a two-phase medium and explain the basic mechanism which drives bubbles in Guinness downwards.

2. Mathematical Modelling

Since we attempt to explain the downflow of bubbles in Guinness by the geometry of the container and not by a physical effect, we shall use the standard model for bubbly flows included in the COMSOL Multiphysics package, based on the finite element method. We shall not discuss this model’s physical foundations, as they are described in detail in [2], but mention only that it assumes that the bubbles are all of the same size. In view of the problem’s axial symmetry, the axisymmetric version of the model is used.

Two geometries were examined (see Fig. 1): a pint and an ‘anti-pint’, i.e. the pint turned upside-down. In both cases the initial distribution of bubbles was uniform. The results of typical simulations are shown in Fig. 1. One can see that an elongated vortex arises near the sloping part of the pint container, resulting in a downflow of bubbles along the wall. A similar vortex also exists in the anti-pint, but it rotates in the opposite direction and, thus, causes an upward flow.

The latter results can be explained using the same kinematic argument as those for the pint geometry: if the container widens downwards, bubbles travel towards the wall (as illustrated in Fig. 1 (right)). This increases the near-wall density of bubbles and, thus, the upward drag applied to the liquid, resulting in an upward flow.

3. References

MATERIALS

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Development of an Integrated Experimental and Numerical Technique to Predict the Three-dimensional Stress Field in Complex Structures
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Abstract
A method is under development which automatically builds and validates 3D finite element models of components using 3D Digital Image Correlation (DIC). The 3D surface deformation field, provided by the DIC, is applied as a boundary condition to the FEA model, ensuring the FE model is experimentally exact at the surface. The FE solver then calculates the internal state of stress in the model. Experimental validation of the method will be provided by embedded strain gauge models.

1. Introduction
3D Digital Image Correlation (DIC) can experimentally measure the in-plane and out-of-plane surface deformations on components of arbitrary shape. The method works by tracking the displacements of points, sprayed onto the surface, with two cameras; the surface strains are then computed by appropriate differentiation of the measured displacement field. Often experimental measurement of surface strains is inadequate for the analysis of the state of stress in a body, as the critical stresses may occur at internal points. While advantageous as a non-contact tool for the measurement of surface deformations, DIC alone does not allow for measurement of strains internal to the model. By using data obtained from DIC testing to define the boundary conditions used for the finite element analysis, an experimental-numerical picture of the state of internal stress in the model is achieved. For this work, DIC will be integrated with finite element analysis to automatically carry out an experimentally consistent, three-dimensional stress analysis of complex structures. This new approach will produce a-priori experimentally validated computer models of structures.

2. Methodology
MATLAB and Python are used to integrate the DIC results into finite element solver. ABAQUS CAE will be used as the solver. User-defined subroutines will be written using Fortran to define the contact behavior including frictional effects.

A pin-loaded lug was chosen as the geometry used for experimental validation of the method, as through-thicknesses stresses are caused by pin/lug surface interactions when loaded in tension. By positioning the embedded gauges near the contacting surface, the model will be validated in areas of high stress gradients and high stress concentrations. Accurate modeling of the contact to include friction will also be assessed. Tests will be conducted for different co-efficients of friction at the contact interface, and for different pin/hole clearances and pin/lug relative rigidities. The effects of applying unequal loads to the ends of the pin, thereby inducing significant through-thickness stress gradients, will also be evaluated.

3. Experimental Model
The experimental model is manufactured from CT1200/HT907 epoxy as this is a suitable material for embedded strain gauge analysis. Gauges are embedded close to the contacting surface of the pin and hole where high stress concentrations occur. The gauges are located at 3 planes through the model; for each plane, 5 biaxial strain rosettes are located in the vicinity of the hole (Figure 1). The strain gauges are orientated to measure strains radially, tangentially and axially with respect to the central axis of the hole. Two models are to be made with the strain rosettes positioned in the same positions in both, but aligned in different directions. In this way, the strains in the three orthogonal directions are measured at the same geometric points.

![Figure 1: (a) 3D view of test geometry including cylindrical co-ordinate system for applying gauges in radial (r), tangential (θ) and axial (a) directions; (b) front view showing position of embedded gauges (+) in each plane; (c) side view including planes A, B and C in which strain gauges are embedded.](image)

4. References
Experimental Numerical investigation into unidirectional composite fracture
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Abstract
Composite materials are already widely used in engineering structures, especially in the aeronautical, and, indeed, the aerospace industries where their high specific strength and stiffness make them ideally suited to realise lower mass components. However, a major weakness of these laminated materials is that they are prone to delamination at both the interface between the plies (interlaminar) and within plies (intralaminar), which hinders reliable prediction of their durability in service. It is therefore of primary importance to devise reliable experimental and numerical techniques to study and predict the fracture behaviour of existing materials. In this work, the use of a centre notched tension and single edge notched specimens is investigated for determination of the fracture behaviour of a unidirectional composite. An XFEM model has been developed to represent the fracture behaviour and here an experimental determination of intralaminar fracture toughness of unidirectional carbon fibre (HTA 6376) composite is obtained.

1. Introduction

The longitudinal fracture toughness characterises the materials resistance to fracture when a crack propagates parallel to the fibres. In determining the longitudinal fracture toughness, digital image correlation (DIC) is used to obtain displacement measurements, about the crack tip just before propagation. This displacement data is then used in conjunction with a J-Integral approach to determine $K_I$ and $K_{II}$, the critical Mode 1 and Mode 2 stress intensity factors (SIFs) and hence $G_c$, the mixed mode fracture toughness of the material. This data further validates our in-house developed XFEM (extended finite element method) approach to predicting crack propagation angle, and this will also be presented.

2. Methods

Experimental testing, involving a tensile testing machine, high speed camera and associated DIC equipment were used to test the unidirectional composite specimens. Commercial software ‘StrainMaster’ by DaVis inc was used to capture displacement values radially about the crack tip.

J-Integral approach incorporating an interaction integral is utilised to evaluate the SIFs ($K_I$ and $K_{II}$) of the crack at the critical loading just before failure.

3. Results

A total of 15 samples were tested with three samples of each material orientation tested. The orientations tested were 0, 30, 45, 60, 90 degrees off axis. The load displacement behaviour was recorded and used to validate the XFEM model developed.

A MATLAB code has been developed in order to experimentally obtain the critical SIFs or Fracture toughness values and is currently being validated.
The Thermal Behaviour of a Flip-Chip Laser Array within a Photonics Integrated Circuit (PIC)

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Abstract
In this paper, a parametric study was carried out on a flip-chip laser array within a PIC in order to investigate the influence of metallization geometry, laser-to-laser spacing, and adjacent heat dissipating devices on the temperatures of the flip chip laser device. Using both analytical and numerical models, a predictive method was developed to determine the temperature across the flip-chip array, heat spreader, and TEM. This study conclude that there are optimal design parameters for photonic laser arrays.

Introduction
In the telecommunications industry, Photonic Integrated Circuits (PICs) are utilized to realize optical transmitters and receivers for data transmission. PICs offer compelling advantages in terms of performance, miniaturisation and – in some applications – energy efficiency. As communication devices move towards greater miniaturization, thermal management becomes a limiting factor. In the thermal design of optical laser arrays, issues such as tight temperature limits (±0.1K), low operating temperatures (as low as 15-25°C), moderate heat loads (~1-10W) which yield high heat fluxes (over 10^2 W/cm^2) need to be addressed. Contemporary thermal control methods involve a thermoelectric module (TEM), combined with an external heat sink, to remove thermal energy from the packaged PICs. Existing packaging methods typically feature low profile multilayer substrates placed between the laser array devices and the TEMs. These layers provide thermo-mechanical compatibility with the semiconductor devices, high thermal conductivity and electrical interconnection. Typically, these substrates are fabricated from Aluminium Nitride (AlN) or silicon with metalized layers and plated vias, which provide an interconnection density suitable for flip-chip mounting of laser array and driver devices.

Modelling Techniques
Two modelling techniques were used in the analysis of the device; analytical and numerical. The analytical modelling was initially developed based on the approach of Yovanovich’s heat spreading models [1]. The numerical models were further developed using finite element software. A detailed parametric study examined the influence of device-level and substrate-level parameters on the source-to-ambient thermal resistance of the laser array. A range of metallization thicknesses, and layouts were assessed and laser-to-laser spacings were also varied.

Consideration was also given to additional heat loads within the carrier substrate associated with driver devices and associated passives.

Results & Conclusions
It was found that the representative models developed provided good agreement with heat spreading trends found through experimentation carried out by Liu [2]. To reduce computation time, an isothermal boundary condition was imposed upon the lower surface of the heat spreading substrate; this reduces the complexity and computational time of the numerical model by eliminating the modelling of the TEM. The effect of passives upon the source laser temperature is negligible, as the sphere of influence does not encompass the laser, for the heat dissipated. Finally the optimal geometry and spacing for the metallization surrounding the laser is; 200 μm wide by 40 μm thick for a length of 1mm, with a spacing of 500 μm between each laser to achieve thermal independence. The outcome of the paper is an enhanced understanding of the thermal behaviour of a representative flip-chip laser array. This paper represents the initial results of an extensive programme of work on packaging-related aspects of next-generation PICs.

References
Computational micromechanics of damage of composite materials
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Abstract
Aircraft companies seeking to reduce the weight of their products are constantly looking to replace conventional materials such as aluminium with more lightweight solutions. While failure processes in these conventional materials are well understood, the same cannot be said for composite materials, as their heterogeneous composition causes a range of competing damage mechanisms. The aim of this project is to investigate the damage behaviour of the bond between an adhesive and a composite adherend.

1. Introduction
Previous work focused on characterisation of the high strength composite material HTA/6376. Good correlation with the experimental data of [1] has been achieved under transverse tension ($\sigma_{22}$), transverse shear ($\tau_{23}$) and in-plane shear ($\tau_{12}$).

2. Model Development
A model has been developed consisting of a section of composite and a layer of adhesive. The composite has been modelled using the previously developed RVE. The adhesive layer was modelled as an elastic-plastic material, where plastic yielding was predicted according to the Mohr-Coulomb criterion. The boundary conditions were chosen to represent a region away from the edges of an adhesive joint. The loading conditions were chosen to reflect pure Mode I loading of an adhesive joint.

2. Results
The thickness of the adhesive layer has been shown to affect joint strength [2]. This effect has been investigated using the adhesive layer model. A perfect bond was assumed between the composite and fibres. An increase in adhesive layer thickness corresponds to a decrease in strength of the adhesive joint which corresponds with the findings of [2]. A sample stress strain plot including failure is shown in Fig. 1.

It is known that different adherand surface treatments can improve joint strength. An investigation was carried out where the strength of a layer of cohesive elements between the composite and the adhesive was varied to reflect different bond strengths. It was found that failure within the composite provided the upper limit on the strength of the joint, and a contour plot of the plastic strain within the model is shown in Fig. 2, with loading in the vertical direction. Damage occurred entirely within the composite region.

4. Conclusions
- Thinner adhesive layers produced lower joint strength.
- A weak bondline causes failure totally within the bondline, while a strong bondline causes failure within the composite surface ply.

5. Future Work
- Subject models to Mode II loading
- Results from the mode I and mode II adhesive layer modeling to be incorporated into a cohesive zone model
- In-situ SEM testing will be carried out on small scale samples.

6. References
An Investigation into the Relationship Between Intralaminar Crack Growth and Delamination, Leading to Compromised Structural and Mechanical Performance
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Abstract
A major drawback with current generation continuum damage models for composite materials is that the interlaminar crack growth (i.e., delamination) is treated as a separate damage mechanism to intralaminar damage (i.e., matrix cracking, fibre failure). It has been shown that these failure mechanisms are in fact highly coupled, with matrix cracks propagating to ply boundaries and forming micro-delaminations. These delaminations then coalesce to form macroscopic delaminations, which seriously degrade the integrity of the laminate. This study presents an investigation into the relationship between intralaminar crack growth and delamination using micro-mechanical testing procedures.

1. Introduction
The behavior and mechanism of delamination when testing specimens in three and four point bending have been studied with the aim of characterizing this behavior for comparison with a damage model. The theory of laminates was studied and utilized to explain the behavior observed during testing.

2. Method
HTA/6376 laminates were produced with the following fibre orientations where $0^\circ$ fibres lie perpendicular to the viewing angle: $[90_0/0_7/90_0]$, $[90_0/0_7]$, $[90_0/0_7/0_2]$, $[0_2/90_0/0_4]$ and $[0_4/90_1/0_4]$. A test matrix was produced and specimens from these layups were tested in three point and 4 point bending as well as four point offset bending. These tests were carried out in conjunction with tensile and compressive testing. The three and four point bend tests were used to quantify the difference in material behavior in relation to the nature of the applied shear stress exhibited. Differences such as the large peak in shear stress in the centre of the specimen under three point testing when compared to the more evenly distributed shear stress associated with the four point bend testing. A scanning electron microscope (SEM) was used in conjunction with an in-situ micro mechanical tester to establish the nature of the propagation of matrix microcracks in three and four point bending. An integrated delamination-intralaminar damage model will be created in Abaqus Finite Element Analysis software, and the experimental testing with the micro mechanical tester will then be used to validate the results, then being used to aid in the accurate prediction of delamination in composites.

3. Current Research
Figure 1 below shows the typical results achieved during bend testing of a laminate with ply orientation $[90_0/0_7/90_0]$. Using the SEM and the microtester, the growth of the crack was tracked and recorded until it began interacting with the plies perpendicular to it and delamination began.

Fig 1: Crack Growth leading to Delamination

It is expected that with the different ply orientations specified previously that the laminates will crack slower/faster than the benchmark example, in particular the thickness of the $90^\circ$ plies should be an important variable in terms of strength of the laminate and ease of tracking crack growth. A Matlab program was developed that can calculate the stresses in the $x$ and $y$ direction as well as the shear stress for each individual ply of a given laminate. This tool is to be used in conjunction with shear force bending moment diagrams to predict the regions of highest stress concentration and the difference between the shear stresses observed in the individual plies in three and four point bending. Future work will involve using the information and material characteristics determined from the testing to incorporate into user subroutines written for Abaqus which will help to more realistically simulate the relationship between the intralaminar crack growth and delamination of the composite.
Micromechanical characterisation of P91 martensitic steels used for power generation

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Abstract
In this study, a micromechanical characterization is performed to identify the microstructural mechanisms in a ferritic power plant steel (P91). Electron backscatter diffraction (EBSD) is used to quantify polycrystalline microstructure. Based on the obtained microstructural information, a crystal plasticity based finite element analysis is then carried out to examine the multiscale deformation behavior within the ferritic steel by accounting for realistic micromorphology, thermally activated kinematics of dislocation slip, rate-dependence, lattice rotation or texture evolution, latent-hardening and geometric distortion at finite deformation, and damage evolution. Furthermore, the effect associated with the latent hardening of multiple slip systems is also quantified as a result of altered work hardening at the microscale.

1. Introduction
The steel of interest in this project is a 9%Cr power plant steel, P91. This steel is widely used in ESB power plant headers and other piping functions. The steel itself has a complex microstructure that is difficult to model analytically, making failure predictions troublesome to achieve. Several methods of modeling will be investigated, including EBSD mapping and RVE generation.

2. Aim
The aim of the project is to represent the microstructure of P91 steel in the most accurate manner possible. Utilizing various techniques, including electron backscatter diffraction (EBSD) and developing representative volume elements (RVE), a multiscale analysis of P91 can be achieved. A comparison of each method of modeling with experimental data will be essential to validate each method and also to develop the modeling stage further.

3. Microstructure of P91
P91 steel consists of a fine lath martensite microstructure. This arrangement is very complex, with each lath measuring 0.3-1 micrometer in width. Figure 1 shows a schematic of the structure present in P91. The figure highlights the various subgrains, consisting of packets, blocks and laths.

4. EBSD Analysis
Shown in figure 2 is the EBSD contour map for P91 steel. The map was obtained using MSSI’s scanning electron microscope (SEM). The subgrains can be identified and also a good approximation of grain size can be achieved.

5. Future Work
- Further develop an RVE to more completely represent P91 steel
- Continue EBSD and EDS analysis of P91
- Compare both methods of microstructure representation

6 References.
FE Modelling of Countersunk Composite Joints for Next-Generation Aircraft

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Abstract
As fibre-reinforced composites account for large proportions of next-generation aircraft structures, there is an increased focus on the efficient joining of such sections. Optimising countersunk composite joints using computational methods, can reduce conservatism in the design, and curtail the cost of physical testing programs. In this paper, 3D Finite Element (FE) modelling was carried out on single-lap, countersunk carbon-epoxy joints, designed for a next-generation aircraft skin structure. A single-lap joint configuration is typical for an aircraft skin application, while countersunk fasteners enhance aerodynamic efficiency. A 3D composite damage model is developed, to capture the microstructural failure events which occur at the loaded hole. Extensive use is made of the Explicit Dynamics method. This was found to be more robust than implicit FEA in dealing with complex contact conditions and material softening.

1. Introduction
3D FEA, of composite structural details, including failure prediction, is currently very limited in the aeronautical industry. Shell elements are used extensively, but fail to account for the 3D nature of the laminate stress distributions and provide for inadequate composite damage modelling. In this work, detailed 3D models of countersunk composite joint are analysed. A damage model was developed to capture failure in the carbon-epoxy plies. The approach, developed in Abaqus/Explicit, is capable of analysing larger problems and high speed loading scenarios.

2. Methods
The FE model of a case study joint, is shown below in Fig. 1. The loading conditions mimic an ASTM test for joint bearing failure.

3. Results & Conclusions
Previously unpublished stress distributions at countersunk holes in laminates were studied in detail. A sophisticated 3D VUMAT damage model has been validated against experimental results (e.g. see ‘action plane’ failure of Fig. 3), and implemented successfully in the joint models (Fig. 4). Multi-bolt models and high-speed loading scenarios will now be investigated.

References
Mechanical Behaviour of Inter-linked Carbon Nanotube Ropes for Nanocomposites

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1. Introduction

During their production, individual single-wall carbon nanotubes (CNTs) agglomerate to form CNT ropes due to attractive van der Waals forces. Using modified processing techniques, CNT rope alignment can be achieved and the inclusion of these ropes in matrices could be used to toughen composites. Unfortunately, van der Waals forces between CNTs are too weak and there is easy relative sliding between CNTs, meaning that load transfer into the rope is limited. Inter-tube shear strength could be increased by introducing controlled levels of inter-tube bonding between CNTs using irradiation. However, irradiation also introduces defects; thus, the interplay between enhanced inter-tube shear and decreased tube tensile strength must be examined in order to identify what irradiation energy and dosage is optimal.

2. Materials and methods

Molecular dynamics (MD) simulations are used to model the process of energetic carbon atom impingement, as arises in pulsed laser deposition (PLD) processes, on to hexagonal 7 CNT bundles with no initial inter-tube bonding. The LAMMPS code is used with a new modified 2nd generation Brenner potential [1] that can accurately account for both bond breaking and reforming processes in carbon structures.

After C atom deposition, the resulting ropes are tested via MD to determine rope tensile strength and inter-tube shear strength via tensile and pullout tests respectively.

3. Results

Figure 1 illustrates shear/tensile strengths for pristine (non-irradiated) and irradiated cases.

4. Discussion

A substantial (three-fold) increase in shear strength with increasing irradiation dosage is seen, which is caused by inter-tube bonding between CNTs in the bundle (both direct cross-links and interstitial bridges). Irradiation also causes a decrease in tensile strength from ~90 GPa to ~45 GPa for the highest dosage (200 eV, 39.3 MGy). This decrease in strength is caused by intra-wall vacancies/defects formed during irradiation.

The overall effect of C atom deposition thus appears to be positive, with a greater increase in pullout force than accompanying decrease in tensile strength. The importance of carefully controlling the energy and dosage is clearly highlighted.

5. References

Film Thickness Measurements in Liquid-Liquid flows in a Mini-Channel Geometry

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Abstract

The aim of this work is provide a direct measurement of the thin film that exits within two phase flow regimes between the aqueous slug and the channel wall. The primary focus of this study was to investigate the effects of water slug length and viscosity changes on the film thickness. To the best of the authors’ knowledge there are no such works that directly measure the thickness of the liquid film that encapsulates the aqueous slug in liquid–liquid flows.

1.0 Introduction

Two phase flow systems are a very effective means of achieving high levels of heat and mass transfer, and are therefore employed in numerous engineering applications, which include pharmacology, cooling of high heat flux electronics, polymerase chain reaction (PCR) processes and a number of other bio-micro electromechanical systems (MEMS). To date, there exists a large body of numerical, computational and experimental studies in the literature pertaining to gas-liquid flows and to a lesser extent the behaviour of single liquid slugs suspended in a liquid carrier medium. Conversely, there is a dearth of knowledge relating to liquid-liquid flows. The addition of a second, immiscible fluid stream generates a mono-dispersed flow structure of aqueous phase slugs or droplets suspended in a carrier phase, figure 1.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Immiscible liquid-liquid flow structure consisting of slugs of water dispersed in a continuous organic phase carrier oil (Scale 1mm increments)}
\end{figure}

2.0 Methodology

Two distinct methods were used to generate the two phase flow regime in this study, namely, T-junctions and segmenters. Segmenters work by periodically creating and rupturing a liquid bridge between two opposing capillary tips. Whereas T-junctions rely upon the sheer force applied by the carrier phase on the water to generate the water slugs. The flow passed through a transparent circular capillary of 1.5875mm ID which allowed the film to measured non-invasively. The experiments were conducted for Reynolds number of 13.77 \(\leq Re \leq 103.65\), based on mean flow velocity and capillary diameter, for Capillary numbers of 0.00094 \(\leq Ca \leq 0.0113\) and for Weber numbers of 0.032 \(\leq We \leq 0.737\). Water slug length varied from 1.38mm – 12.88mm.

3.0 Results and Discussion

The results from this study are the first of their kind, as they give a direct measurement of the film thickness in a liquid-liquid flow regime. Images of the flow show that the film does not remain constant along the length of the water slug. A comparison was also made between the thicknesses of the film surrounding a single slug in the capillary with the multiple slug case. Data is also compared with that of the previous correlations within the literature. A correlation for liquid film thickness in liquid-liquid flows is proposed based on dimensionless quantities of Capillary number (Ca), Reynolds number (Re) and Weber number (We).
THE INFLUENCE OF SOLAR SHIELDING ON THE THERMAL BEHAVIOR OF OUTDOOR COMMUNICATION EQUIPMENT

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Abstract

This paper aims to assess the efficacy of solar shields for outdoor communications equipment which enhance cooling by inducing a chimney flow effect. A combination of analytical and numerical modelling of a representative outdoor communications device, with solar shielding and without solar shielding, was undertaken in order to examine the effect of solar shield length on chimney flow. A 19.9% increase in heat dissipation occurred when the length of the shield was extended to 3x the sink length. If an extended shield is deployed, the device should be located close to the base of the shield, in order to maximise the benefits of chimney flow.

1. Introduction

Remotely-deployed wireless devices such as tower-top antennas, remote radio heads, pico- and femto-cells are an increasingly prevalent feature of communications systems. For such devices, significant packaging challenges are evident: stringent reliability requirements; harsh environmental conditions; the imperative of passive cooling; strict constraints on weight (~15-20 kg) and volume, and strict Ingress Protection (IP) ratings. While many wireless devices are relatively low power, they are typically constrained in size and, as a consequence, the power density and surface heat flux can be considerable. Outdoor devices can require a high amount of heat (~100 W) to be dissipated, and can operate in harsh atmospheric conditions with ambient temperatures as high as 55°C and wind speeds as low as 0 m/s during peak solar loads (over 700 W/m2). Contemporary thermal solutions involve heat sink structures, optimised for passive cooling, within a secondary casing that serves as a solar shield.

Figure 1: Heat sink and solar shield

2. Method

Using equations for convective and radiative heat transfer from literature, an analytical model to estimate the temperature of the heat sink within the device under varying conditions was created. The analytical model used semi-empirical correlations to calculate convective heat transfer coefficients while determining the view factors for radiation. A numerical model using Computational Fluid Dynamics (CFD) was also created in Star-CCM+ to simulate the thermal conditions within the device. A constant temperature boundary condition of 80°C (25°C over ambient) was imposed on the baseplate of the heat sink, and the heat dissipation from the sink was recorded by evaluating the conductive heat transfer through a plane of cells within the baseplate. The device was modelled with and without a solar shield, and the influence of a range of parameters was investigated – solar load (irradiation and orientation), ambient temperature and shield geometry.

3. Results

In this paper, the following conclusions have been determined:

- For a constant temperature boundary condition of 80°C on the baseplate of the heat sink, the dissipation from the sink was a strong function of time of day, reaching a minimum at 13:30.
- Heat dissipation from the sink and shield configuration to ambient was higher than the unshielded case during the period from 14:00 to 17:30, with a maximum difference of 3.59% at 16:00. However, under worst-case conditions at 13:30, the heat dissipation from the shielded configuration was 3.6% lower than the unshielded case – a marginal difference.
- a 19.9% increase in heat dissipation occurred when the length of the shield was extended to 3x the sink length. If an extended shield is deployed, the device should be located close to the base of the shield, in order to maximise the benefits of chimney flow.
- Clearance between the surfaces of the shield and the sink has a minor influence on heat dissipation.

4. Acknowledgements

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Interfacial strain analysis of Si, SiGe Strained-Layer Superlattice Structure using Convergent Beam Electron Diffraction

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Abstract
Due to the mechanical thinning of Strained-Layer Superlattice (SLS) structure, two types of relaxation occur. One type of relaxation arises between adjacent layers of SLS and another between whole SLS and its substrate. In the present work by combining Low Angle Annular Dark Field (LAADF) imaging with Convergent Beam Electron Diffraction (CBED), the relaxation that appears between whole SLS and its substrate of Si, SiGe structure has been studied.

Introduction
Understanding the interfacial strain phenomenon of Strained-Layer Superlattices (SLS) and quantum well semiconductors at nanometer level is very important in designing advanced electronic devices. Due to the difference in lattice parameters of epitaxially grown materials, strain exists at adjacent layers of SLS and also between whole SLS and the substrate. The nature of the strain will be homogeneous when the SLS is in its bulk form. But as the complete structure is thinned down to electron transparency owing to elastic relaxation phenomenon, strain state will be altered. To quantitatively determine the local behavior of strain, Convergent Beam Electron Diffraction (CBED) is an excellent technique to study the layers of SLS with high spatial resolution.

Material & Methods
The specimen analyzed in this work is a TEM calibration sample known as MAG-I-CAL®. It is a <011> cross sectional SLS structure with alternating strained Silicon-Germanium (Si₀.₈₁Ge₀.₁₉) and Silicon (Si) layers grown epitaxially on Si substrate. CBED analysis was performed at a nominal voltage of 200kv in JEOL 2100 FEG TEM and all strain measurements were performed in [340] Zone Axis (ZA) which is 8° apart from [011] ZA.

As the conical electron beam is used to illuminate the specimen surface, CBED patterns consists of pairs of deficit and excess High Order Laue Zone (HOLZ) lines appear in its transmitted and diffracted disks. The positions of these lines are very sensitive to the changes in local lattice parameters and Transmission Electron Microscope (TEM) accelerating voltage. Hence for the quantitative study of strain nature, initially TEM accelerating voltage has been calculated with accuracy down to 0.05 kv by means of dynamical simulations using JEMS electron microscopy software. And for precise handling of electron beam on the specimen surface, CBED has been performed in Scanning Transmission Electron Microscope (STEM) mode.

Results & Discussion
When the electron beam sampled specimen surface away from SLS and substrate interface, sharp HOLZ lines have been obtained. This has been interpreted that there is no strain gradient along the electron beam direction. As the beam approached the interface, sharp HOLZ lines appeared to be in split HOLZ lines and Low Angle Annular Dark Field (LAADF) image taken in this region has shown contrast variation. This has been believed that at the interface, crystal lattice planes are bent and produces non-uniform strain along beam direction. With the help of kinematic simulation, from the width of the split HOLZ lines, lattice plane bending angle has been quantitatively determined and using Finite Element Modeling, work is ongoing to correlate strain variation in TEM specimen and bulk structure.

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Finite Element Simulation and Experimental Validation of Fretting Wear in Thin Steel Wires

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Abstract
Fretting wear is one of the main degradation mechanism produced in steel wire ropes. With the aim to reduce the cost and the time consuming related to the experimental characterization of this phenomenon, an optimized methodology for wear scars simulation in thin steel wires has been developed. This methodology has been implemented in a finite element (FE) adaptive mesh framework in ABAQUS. The wear behavior is implemented incrementally in each fretting cycle using Archard’s local wear model. Tribological tests for the friction and wear behavior characterization of thin steel wires have been performed. Good agreement is shown between experimental and numerical results.

1. Introduction
Steel wire ropes (Fig 1) are the main elements used in the lift industry due to their high axial strength and bending flexibility. Nevertheless when the ropes run over sheaves, an oscillatory motion between the wires is produced and as a result fretting wear is prone to occur \cite{1}. As a consequence, the stresses at the worm cross-section increase and the failure of the wire is produced.

![Figure 1. Wire rope used in electric elevators for people transporting.](image)

The experimental analysis of the parameters involved in fretting wear, require high number of tests, with high time consuming and the associated cost. For this reason and due to the complexity of the wire rope construction, a methodology for the simulation fretting wear in thin steel wires has been developed and validated.

2. Methodology
Fretting wear tests \cite{2}-\cite{3} were carried out in a range of average contact pressures that goes from 1827 MPa to 3560 MPa, two strokes 65 \mu m and 130 \mu m and different crossing angles that goes from 15\(^\circ\) to 90\(^\circ\). After each test the coefficient of friction \(f\) and the coefficient of wear \(k\) were calculated. 0.45 mm cold-drawn steel wires with tensile strength greater than 2800 MPa were used. A FE wear model for the simulation 3D crossing cylinder geometries is developed and validated. A user subroutine UMESHMOTION, based on the Archard’s local wear model proposed by McColl et al. \cite{4}, was used to incrementally simulate wear damage. An optimized wear simulation methodology, based on the effect of mesh size, simulation wear increments per fretting cycle and cycle jump \(\Delta N\) technique is implemented. A validation procedure, which consists of the comparison of the wear scar dimensions, maximum wear depth profile, and wear scar volume, is defined.

3. Results and conclusions
An optimized wear simulation methodology to reduce the computational time has been developed. An optimum mesh size between 3%-4% of the final longitudinal wear length for 90\(^\circ\) case and 5%-6% for crossing angles has been found. Optimum simulation parameters without any distortions in profile, which consist of 100 fretting FE cycles, 40 increments per cycle and the corresponding \(\Delta N\), have been defined.

![Figure 2. FE vs experimental wear scar for: a, b) 90\(^\circ\) crossing angles; c, d) 15\(^\circ\) crossing angle.](image)

4. References
\cite{1} Urchegui, M. A. et al. JMEP 17 (2007) 550-560.
\cite{2} Cruzado, A. et al., Wear 268 (2010) 1409-1416.
\cite{3} Cruzado, A. et al., Wear 273 (2011) 60-69.
Development of an Inexpensive Polymer Liner for CF/PEEK Cryogenic Fuel Tanks

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Abstract
Rotational moulding is examined as an inexpensive manufacturing process for the production of polymer liners to replace standard titanium liners in Composite Overwrapped Pressure Vessels (COPVs). The use of polymer materials is discussed and factors such as void content and permeability are characterised to determine prospective liner materials.

1. Introduction
The storage of cryogenic fuels for the operation of critical systems aboard space craft and satellites has been undertaken by COPVs utilising a thin titanium liner to stop leakage and a composite overwrap to contain the pressure. The high cost of the precision machined titanium liner has highlighted the need for the development of new materials which can reduce the price of the vessel while still providing high specific strength and a low level of permeability [1]. Polymer materials have been identified as a prospective liner material due to their resistance to chemical attack, low permeability and relatively low cost. This research aims to characterise rotational moulding as an alternative manufacturing process for COPV production.

2. Materials & Methods
The size of the hydrogen molecule at around 2E-10 metres means that it can permeate materials easily making hydrogen storage very difficult. Any material employed in hydrogen storage must have a low permeability rate to ensure leakage does not occur. With polymers, a leading cause of leakage is void content, so to utilise polymers in hydrogen storage the void content must be kept to a minimum [2].

Air voids form in polymers during processing as the powder melts and traps air bubbles in the component [3]. Tests have been conducted here to vary temperature cycle times to determine the optimum parameters for reducing void content in samples. Using environments similar to rotomoulding processes, polyethylene sheets were made at different cycle temperatures and hold times to reduce the void content in samples.

3. Results
![Mass Flow Rates at Different Values of X Along Element](image)

Figure 1. Predicted finite element distribution for mass flux rate of a circular air void in HDPE.

4. Discussion
As theory would suggest, the void content has an effect on the permeability of the polymer as shown by the finite element outputs in Figure 1. The temperature cycle variation resulted in a reduced void content as the trapped air had more time to diffuse out of the sample and remove the air bubbles.

Future work will aim to apply accurate control of cycle times and temperature histories to ensure the low permeability of polymer liners. Permeability predictions and the development of an optimised liner for low permeability applications will also be investigated.

5. Acknowledgements
The research is co-funded by the European Space Agency Network Partnering Initiative and by the IRCSET Enterprise Partnership Scheme (EPS).

6. References
Multiaxial Fatigue Damage Evolution in GFRP
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Abstract
A finite element methodology for multiaxial failure of GFRP composites is presented. The method is based on the Puck failure criteria and simple [1] models for fatigue damage of the on-axis plies.

Introduction
Glass-fibre reinforced polymers (GFRP) are candidate low cost materials for use in ocean energy structures. Fatigue performance of these materials while immersed is expected to be a key design selection variable. The first step described here relates to the testing and prediction of their behaviour in air.

Methodology
The Puck static failure methodology looks at the fibre bundle and assumes two failure modes. First is simple tensile fibre failure and second is the more complex inter fibre fracture (IFF) mode in which cracks occur in the matrix material between and parallel to the fibres.

Degradation of the shear and transverse moduli can be predicted using the stress exposure which is the ratio of the magnitude of the current stress vector to the magnitude it would have if extrapolated until it reaches the failure surface. The equations are non-linear both before and after IFF. The reduction in moduli of the off-axis plies transfers load to the on-axis plies. During fatigue cycling these on-axis plies sustain damage to both moduli and strength. The modulus degradation normally follows an s-shaped curve with high rate of degradation at the beginning and end of the fatigue life as shown in Figure 3.

Next Steps
Addition of residual strength degradation will enable fatigue failure prediction using this model.

References
The Role of Blood Vessel Geometry in Coronary Stent Computational Analyses

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Abstract

Coronary stents are small meshed tubular devices that are used to expand atherosclerotic arterial vessels restoring normal blood flow. However, a persistent clinical problem is in-stent restenosis (ISR), where an arterial vessel can become reblocked. Improved design and testing of coronary stents is needed to effectively deal with ISR.

1. Introduction

The paper outlines the importance of a thorough representation of the blood vessel in computational modelling of the stent implantation procedure. A population specific arterial test-bed is presented which analyses the effects of arterial curvature and stenosis severity on in silico stent implantation. The test-bed is capable of predicting tissue damage and the scaffolding ability of a stent design and represents a design tool for reducing risk of ISR. The paper provides recommendations on the specificity of the blood vessel for regulatory requirements, as it is proposed that the blood vessel description is too vague in its current form.

2. Materials & Methods

A geometrical test-bed comprising nine arterial models of varying curvature and stenosis level was developed. Two stent designs (A and B), representative of commercially available stents, were deployed in silico by inflating a tri-folded balloon using the finite element code Abaqus (v6.10).

The collagen fibre orientations within each arterial layer were accounted for using an anisotropic hyperelastic constitutive model1. A third order polynomial, isotropic constitutive law2 was adopted for the lesion, which was considered cellular. Standard material properties from literature were applied to the 316L stainless steel stents, nylon balloon and HDPE catheter.

3 Results & Discussion

Figure 1A illustrates the stages of deployment in the expansion of stent A. To assess the performance of both stent designs intimal layer damage estimates and stent scaffolding abilities were compared.

While both stent designs appear to have similar scaffolding abilities (see Figure 1C), they differ significantly in terms of intimal damage predicted (see Figure 1B). Stent A generates lower intimal stress in a 50% stenosed straight vessel whereas stent B generates lower intimal stress in a 60% stenosed straight vessel.

4. Conclusion

The results of the population specific test-bed have shown the importance of modelling different realistic arterial environments to assess stent performance. This test-bed shows that different stent designs may be suited to different stenosis levels, which is an important point for clinicians. Current FDA guidelines do not specify that a stenosis (or varying stenosis level) should be included in an analysis but demand certain levels of curvature be modelled. This research highlights the importance of modelling the stenosis and varying this level.

5. References


6. Acknowledgements

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Experimental and Computational investigation into the effect of Extracellular Mechanics on Bone Cell Differentiation

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Abstract
Biological cells are responsive to the surrounding mechanical environment they experience in the body, and this environment dictates cell behaviour within the body. The objective of this study is to investigate the effects of substrate stiffness and cell seeding density on the differentiation of MC3T3 cells (a pre-osteoblast model) into mature osteocytes using a combination of experimental and computational investigation.

1. Introduction
It is known that the extra-cellular mechanical environment plays a crucial role in regulating the growth and activity of many biological cells\(^1\). Osteocytes are cells that live within our bones, which are derived from bone’s building cells - osteoblasts. These cells have undergone major changes in structure and gene expression from osteoblasts, including the development of long extensions of the cell body, known as cell processes (or dendrites), to contact neighbouring cells.

However, it is not yet clear what mechanical environment regulates the change from an osteoblast to an osteocyte. The objective of this study is to use experimental and computational methods to understand how the mechanical environment triggers osteoblast cells to change their structure and gene expression to become osteocytes.

2. Methods
Osteoblast (MC3T3) cells were plated at \(10^3\) or \(10^4/cm^2\) on collagen based substrates of different stiffness but identical chemical composition. Cells were stained with phalloidin-TRITC (Sigma) to allow for morphological analysis. Colorimetric assays were used to quantify both ALP expression and substrate mineralisation, both strong indicators of bone cell development, on a subset of conditions at 1, 4, 9 and 14 days of culture. ALP activity increases as the cells become mature osteoblasts and decrease as they mature to osteocytes. Mineralisation increases as the cells become mature osteoblasts and again as they become osteocytes.

Substrate stiffness was measured using a silicon-nitride AFM probe (Windsor scientific). Substrate stiffness was related to tip deflection and piezo movement through an idealised Hertzian equation.

Finite element simulations of spread and dendritic cell morphologies were created using ABAQUS software (see figure 1). A thermal contractility load was applied to the cells to simulate intrinsic cell contraction on each of the investigated substrates. The internal strain generated in response to the resistance of each substrate was then calculated and compared across substrates and cell types.

3. Results
The substrates ranged in stiffness from 9 to 980 Pa. Morphological analysis showed that the highest percentage of dendritic cells was found on the softest two substrates when the cells were cultured at the lower seeding density of \(10^3/cm^2\), with 33% and 37% of cells being classed as dendritic after 14 days of culture. In contrast only 1% of cells were classed as dendritic on the stiffest substrate after 14 days of culture at the higher seeding density of \(10^4/cm^2\).

ALP activity showed a peak after 9 days of culture in cells cultured at \(10^3/cm^2\) on the two softest collagen based substrates. ALP activity continued to increase until 14 days of culture in all other conditions. Substrate mineralisation was shown to be highest in the cells cultured on the softest collagen substrate at \(10^3/cm^2\), further indicating differentiation of the cells along the osteogenic pathway.

FE simulations show marked differences in internal cell strain based on both substrates stiffness and cell morphology.

4. Discussion
Experimental results indicate that a combination of a soft collagen based extra cellular matrix and a high degree of intercellular separation encourages osteocyte differentiation. FE simulations show that the internal cell strain generated in response to substrate stiffness is greatly dependant on cell shape. We propose that the morphological change undergone by the cells on these is necessary in order to maintain the cells preferred level of internal strain.

5. References
Finite Element Modelling of Damage and Permeation in a Quasi-isotropic CF/PEEK Laminate
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Abstract
This work outlines a model for predicting tank wall permeability based on the presence of pre-existing microcracks in Carbon Fibre/PEEK (AS4/APC-2). A Finite Element (FE) model of a composite laminate has been used to characterise the delaminated crack opening displacement (DCOD) of pre-existing microcracks due to thermal loading. The output from this FE model is then used to calculate the laminate permeability in accordance with Darcy’s Law.

1. Introduction
The reduction of structural weight is a key issue for the next generation of space launch vehicles. Carbon fibre composites, with their high specific strength and stiffness, are an ideal candidate material to replace the aluminium alloys which have traditionally been used in the construction of the cryogenic fuel tanks. One of the challenges of using composite materials is their propensity to microcrack under the high thermo-mechanical loads experienced during spaceflight. Thus it is essential to accurately predict microcracking and the subsequent permeability of the fuel tank walls in order to ensure an adequate service life in this high risk/high cost industry. This work outlines a model for predicting tank wall permeability based on the presence of pre-existing microcracks in Carbon Fibre/PEEK.

2. Methods
Damage initiation for AS4/APC-2 was predicted using a FE shell model of a quasi-isotropic laminate (Fig 1) which was subjected to cryogenic loading. The resulting maximum stress in the transverse plies was then used to plot an S-N fatigue curve for the laminate based on material constants obtained from experimental work[1].

A 2D plain strain FE model of the laminate based on the work of Roy[2] was then used to determine the delaminated crack opening displacement of the transverse crack under a thermal load for a given delamination length and crack density.

The permeability of the laminate can then be calculated based on the overlap area created by the crack opening displacements in adjacent plies using the following equation[2].

$$B_o = C \left( \sum_{K=1}^{N} \left( \frac{\sin \theta}{N_{K}N_{K+1}\Delta_{K}\Delta_{K+1}} \right) \right)^{-1}$$

3. Results
Based on the fatigue curve for AS4/APC-2, damage initiation was predicted after just 9 cycles in the transverse plies of the laminate. Applying the same thermal load to the 2D FE model, a linear relationship was found to exist between the DCOD and the delamination length for a constant ply crack density, with the crack opening displacement increasing with increasing delamination length.

The permeability of the laminate was also predicted to increase with increasing delamination length, while an increase in crack density similarly affected the permeability as shown in Fig 2.

![Figure 2 Variation of permeability with delamination length and crack density.](image)

4. Acknowledgements
The research is co-funded by the European Space Agency Network Partnering Initiative and by the IRCSET Enterprise Partnership Scheme (EPS).

5. References
A Systematic Framework for the Commissioning of Medical Equipment in Healthcare

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Abstract

A critical phase in the quality assurance of medical equipment is the commissioning stage; ensuring that the specified equipment performs as intended, both as a standalone piece of equipment and within the healthcare delivery system. Building on techniques used in safety critical industries such as nuclear power generation, automobile and medical device manufacturing, this paper introduces a systematic framework for the commissioning of medical equipment to the domain of healthcare.

1. Background

The ‘To Err Is Human’ report by the Institute of Medicine (IOM) attributed adverse health care events with up to 98,000 deaths and 1.3 million injuries per year in the US [1]. Burroughs et al. in a survey of patients about their experiences of patient safety events while in hospital, found that 39% of patients reported that they had experienced at least one of seven listed concerns during their hospital stay, most commonly medication errors (17%), nursing mistakes (15%), problems with medical equipment (10%), misdiagnosis (10%) and mistakes by physicians (10%) [2]. The Department of Health in Ireland noted these reports and accepted that “Although there are no available statistics for Ireland in this context, it must be assumed that the rate of preventable error in Ireland matched those described,” in its report ‘Building a Culture of Patient Safety’ [3]. Furthermore, the Irish Medical Board stress that the way in which medical equipment is purchased, managed and used can have a significant impact on the quality of care that is delivered to patients [4].

It is clear, therefore, that there is an immediate need to address the management of medical equipment and reduce medical errors, this need has forced the health care domain to turn to other industries for proven techniques in systems development, human error analysis and safety management.

2. Equipment Qualification

Equipment Qualification (EQ) is a formal quality assurance process which establishes confidence that specified equipment and ancillary systems are suitable for their intended use and are capable of consistently operating within established limits and tolerances. The EQ process includes four stages of qualification: design qualification (DQ), installation qualification (IQ), operational qualification (OP) and performance qualification (PQ):

![Equipment Qualification Framework]

3. An Advanced EQ Framework

While Equipment Qualification is typically utilised for process output validation only, it potentially can serve a much wider range of needs. In light of the demonstrated need to reduce medical errors and cognisant of the current difficult economic climate, it is clear that an equipment qualification framework which can serve the resource and patient safety needs of healthcare providers is necessary. This research aims to provide such a framework, drawing on the programs, tools and techniques of systems engineering, human factors engineering, risk management, quality management, environmental management and Lean Six Sigma.

4. References

Characteristic of a leakage flow near hinges in a SJM Bileaflet Mechanical Heart Valve

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Abstract
Two scaled-up hinge models based on standard St. Jude Medical Bileaflet Mechanical Heart Valve, were designed, built and put into operation under physiological conditions to investigate flow-induced thrombosis. Using (2-D) Particle Image Velocimetry it was possible to study the hinge flow at spatial resolution of 50 μm. The velocity field was measured downstream of the hinges, above the hinge housing. Velocity data at the outlet of the hinge gap revealed higher velocities 6 m/s than reported in comparable investigations (1.5 – 3 m/s), conducted at lower spatial resolution.

1. Introduction
Available Mechanical Heart Valves (MHVs) prosthesis are associated with problems such as thrombosis, thromboembolism or haemolysis. It has been shown that non-physiological flow, which results in abnormally high shear stress, may lead to rupture of red blood cells as well as platelet activation [1].

One of the most widely used MHVs is the St. Jude Medical (SJM) Bileaflet Heart Valve. Experiments have suggested that during the leakage flow phase, hinges and housing regions are the most critical areas for thrombus formation [2]. Thus the aim of this study was to evaluate the flow near hinges during the leakage phase in a scaled-up model, based on a bileaflet valve under physiologic conditions using 2-component Particle Image Velocimetry (PIV).

2. Materials and Methods
The model was designed on the basis of a 27 mm SJM heart valve. Two hinges, scaled up by a factor of 11.6 in length, with equivalent hinge gap widths of 150 μm and 250 μm, were fabricated. All components were made of PMMA (Perspex®). The model was placed in a transparent tube and connected to a piston pump which drove steady reverse leakage flow through the closed heart valve. As a blood analogue fluid, water was used. To maintain complete dynamic similarity between the physiological valve and the scaled-up model, the Reynolds number $Re_D = U D/v$ was preserved, where $U$ is velocity, $D$ is valve diameter and $v$ is kinematic viscosity. To visualise and measure the flow field during leakage flow phase, Particle Image Velocimetry (PIV) was used. The velocity field was measured downstream of hinges for five different planes above housing base at heights of 86 μm, 172 μm, 258 μm, 344 μm, 430 μm. (All quantities are reported in physiological scale).

3. Results and discussion
The two scaled-up hinge models were designed, built and put into operation to investigate flow-induced thrombosis in mechanical heart valve. Combining the scaled-up model and PIV made it possible to study the hinge flow at unmatched spatial resolution of 50 μm. Measurements were collected in leakage flow conditions. Velocity data at the outlet of the hinge gap reveal velocities of 6 m/s, higher than reported in comparable investigations (1.5 – 3 m/s), conducted at lower spatial resolution [2],[3]. The results indicate that a larger gap width causes a higher value of velocity. That implies larger shear stresses on blood cells, suggesting higher levels of platelet damage than commonly estimated. To confirm accuracy of the results further research are required.

Figure 1. Velocity fields measured downstream of hinge during leakage flow phase. Top hinge gap width of 150 μm; bottom hinge gap width of 250 μm; illumination plane z = 172 μm

4. Acknowledgements
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5. References
The Role of Intracellular Forces in the Osteogenic Differentiation of Intramembranous Stem Cell Aggregates

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Abstract

Mechanical force is one of the most important factors affecting bone biology in the adult skeleton [1]. It has been observed that mechanical loading influences the differentiation of Mesenchymal stem cells (MSCs) [2] by causing the adhesion junctions (AJs) between aggregated cells to release signalling molecules which lead to the synthesis of osteogenic factors [3]. Thus mechanical forces at AJs may play a regulatory role in the osteogenesis of the stem cell niche. This study seeks to provide an improved understanding of the role of mechanical forces in intramembranous ossification to inform mechanobiology based approaches for bone tissue regeneration in vitro.

1. Introduction

Intramembranous ossification is a bone forming process that occurs during early craniofacial bone development, but is also responsible in part for bone healing and remodelling. This process is characterised by the excretion of a matrix by osteogenic stem cells upon which they adhere and form bone. Previous studies have shown the potential of stem cell based therapies for bone regeneration by identifying the biochemical and physical factors that encourage osteogenesis in vitro. However existing approaches are limited and clinical applications are few. Research has shown that regenerative therapies using stem cell aggregates yield better results than those using dissociated stem cells [5]. Understanding the mechanics within an aggregate could lead to more effective regenerative treatments. We propose that an in vitro approach that mimics the mechanics of intramembranous ossification could provide a viable clinical bone regeneration strategy.

The objective of this study is to understand the role of mechanical factors in regulating osteogenesis within the intramembranous stem cell niche. A combined experimental and computational approach will be used to study the MSC niche.

2. Materials and methods

2.1 Cell Culture:

An osteoblast cellular multi-layer culture was grown in vitro using a multilayer culture method adapted from Schneider et al. [4] incorporating media supplemented with ITS, Ascorbic acid, β-glycerine and calcium. Immunofluorescent staining (Figure 1 A) of adhesion junctions in monolayer culture using N-cadherin polyclonal primary antibody (1/100) and goat-anti-rabbit secondary antibody (1/100) was performed to quantify adhesion junctions on the interface of MC3T3 cell membranes at Day 7 and to optimise antibody concentrations. The locations and numbers of AJ proteins were monitored.

2.2 Micropipette Aspiration:

A micropipette aspiration technique was implemented to study the effects of cell-cell adhesion forces within the osteoblast multi-layer. Preliminary studies were performed in which an MC3T3 cell was held by a suction pressure in a micropipette and pulled from the surface of the monolayer culture (Figure 1 B). The pressure used was recorded and the resulting effect on intercellular protein movement with respect to the number of adhesion junctions involved will be quantified and compared.

2.3 Modelling:

Abaqus FEA software will be used to make a model of the multi-layered cells, their matrix and the cell-cell interactions as quantified in the in vitro experiments which will predict the role of intramembranous mechanics for regulating osteogenesis within the MSC niche.

3. Results and Expected results

Preliminary AJ quantification results have been obtained through antibody optimisation and micropipette aspiration of a monolayer. The suction pressure required to cause an osteogenic reaction in an MC3T3 cell will be quantified and the reaction of AJ associated proteins will be monitored. This data will be used to develop a 3D model predicting the role of intramembranous mechanics in osteogenesis. Matrix composition will be quantified and compared to adhesion forces found for each multilayer cell culture.

4. Discussion and Future work

Adhesion junctions provide an interface between applied mechanical force and intracellular biochemical reactions which lead to the stimulation of osteogenesis. The proposed experimental and FE models of MC3T3 cell AJs will provide an understanding of the role of intercellular mechanical forces in encouraging osteogenesis. This methodology can then be applied to MSCs and a model of MSC differentiation can be developed which predicts the role of intracellular mechanical forces in the development of osteogenic aggregates.

5. References


6. Acknowledgements

BMERM Structured PhD programme
Designing the Next Generation of Coronary Stents
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Abstract
A new generation of coronary stents that gradually dissolve in the body are currently under development. Bioabsorbable metallic stents are showing much promise in early clinical trials, however some challenges still need to be overcome in their development. In this study, computer simulation tools are applied in gaining a better understanding of the behaviour of these devices in the body and toward improving their design.

1. Introduction
Coronary stents are small metal scaffolds that provide mechanical support to the arteries of the heart following the angioplasty procedure. Over time the arteries gradually heal and a stent is no longer required, with the long-term presence of the stent actually increasing the risk of patient injury. As such, there is now much interest in the development of stents that gradually dissolve in the body.

Bioabsorbable metal stents have shown promise in early in-human clinical trials. However it was found that these devices were losing mechanical scaffolding ability too quickly to give the artery a chance to fully heal. Overcoming this shortcoming in current bioabsorbable stent technology requires an improved understanding of how the device is performing in the body and improved device design.

Computer simulation of coronary stenting procedures is an efficient and flexible method of evaluating candidate stent designs and reduces the dependence on costly experimental testing. The focus of this work is the development and application of computer simulation techniques specifically for the assessment of bioabsorbable metallic stent performance.

2. Methods
The performances of a range of bioabsorbable metal stent designs are assessed using finite element (FE) analysis in terms of their short-term and long-term scaffolding ability. In assessing short-term performance, simulated bench testing is used to compare the performance of candidate designs to that of conventional, permanent stents to allow the identification of designs with acceptable short-term scaffolding performance.

The long-term scaffolding ability of each design is then assessed through applying a previously developed FE corrosion model [1], which simulates the dissolving of the stent in the body. The long-term scaffolding performance of each design is then compared, allowing the identification of particular stent design characteristics which can lead to improved scaffolding duration.

3. Results
Fig. 1.(a) FE simulation of stent deployment in a stenosed vessel. (b) As the stent dissolves the vessel diameter reduces over time due to a reduction in effective strut dimensions, shown in (c).

It was found that bioabsorbable metallic stents required larger strut dimensions than permanent stents to achieve comparable short-term scaffolding performance. Higher strut dimensions were also found to improve the long-term scaffolding performance of the stent, with an upper limit on device dimensions governed by the limited mechanical properties of currently available bioabsorbable metals.

4. Conclusions
• Potential improvements in bioabsorbable stent design have been identified.
• The mechanical properties of currently available bioabsorbable alloys limit the range of feasible stent designs.

5. Acknowledgements
This work is funded through an IRCSET scholarship under the EMBARK initiative.

8. References
Contribution of Stress Fibre Remodelling to the Response of Cells during Micropipette Aspiration

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Abstract

Endothelial cells are aspirated into a pipette under a constant applied pressure. Aspiration length increases rapidly for ~20 s and then decreases reaching a steady state of ~40 μm after 150 s. Experiments are simulated using an active bio-chemo-mechanical model to investigate the role of the actin cytoskeleton in micropipette aspiration. Simulations accurately predict aspiration length and stress fibre formation.

1. Introduction

Remodelling of the active cytoskeleton plays a critical role in the response of cells to mechanical stimuli. Furthermore, the mechanical environment plays an important role in cell differentiation [1]. Previous studies have investigated micropipette aspiration using only passive viscoelastic models for the cell cytoplasm [2-4], which offer limited insight into the key biochemical processes. This study investigates deformation during micropipette aspiration of spread cells using an active formulation for cytoskeletal remodelling in response to external loading [5].

2. Materials and Methods

Experimental: A pressure control system generates aspiration pressure, ΔP, by applying a known pressure head, Δh, in a u-tube manometer. This vacuum pressure is transferred to the micropipette tip through a 3-way stopcock. An inverted microscope is fitted with a protected silver mirror aligned at 45° to enable visualisation of cell micropipette aspiration. HUVEC cells are seeded onto glass slides for 3 hrs. Cells are aspirated with micropipettes of internal diameter (D_a) of 16 μm at a pressure of 100 mmH2O for 200 seconds.

Computational: Signal induced formation and tension dependent dissociation of the actin cytoskeleton is captured using a first order kinetic equation:

\[ \dot{\eta} = \left(1 - \eta \right) \frac{C k_f}{\theta} - \left(1 - \frac{\sigma}{\sigma_o} \right) \frac{\eta k_p}{\theta} \]

where \( \eta \) is the dimensionless activation level of a fibre bundle and \( C \) is an exponentially decaying signal.

The contractile response of the bundles is modelled using the following Hill-like equation:

\[ \frac{\sigma}{\sigma_o} = 1 + \frac{k_p}{\eta} \frac{\dot{\varepsilon}}{\varepsilon_o}; \quad \frac{1}{k_p} \leq \frac{\dot{\varepsilon}}{\varepsilon_o} \leq 0 \]

This constitutive formulation is incorporated into the commercial finite element software Abaqus.

3. Results

Following application of a step aspiration pressure (ΔP), the aspiration length (L_a) increases rapidly for ~20 seconds (Figure 1A). Aspiration rate then decreases, reaching a steady state aspiration length of ~40 μm after approximately 150 seconds. The active computational framework predicts a similar response to that observed experimentally.

Figure 1B shows a cell geometry before and after aspiration. Finite element analyses predict a high level of stress fibre alignment at the base of the cell both before and after aspiration. An increased alignment above the nucleus is present following aspiration.

4. Discussion

The active computational model provides an accurate prediction of cell aspiration length as a function of time. Simulations also predict an increase in fibre alignment and significant nucleus deformation.

Future work will entail imaging of actin cytoskeleton and the nucleus post aspiration in order to validate computational predictions. Additionally, the influence of cell geometry and stress fibre distribution on cell aspiration will be investigated.

5. References


6. Acknowledgments
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Experimental and Numerical Characterisation of Fretting Fatigue Damage
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Abstract
An experimental fretting fatigue bridge-type arrangement has been developed to validate a novel microstructural-sensitive crack initiation model for fretting fatigue.

1. Introduction
Fretting is a phenomenon that occurs when two materials in contact under a normal load are subjected to cyclic tangential displacements typically in the range of 5 to 100 μm. This leads to severe stress gradients and surface damage (fatigue and wear) at size scales competitive with material microstructure. It is a detrimental and premature mode of failure in many industrial applications, including the offshore oil and gas industry, biomedical applications and aeroengine transmissions.

2. Methodology
A bridge-type fretting fatigue rig has been developed to study the effects of stress amplitude and normal load on part life, see Figure 1. Comparisons against plain fatigue samples show the detrimental effect of fretting damage and premature crack initiation.

A crystal plasticity finite element (FE) cylinder-on-flat contact geometry is validated against the experimental fretting rig for part life predictions. The crystal plasticity formulation uses representative grain size and microstructure. Figure 2 shows an image of etched 316L SS microstructure highlighting a typical grain size, 19 μm.

3. Conclusions
A distinct difference in part life exists between plain and fretting fatigue specimen. The detrimental effect of normal load is also observed experimentally in fretting fatigue tests. A microstructure-sensitive fretting crack nucleation prediction methodology is developed with the ability to predict crack nucleation sites as observed experimentally.

4. References
Modelling of Advanced Materials for Next Generation Power Plant Operating Under Increased Flexibility Loading

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Abstract

A multi-axial unified viscoplastic material model has been developed to accurately model the behaviour of advanced steels under high temperature cyclic loading. The material model accounts for rate-dependent effects associated with high temperature creep and cyclic phenomena such as isotropic and kinematic hardening, under isothermal and anisothermal loadings. The model is implemented in a material user subroutine and validation is achieved by comparison with test data.

1. Introduction

To achieve an increase in overall plant efficiency and a reduction in CO\textsubscript{2} emissions, Irish power generation will move to ultra-supercritical (USC) operation. This form of power generation requires increased steam pressure and temperature. Coupled with this increased steam loading is the need for next generation plant to facilitate renewable energy technologies. The unpredictable nature of renewable energy requires significantly more flexible operation of fossil fuel based plant (load-following mode). This increased flexibility will result in significant cyclic thermal gradients, leading to thermo-mechanical fatigue (TMF) of plant components.

The current generation of materials (e.g. 9Cr1Mo steel) are susceptible to Type IV cracking in the heat affected zone (HAZ) of welded connections under subcritical conditions. Hence, the need exists for identification and characterisation of more advanced materials (e.g. 9Cr2Mo steels) capable of dealing with current and future complex loading conditions. Accurate next generation plant life prediction, under realistic loading histories, including real-time monitoring, requires effective and efficient computational material models\textsuperscript{[1]} for life prediction.

2. Methodology

The methodology used in this research is to develop a constitutive model capable of predicting the effects observed in candidate materials, such as 9Cr steels. The model employs a sinh unified viscoplastic formulation to model the creep-fatigue interaction. The equation defining effective plastic strain rate is:

\[ \dot{\varepsilon} = \alpha \sinh \beta (\sigma_e - R - k) \]

where \( \alpha \) and \( \beta \) are creep related material constants, \( \sigma_e \) is the effective stress, \( R \) is the isotropic hardening parameter and \( k \) is the initial yield stress. The sinh formulation has specific advantages with respect to (i) the deformation mechanisms for TMF, (ii) more flexible thermo-mechanical cycling of plant and (iii) reliable extrapolation from limited test data.

3. Results

Uniaxial validation of the constitutive model is achieved via comparison with published experimental data from isothermal and anisothermal TMF tests\textsuperscript{[2]}. Figure 1 shows an example of the excellent correlation achieved in terms of isothermal, cyclic stress-strain response for P91 steel at a temperature of 400 °C.

4. Conclusion

A material model for life prediction of advanced high temperature alloys for next generation (increased efficiency, reduced emission) and flexible power generation is presented. The model is validated against uniaxial thermo-mechanical fatigue test data.

5. References

Can we enhance entrepreneurial self-efficacy (ESE) in potential entrepreneurs through entrepreneurial education?

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Abstract
Entrepreneurship is an important wave. For example, Gartner (2008) writes “entrepreneurship is a phenomenon, not a theory”. Sarasvathy and Venkataraman (2010) echo this viewpoint while suggesting that the “method” of entrepreneurship should be taught to everyone (potential entrepreneurs) so that all can surf this entrepreneurial wave. It is increasingly clear that society needs a steady flow of competent and motivated potential entrepreneurs. Indeed, educating the next wave of entrepreneurs is of major importance for governments and policy-makers worldwide.

Entrepreneurial intention is a motivational construct important for potential entrepreneurs in the enterprise creation decision since intention precedes action. Moreover, entrepreneurial self-efficacy (ESE) is a key antecedent to entrepreneurial intention. ESE, or self-confidence in the task and domain of entrepreneurship, has received much attention in the literature and is based on a persons perception of their entrepreneurial competence. Wilson et al. (2007) explain ESE as a task and domain specific construct that measures an individuals belief in their capacity to create an enterprise. While McGee et al. (2009) suggest ESE may be enhanced through entrepreneurial education.

Much research has been done on ESE, yet it is a vague construct with many antecedents that is hard to accurately measure. Where ESE is measured, self-report scales are typically used and such instruments involve obvious limitations. Other problems and gaps exist. For example, what is the link between ESE and entrepreneurial education? Indeed, what are entrepreneurial competences? Other questions include: What is entrepreneurial education and where does it happen? Who are the learners? Who teaches it and what is taught? Is entrepreneurial education effective in raising ESE in learners? The entrepreneurial education agenda is alive and well so these questions are important for researchers, policy-makers and governments alike particularly when gurus like Birch strongly suggests that you cannot teach people to be entrepreneurs even if you really wanted to (Aronsson, 2004).

However, first we know from Kuratko (2005) that an entrepreneurial mindset can be developed in people. Indeed, Kuratko tells us the debate has switched from can it be taught to “what should be taught and how should it be taught?”. Second, we are reminded by Fiet (2000) that there is indeed a theoretical side to teaching entrepreneurship while there is also very much a pedagogical side to entrepreneurship theory. Third, Wilson et al. (2007) suggest the main issue becomes the effectiveness of entrepreneurial education interventions in raising ESE and strongly argue for “incorporating entrepreneurial self-efficacy into the pre- and post measurement” of such interventions.

The race is on to educate the next wave of entrepreneurs as evidenced by the many related publications from the EU (2009), OECD (2010), and WEF (2009). Further, many national governments place significant importance on enhancing entrepreneurial competence in their people at all levels of education. In this regard, some have comprehensive national policies and strategies already in place. This research is situated in an Irish context and seeks to use the lens of adult education to investigate and address the research problems and gaps identified above. More specifically, this research is concerned with the question: can we enhance ESE in potential entrepreneurs through entrepreneurial education? This research is particularly important since Ireland Inc. does not, as yet, have an entrepreneurship policy or an entrepreneurial education strategy. Both are potentially important vehicles in reaching the crest of the entrepreneurship wave and this research seeks to provide answers that inform this journey.

The following methodology with five distinct phases is proposed for this research: 1) Foundation: this phase will incorporate definition of the theoretical domain from the literature, focussing the research, defining the broad problem definition and determining the specific scope of the study. 2) Induction: this phase will encompass preliminary data gathering to develop and shape initial hypothesis and also extracting confirmation of hypothesis from the literature. 3) Iteration: this phase will involve collecting data, extending hypotheses, developing conjectures and refining the overall work. 4) Presentation: this phase will encompass developing, introducing, presenting and explaining the research findings and associated framework. 5) Verification: this phase will involve evaluating and verifying the framework developed and suggesting directions for future research.

References
Computational and Experimental Analysis of Osteocyte Mechanobiology
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Abstract
Bone is an adaptive material, which is particularly responsive to mechanical loading and can adapt its mass and structure to meet the mechanical demands experienced throughout life. The osteocyte acts as the main sensor of mechanical stimulus in bone, controlling signalling for bone growth and resorption in response to changes in physiological loading. However the precise mechanical stimuli that osteocytes experience in vivo are not fully understood. The objective of this research is the development of computational and experimental studies to investigate the in vivo mechanical environment.

1. Introduction
The osteocyte is believed to act as the main sensor of mechanical stimulus in bone, controlling signalling for bone growth and resorption in response to changes in the mechanical demands placed on our bones throughout life. As osteocytes are embedded in a mineralised matrix direct experimental studies are unfeasible. High resolution imaging of bone cells under mechanical loading is limited to 2D imaging of cells on an exposed optical microscopy plane [1]. Recent theoretical and computational models of osteocytes have shown that the pericellular matrix and extracellular matrix projections amplify strain at the cellular membrane [2]. However these studies employed idealised geometries, which do not accurately represent osteocytes in vivo. The objective of this research is to use computational methods to predict the physiological loading on osteocytes. We employ confocal microscopy to develop 3D finite element models of osteocytes and investigate the role of the pericellular matrix (PCM) and extracellular matrix (ECM) projections as strain amplifiers for osteocytes. Additionally we design a customised loading rig for confocal microscopy to provide a unique insight into the mechanical environment of osteocytes in situ.

2. Materials and Methods
Computational Model: Transverse sections of rat tibia were fixed in formalin and stained with fluorescein isothiocyanate (FITC) solution to visualise the peri-cellular space [3]. Confocal scans (Zeiss LSM 51 confocal microscope) were taken with a 40x oil immersion lens and wavelength excitation of 488 nm, see Figure 1a. Four finite element models of individual osteocytes and their surrounding extracellular and pericellular matrices were generated from confocal images using MIMICS voxel-meshing software. The osteocyte cell membrane (E=4.47kPa, ν=0.3), the surrounding PCM (E=40kPa, ν=0.4) and the ECM (E=16GPa, ν=0.37) were modeled as linear elastic materials using ABAQUS finite element software. Physiological compression levels of 500, 1,500, and 3,000 με were applied to the ECM surrounding the cell. An idealised geometry of an osteocyte was also generated for comparison. ECM projections into osteocyte canaluli were included to investigate their strain amplification role [4].

Experimental Validation: To validate our computational models we carry out experimental analyses of microscopic bone specimens. Long bone sections (10 mm length, 0.5 mm thickness) are cut from the medial section and stained with FITC. These are placed in a custom loading device positioned approximately 10,000 με above 3,500 με throughout 7-28% of their volume, whereas in the idealised model these strains were only observed in 2% (Figure 2). Models without a PCM saw these high strains predicted in 3-18% of realistic and <1% of idealised osteocyte volumes. ECM projections in idealised models were found to amplify maximum strains by 70-200% of the applied strain. Furthermore cellular strains above 10,000 με were predicted in 1% of the realistic cell volumes.

3. Results
Computational analysis shows that all realistic osteocytes experienced strains greater than 3,500 με throughout 7-28% of their volume, whereas in the idealised model these strains were only observed in 2% (Figure 2). Models without a PCM saw these high strains predicted in 3-18% of realistic and <1% of idealised osteocyte volumes. ECM projections in idealised models were found to amplify maximum strains by 70-200% of the applied strain. Furthermore cellular strains above 10,000 με were predicted in 1% of the realistic cell volumes.

4. Discussion
This study provides direct evidence that (1) anatomically accurate models of osteocyte predict greater strain amplification experienced by osteocytes compared to an idealised cell, (2) the PCM increases the cell volume stimulated above 3,500 με by 4-10% and (3) ECM projections amplify strains to the cell by approximately 70-200%. Cell culture studies have shown that osteocytes require strains at approximately 10,000 με to elicit a biochemical response. Interestingly these strains were observed in the cell, which are significantly greater than surface strains of 2,000-3,000 με reported for whole bones. Most interestingly the realistic geometries and the PCM were both shown to increase strain transfer to the cell, suggesting that anatomically accurate models provide a clearer understanding of the osteocyte mechanical environment. Our findings support the theory that PCM and ECM constituents play important roles in bone.

Ongoing experimental validation of these computational models will significantly advance understanding of bone mechanobiology by enabling prediction of the physiological loading conditions experienced by osteocytes in vivo.

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Thermomechanical life prediction for P91 power plant headers

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Abstract

A time-dependent, elastic-plastic-creep, thermomechanical methodology has been developed to characterize and predict the life of P91 power plant header subjected to realistic loading histories.

1. Introduction

9-12%Cr ferritic steels are commonly used in fossil fuel power plant headers. The P91 alloy (9Cr-1Mo) is the focus of this investigation. This is primarily due to its high creep resistance at high temperatures. Increasing operational steam pressures and temperatures will improve plant efficiency. Therefore to achieve more efficient plant there is a need to understand the performance of candidate materials at higher temperatures and pressures [1].

2. Material model

An anisothermal cyclic viscoplasticity material model has been implemented for P91 material. Sample isothermal results are shown in Figure 1. The material parameter identification is based on published material data from [2-4]. This material model encompasses cyclic isotropic softening effects, non-linear kinematic hardening effects, strain rate effects, as shown in Figure 1a and 1b.

3. Methodology

A methodology was developed to incorporate the cyclic viscoplasticity model into a thermo-mechanical analysis of a P91 header, as depicted in Figure 2.

A method of predicting fatigue life of the header based on the stress-strain response at selected regions was also developed. A critical plane method was used which to convert on all 3D candidate planes at a given point to identify normal stresses and strains, shown in Figure 3.

4. Results and Conclusion

A transient thermo-mechanical analysis methodology has been implemented for a P91 power plant header, incorporating a transient thermal model and a multiaxial viscoplasticity model. Figure 4 (inset) shows typical predicted thermomechanical loops for power plant pipes. Large stress ranges > 300 MPa with tensile mean stresses of 180 MPa were predicted. Figure 5 shows a von Mises stress contour plot from the global and submodel showing stress hot-spots.

5. References

A multiaxial damage mechanics methodology for fretting-fatigue prediction

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Abstract

The three-dimensional finite element implementation of a continuum damage mechanics formulation for multiaxial fatigue is presented, incorporating elastic modulus reduction due to fatigue damage. The implementation is validated against theoretical and published experimental results for uniaxial and notched multiaxial fatigue under different combinations of mean and alternating stresses for Ti-6Al-4V. A new automatic implementation is developed for efficient computation of damage accumulation and hence stress re-distribution. The method is for fretting fatigue and successfully captures the effect of contact slip on fatigue life. The work is a first step towards a more general fatigue damage approach to unify wear and fatigue prediction for fretting.

1. Introduction

Fretting occurs when two contacting bodies experience small amplitude oscillatory motion. The resulting fretting-fatigue damage significantly reduces the fatigue life of the components, where the ‘notch effect’ can be brought in by the fretting contact. Fretting is normally associated with wear and fatigue crack nucleation. Wear can be considered as a microstructural fatigue mechanism involving material degradation and plastic ratchetting [1]). The latter incorporates microplasticity and void growth. Thus to predict this internal damage, a fatigue damage model which is identified from the SN curves is developed here. The non-linear-continuous-damage (NLCD) model [2] is adopted.

2. Methodology

Based on remaining life and continuum damage concepts, Chaboche and co-workers [2] proposed a NLCD model. Here the 3D version of it has been used to calculate damage evolution for both plain and fretting fatigue, presented as:

$$\dot{D} = \frac{dD}{dN} = \left[1 - (1 - D)^{p_2}\right] \left[\frac{A_g}{M_s(1 - 3b_2\sigma_{\text{max}})(1 - D)}\right]^{q_2}$$

Two fatigue specimens are modelled in FE for the plain fatigue tests, a notched case and an unnotched case, using the general purpose, non-linear, 3D FE code Abaqus. For fretting fatigue, the 2D plane strain assumption is adopted. User material subroutines (UMATs in Abaqus) are used to define non-standard material constitutive behaviour. For the implementation of the coupled continuum damage theory here, it is necessary to employ a UMAT subroutine where the damage is computed at each integration point, throughout the loading history, for each time increment and accumulated continuously. The material studied throughout is Ti-6Al-4V, with a Young's modulus of 116 GPa and Poisson's ratio of 0.34.

3. Results

The evolution of damage distribution is simulated for both plain and fretting fatigue cases. Fig. 1 shows the comparison of FE predicted and experimental fretting fatigue life as a function of slip amplitude. Good agreement is achieved. Fatigue life predictions are validated against published data [3][4][5].

![Figure 1. Hertzian fretting fatigue configuration and comparison of FE predicted and experimental fretting fatigue life as a function of slip amplitude.](image)

4. Hip implant modelling

Based on the identified contact pressure distributions from a 3D FE model of the stem neck-femoral head contact in a prosthetic hip implant, representative tests have been carried out to investigate the tribological behaviour of the materials (CoCr, forged Ti64 and DMLS Ti64) under realistic loading conditions. Using a customised pin, the tribometer tests furnish evolution of coefficient of friction (COF) with tangential displacement cycles, under a fixed normal load, as well as a wear coefficient. 2D axisymmetric modelling of the head-neck contact is employed to predict wear-fatigue interaction for the hip implant.

5. Conclusions

A finite element based method coupled with a nonlinear continuum damage model has been developed and validated for uniaxial and multiaxial plain fatigue, unnotched and notched conditions. The method has also been applied to a fretting fatigue round on flat case for Ti-6Al-4V with comparisons against published data for the effect of slip on life. Tribological tests have been carried out to measure the COF and wear coefficient on the hip implant candidate materials. Stress analyses are done for the head-neck contact in a hip implant.

6. References

10.1 Characterization of Single-crystal Silicon and Vertically Aligned Silicon Nanowire Anodes for Lithium-ion Batteries

10.2 Structural and Electrochemical Characterization of Indium Tin Oxide Nanostructured Transparent Li-ion Battery Anodes Grown by Molecular Beam Epitaxy

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10.29 Methods for Evaluating Sustainability Policies in Small Irish Settlements

10.30 Has the Use of Biocides in Dairy Farming Contributed to the Development and Spread of Antibiotic Resistance in Microorganisms?
Characterization of Single-crystal Silicon and Vertically Aligned Silicon Nanowire Anodes for Lithium-ion Batteries

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Abstract

The increase in energy density and power density requirements for lithium-ion batteries has led to a search for high capacity electrode materials. Silicon has re-emerged with significant interest for use as an anode in lithium ion batteries. This is partly due to the ubiquity of silicon and the fact that it has the highest known theoretical specific capacity (4,200 mAh g\textsuperscript{-1}). Upon Li\textsuperscript{+} insertion however, silicon can undergo volume changes \textgreater400% resulting in the pulverization of the material. Si nanowires (NWs) can expand and contract with three degrees of freedom, significantly reducing the strain caused during charging. The NWs are fabricated by metal-assisted chemical (MAC) etching of the silicon wafer. Here, we detail the fabrication and characterization of Si NW electrodes for lithium ion batteries. The NW electrodes are used as a lithium battery anode in a half-cell configuration. The electrodes are examined by a range of electrochemical tests.

1. Introduction

Current Li-ion batteries contain carbon anodes which have a specific capacity of \textasciitilde372 mAh g\textsuperscript{-1}. This value cannot meet the needs of current portable electronic devices. Silicon however has a capacity of \textasciitilde4,200 mAh g\textsuperscript{-1}[1] and is being investigated as a possible replacement for these carbon anodes. It has been shown that Si expands by \textasciitilde400% upon Li\textsuperscript{+} insertion [2] and this has led to cracking of the Si. This cracking has prevented the commercialization of Si anodes. Si NWs are shown to circumvent these issues and are being investigated as a viable option.

2. Experimental

Silicon (100) wafers were used as the standard silicon substrate in a MAC etching process. The substrates were immersed for two hours in a heated solution of 10 % HF containing 0.04 M AgNO\textsubscript{3} and were maintained at 50 °C using a water bath.

The Si NWs were then investigated by various microscopic and spectroscopic techniques including: SEM, TEM, XRD, XPS, and EDX. The anodes were then electrochemically tested in a two electrode coin cell using 1:1 volume mixture of dimethyl carbonate and ethylene carbonate with LiPF\textsubscript{6} salts as the electrolyte and an Indium-Gallium eutectic as the electrical contact to the Si.

3. Results and Discussion

From SEM images (Fig. 1) it was calculated that the Si NWs have a height of \textasciitilde120 \textmu m and have a mean diameter of 91.8 nm. TEM images (Fig. 2) show us that the NWs are single crystal, have a rough outer surface with a solid core and retain the (100) orientation of the original Si wafer. XRD of the Si before and after the etching process shows that the crystal structure of the Si did not change.

Cyclic voltammograms (Fig 3) of the n-type and p-type bulk Si show the insertion and removal potentials of Li into Si and from these we can identify Li\textsubscript{x}Si\textsubscript{y} phases formed at varying potentials.

4. Summary and Future Work

Single crystal Si NWs were formed from a MAC etching process. They were shown to have a rough outer surface with a solid core. CVs of bulk Si appear to show the Li\textsubscript{12}Si\textsubscript{7} alloy. Future work will include a direct comparison of p-type and n-type Si NWs with their bulk counterparts and each other in a range of electrochemical tests including constant current charging and discharging at varying charging rates.

5. References

Structural and Electrochemical Characterization of Indium Tin Oxide Nanostructured Transparent Li-ion Battery Anodes Grown By Molecular Beam Epitaxy

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Abstract
Indium tin oxide (ITO) is a well-established material for optoelectronic devices such as solar cells and thin film displays. It also has a theoretical reversible charge capacity of 883 mAh g\(^{-1}\), making it ideal as a transparent Li-ion battery anode. Tin oxide is also regarded as a promising material for high performance battery anodes due to its high charge capacity and power density. Here, we present detailed structural and electrochemical investigations of defect-free indium-tin oxide and tin oxide nanostructures grown by molecular beam epitaxy.

1. Introduction
Increasing demand for customer portable electronic devices is the main motive behind the extensive research into lithium-ion batteries. We investigate structural and electrochemical properties of Indium Tin Oxide (ITO) nanostructures, that in the future could be used as a material for transparent batteries [1].

2. Experimental
Samples were prepared by molecular beam epitaxy on silicon substrate. Characterization involved SEM with energy- and wavelength-dispersive X-ray analysis to investigate morphology and composition. Electron back-scattered and \( \mathbf{k} \)-space diffraction coupled with high resolution electron microscopies were used to analyse crystal configuration and quality of each type of nanostructure grown.

3. Results and Discussion
By varying the oxygen partial pressure, deposition rate and growth temperature, distinctively different types of nanostructures, from self-seeded nanowires to core-shell nanowires and nanoparticles (Figures 1 and 2) were successfully grown, without requiring autocatalytic growth from an intermediate phase nor a heterogeneous metal seed for VLS-type growth. The electrochemical lithium insertion and removal characteristics correlate with specific nanostructures and the effect and dependence of charging and discharging on their nanostructure.

4. Future Work
Ongoing work will determine the dependence of the nanostructure composition on the electrochemical performance of this transparent Li-ion battery anode by examining basic lithiation and de-lithiation characteristics.

5. References
Precursor Influence on the Structure of 3-Dimensionally Ordered Tin Oxide Materials for Photonic Crystal Lithium-ion Batteries

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Abstract

Three-dimensionally ordered materials (3DOM) made up of SnO\textsubscript{2} for the use as lithium ion anodes were synthesized using different metal organic and metal salt precursors as the Sn source. Calcination in air at temperatures up to 600°C of a self-assembled arrangement of closely packed uniformly sized polymethylmethacrylate or polystyrene spheres leads to thermal decomposition of the polymer spheres and the oxidation of the precursors forming a regular inverted opal porous network of SnO\textsubscript{2}. The structures were characterized and analyzed using SEM, TEM, XRD and XPS. Different precursors and process conditions lead to distinguishable morphologies, namely 3DOM structures exhibiting mesoporous or dense walls of varying geometry.

1. Introduction

Lithium batteries find widespread use in today’s applications like mobile devices and power tools. Desired uses are power battery vehicles or storage solutions for “green” energy from solar cells. For new portable, electronics and especially to improve electric vehicles, long-life, ultrafast charging and lightweight Li-ion batteries that reduce charging times to minutes, with high, stable capacities are a necessity\textsuperscript{1}. Those future applications demand high energy density and fast charging\textsuperscript{2}, which state of the art carbon electrode Lithium batteries fail to provide. Sn oxide electrode materials for Lithium batteries are potentially able to meet this demand\textsuperscript{3}.

2. Experimental

Closely packed uniformly sized polymer spheres were infiltrated with different Sn-precursors, being metal organic, metal salt and metal alkoxide solutions, dried and calcined in air at temperatures up to 600°C (Figure 1). Characterization of the structures was performed by optical microscopy in order to investigate photonic effects, high-resolution SEM for structure and morphology, high-resolution TEM to determine crystalline features, and XRD and XPS to characterize the composition, crystal types and oxidation states.

3. Results and Discussion

From various different Sn precursors and synthesis methods we successfully obtained a range of inverted opal photonic crystal structures that exhibit different nanoscale crystal sizes and unique, characteristic 3D morphologies. The processing and synthesis understanding gained through this research can be used to specifically tailor SnO\textsubscript{2} battery materials. The difference in processing and precursor choice additionally influences filling factors as well as the respective crystallite sizes. Figure 1 summarizes the processing steps for highly ordered crystalline 3DOM structures.

7. Summary and Future Work

Future work will be focused on the application of these new 3DOM Sn oxides in rechargeable battery cells and the influence of order and geometry on performance will be evaluated. Long term charge-discharge cycling behavior with high discharging and charging rates will be investigated and optimized. The method and allows for cost effective and environmentally friendly processing, for use in fast charging, low weight Li-ion batteries or gas sensors.

8. References

Stochastic Simulation of Electromigration

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Abstract
This work seeks to develop a model of electromigration that exhibits on-off intermittency and criticality. Work done to date exhibits characteristics observed in experiment, such as an on-off intermittent phase and a large-scale phase. The project seeks to validate the model against experiment, investigate it analytically, and determine its applicability to other critical systems.

1. Introduction
Electromigration (EM) is the mass transport of atoms due to momentum transfer with bombarding electrons. The EM process occurs in high power devices that transport large current densities. The dynamics of EM may be studied by measurement of the abrupt resistance changes (ARCs) that occur in devices undergoing EM. Research in UL on the time and statistical behavior of abrupt resistance changes demonstrated that EM exhibits on-off intermittency (OOI) [1] which is an aperiodic switching between extended laminar, low amplitude behaviour, and bursts of high amplitude behavior [2]. Toniolo et al. [3] distinguishes OOI from other types of intermittency through a power law distribution of amplitudes with exponent $\alpha = \frac{-1}{2}$, a $f^{-\frac{1}{2}}$ power spectrum and a distribution of laminar phases with exponent $\alpha = -1.5$. Dalton et al. demonstrated the thermodynamic criticality of ARC fluctuations using a finite size scaling analysis. The intermittent resistance fluctuations were also shown to be scale invariant.

2. The Model
A well-established model of EM by Korhonen [4] was used to develop the following novel model:

$$S_{x,t+1} = \kappa \nabla^2 S_{x,t} + \alpha Y S_{x,t}(1 - S_{x,t}),$$

where $x \in \{1, ..., N_{\text{maps}}\}$, $S_{x,t}$ is a dimensionless variable which models how the concentration of vacancies varies about the zero-stress concentration at time $t$ and position $x$. The material parameter $\kappa$ plays the role of a diffusion coefficient, $\alpha$ is a measure of the electrical driving applied to the system and $Y$ is a uniformly distributed random variable. The laplacian term spatially couples together neighbouring maps. Neglecting the spatial coupling the map has the form of a driven logistic map (DLM). This gives the model a spatial extent which is necessary for the system to exhibit a critical phase. The Ising model [5] exhibits a critical phase and will be used to validate methods of analysis and act as a benchmark for critical dynamics.

3. Results
Figure 1 shows three typical examples of distinct phases occurring throughout the model parameter space.

![Fig. 1 Probability density of summed amplitudes $P(A)$ for $\kappa = 0.01$ and $N_{\text{maps}} = 100$](image)

The power law phase is observed just as the model exhibits long-term activity which is consistent with where OOI occurs in the DLM. With an exponent of approximately $-1$ the power law distribution is potentially exhibiting OOI. A large-scale phase is observed in experiment for an overdriven system. This corresponds to large $\alpha$ in the model and is indeed where the phase occurs. For even higher $\alpha$ a peaked phase is observed in the model. Future work will involve the identification of critical regions through the use of finite size scaling and an analytical investigation of the model.

4. Acknowledgements
This work is supported by the Department of Physics and Energy, UL.

5. References
Inverted Opal V$_2$O$_5$ Photonic Crystal Cathodes for Ultrafast Charging Lithium-ion Batteries

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Abstract

Active battery material electrodes, for current thin film lithium batteries, typically comprise of brittle disordered matrices and therefore have always suffered performance issues, in particular, for high power applications. This project aims to improve battery performance by developing synthesis and assembly routes using self-assembled polymer sphere templates and forced impregnation to create large-area inverted opal photonic crystal thin films. For a high capacity cathode material, V$_2$O$_5$ will be investigated by infilling of its alkoxide precursor. Electrochemical characterisation will be carried out, using coin-cell arrangements, focusing on charge-discharge properties, cycle-life and tolerance to charging rates. Non-destructive optical characterization will be used in-situ to monitor structural changes during lithium insertion and removal. The synthetic, structural/mechanical, electrochemical and architectural influences of the cathode materials investigated here may lead to a major reduction in size and weight, giving reliable, mouldable battery-shape adaptability to portable electronic device designs, with increased performance.

1. Introduction

This project aims to develop a storage technology with both the power density of a supercapacitor and the energy density of a battery$^{[1]}$. Synthesis and assembly routes using sacrificial photonic crystal templates to give three-dimensionally ordered mesoporous and macroporous (3DOM) nickel current collectors onto which the active material V$_2$O$_5$ will be deposited will be developed.

2. Experimental

Polymer sphere templates will be formed on gold (Au) coated silicon wafer substrates pre-functionalized with sodium-3-mercaptop-1-propanesulfonate (MPS) to form a layer of mercaptoalkane that alters the surface charge on the Au in order to affect the type of array formation using the charge interactions between spheres and substrate. Different methods for creation of the colloidal template were investigated to determine the variations in surface coverage and colloidal order. V$_2$O$_5$ alkoxide will be infilled and the spheres calcined to form the porous electrode.

3. Results and Discussion

The dip-draw method was seen to be a promising method for template formation as it allows for greater control and variation of deposition compared to other methods. Template formation depends on a number of parameters: speed of withdrawal, substrate functionalization and the temperature of the templating solution. Withdrawals were carried out with both commercial PS spheres and synthesized PMMA spheres. PS spheres showed improved overall crystallinity compared to the PMMA spheres. This was evident by the manifestation of both hcp and fcc packing of the spheres. Structural defects such as dislocations, vacancies and cracks are also characteristic.

7. Summary and Future Work

Template formation was investigated centering on the role of electrostatic interactions and effects of temperature and withdrawal rate in a dip-draw method of colloidal deposition. Further investigations into the role of substrate and sphere functionalization will be undertaken. Electrochemical analysis of completely formed V$_2$O$_5$ cell will be carried out along with angle resolved reflection experiments to optically monitor structural changes during charging and discharging.

8. References

High Frequency Response of Ferromagnetic Thin Films
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Abstract
This project is based on the high frequency response of ferromagnetic thin films using a scattering parameter technique. Reflection and transmission S-Parameters are recorded for different externally applied magnetic fields. From the microwave absorption observed, the ferromagnetic resonance (FMR) frequency can be determined. The film response to an exciting ac field is compared to current models for energy absorption in the microwave region.

1. Introduction
The constant increase in the data transfer rate of magnetic recording systems has pushed the operational frequencies of magnetic materials into the GHz range. However, the switching speed of magnetic thin films is limited by magnetic damping effects. To gain an understanding of these effects, the frequency response of the magnetic field in the microwave range needs to be measured, analysed and modelled. High frequency candidate materials must have a constant frequency response in the operational range (1-10GHz approx.), which implies no FMR and little damping. The composition and structure of the magnetic material controls this characteristic response.

2. Method
There are many different techniques to measure the high frequency response of ferromagnetic thin films. In this study, a coplanar waveguide (CPW) connected to a Vector Network Analyser (VNA) has been used [1].

A magnetic sample is placed film side down across the CPW. Different magnetic orientations with respect to the CPW can be tested. An electromagnet is used to apply an external magnetic field to the setup. The reflection and transmission S-parameters of the magnetic sample are recorded for each applied magnetic field.

3. Results
Figure 1 shows a typical frequency response of a ferromagnetic sample using the scattering parameter characterization. The absorption peaks are obtained from the difference between the magnitude of the S-parameters of a reference 0 field and the applied magnetic field. Absorption peaks at matching frequencies are found for both magnitude and phase of the S-parameters.

Fig 1. Absorption spectra of a ferromagnetic thin film as a function of applied magnetic field.

Different models to characterise microwave absorption of ferromagnetic films are currently being tested and will be presented and compared. The currently available models will be tested with independently characterized samples to identify the most accurate method of characterization.

4. Future Work
We will investigate in detail models for the analysis of the absorption spectra of ferromagnetic thin films. We intend to characterize and identify novel materials that have low absorption at a wider range of frequencies. As a result we plan to optimize the frequency response of ferromagnetic materials in the microwave frequency range.

5. Acknowledgment
This work is supported by IRCSET. The authors wish to thank Dr. Z. Rahman for access to characterization facilities.

6. References
Vanadium Oxide Nanostructured Cathodes for Rechargeable Lithium-ion Batteries

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Abstract

Rechargeable lithium-ion batteries hold great potential for use in powering electric vehicles and hybrid electric vehicles and continue to be crucial in medical and handheld portable devices. However, power density, energy efficiency and rate performance are three important factors that need to be further improved before their wide spread use in electric vehicles and for them to meet demands for powerful portable devices. This study investigates the use of vanadium oxides to replace the currently used cobalt oxides as a cathode material. Vanadium oxide nanostructures such as nanotubes have attracted increasing attention due to their unique geometry and large specific surface area. In this work, we present a convenient and controllable approach to synthesizing vanadium oxide nanotubes. The charge-discharge performance and overall electrochemical behaviour of nanotubes as lithium battery cathode materials is also correlated with analysis of structural change in the nanostructures.

1. Introduction

Vanadium oxides, while one of the earliest candidates for lithium ion battery cathodes [1], still receive considerable interest due to the material’s high cell potential, a layered high-density intercalation volume and high specific charge capacities. Vanadium oxide nanotubes (VONTs) have attracted increasing attention due to their unique geometry and large specific surface area. [2]

2. Experimental

Vanadium oxide nanotubes were synthesised by hydrothermal treatment of a vanadium oxide xerogel. Lamellar-structured V2O5 xerogel, used as a precursor, was mixed with a range of organic long-chain amines acting as structure directing templates under hydrothermal conditions. Galvanostatic charge/discharge tests on VONTs were carried out using a CHI660B potentiostat.

3. Results and Discussion

In this work, we present a convenient and reproducible method to synthesizing vanadium oxide nanostructures. We demonstrate that during hydrothermal treatment the amine templated vanadium oxide layers undergo scrolling to form the eventual nanotubes through the TEM analysis of early, intermediate and final stages of VONT formation.

We also report on the structural characterization of VONTs with various amines and the optimization of synthetic yield by control of the amine:V2O5 ratio through various spectroscopic and microscopic analyses.

Through galvanostatic discharging, the electrochemical lithium intercalation into V2O5 showed the evolution of phases with degree of lithium intercalation. Galvanostatic discharge tests give an initial discharge capacity of ~200 mAh g⁻¹ in the potential range 2.6–3.8 V.

4. Summary and Future Work

A controllable method for the synthesis of VONTs was presented. It was shown that by varying the molar ratio of amine:V2O5 the yield and interlayer spacings of the VONTs can be controlled. The charge-discharge performance of VONTs was also reported.

Future work will include the determination of the charge-discharge properties and cycling performance of nanostructured electrodes. There will be an investigation of the performance of nanostructured electrodes at high charging rates and also a correlation of results of synthetic processes, structural characterization, and electrochemical measurements.

(a) Electrochemical Li intercalation into V2O5 showing the evolution of phases with degree of Li intercalation (b) SEM image of VONTs.

Figure 1

5. References
Energy Production Potentials from Manure Pyrolysis

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Abstract
The energy balances were calculated for the pyrolysis of the solid fraction of separated pig manure at different process temperatures and compared with the energy produced from wood pyrolysis. The primary data from the experiments shows that the energy input arising from the manure sample pyrolysed at 600°C represents 94% of products energy, while in the case of pyrolysis of wood equates to only 16% of the energy output.

1. Introduction
Spreading of the pig-manure directly to a field enhances soil mineral content, however overdosing P and N can give rise to environmental problems such as surface water eutrophication, ground water pollution, greenhouse gas emissions, odour problems during storage and/or application [1]. In the areas of intensive livestock production there is a necessity to apply/develop environmentally friendly technology for manure waste management related to energy and nutrient recovery.

Pig manure can be converted into energy using two main platform process technologies: biochemical/biological and thermo-chemical. Thermo-chemical conversion requires relatively dry feedstock. This imposes a requirement for technologies to separate raw manure into a nutrient-rich solid fraction and nutrient-poor liquid fraction is used to reduce weight and volume.

Pyrolysis processing of pig manure converts it to gas, vapours (which condense into a crude oil) and char (bio-char) [2]. The energy consumption for drying and pyrolysis was determined, and the products were collected and characterised.

2. Materials and Methods
Mechanically separated pig manure samples were dried to constant mass and pyrolysed at process temperatures between 400 and 600°C. The following properties of the products were measured:

Bio-oil: composition (GC-MS), % w/w of C, H, N (Elemental Analyser), pH, acid number and water content. The higher heating value (HHV) was calculated based on C, H, and N contents.

Bio-char: the ash, volatile matter, fixed carbon, C, H, N content as well as BET surface area and HHV measured by calorimetric bomb.

Gas: the concentration of CH₄, CO₂, CO, H₂, C₂H₄ and C₃H₆ were measured using micro-GC and HHV was determined.

3. Energy balances
The energy input for separation step, drying and pyrolysis process were expressed as a per cent of products energy and total energy input and output was evaluated (Table 1).

Table 1. Energy balance for pyrolysis of pig manure and wood at the same pyrolysis conditions.

<table>
<thead>
<tr>
<th>Product</th>
<th>Pig manure</th>
<th>Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Separation</td>
<td>-3.98</td>
<td>-</td>
</tr>
<tr>
<td>Drying</td>
<td>-84.92</td>
<td>-4.86</td>
</tr>
<tr>
<td>Pyrolysis</td>
<td>-4.77</td>
<td>-11.09</td>
</tr>
<tr>
<td>Total input</td>
<td>-93.67</td>
<td>-15.95</td>
</tr>
<tr>
<td>Energy output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bio-Oil</td>
<td>19.83</td>
<td>36.02</td>
</tr>
<tr>
<td>Bio-Gas</td>
<td>22.85</td>
<td>22.23</td>
</tr>
<tr>
<td>bioChar</td>
<td>57.32</td>
<td>41.75</td>
</tr>
<tr>
<td>Total output</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

4. Conclusions
The energy balance for wood looks more efficient than for pig manure, which raises the possibility of mixing manure with wood (saw dust) prior to pyrolysis in order to improve the energy recovery balance. In the full paper we present the complete set of data and relations between the applied separation system, feedstock properties and pyrolysis process conditions

4. Acknowledgment
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5. References
Bioelectrochemistry Of Redox Enzymes Immobilized On Mesoporous Gold Electrodes

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Abstract

The high surface areas of nanostructured electrodes provide for significantly enhanced surface loadings of electroactive materials. Robust nanoporous gold electrodes are prepared by sputtering a gold and silver alloy onto a glass support and subsequent dealloying of the silver component. Such nanoporous gold electrodes enable high loading of redox enzymes can be applied in biosensors and biofuel cells.

1. Introduction

Electron transfer between the electrode surface and the active site of an enzyme is essential for the efficient use of biosensors and biofuel cells. Electrodes with high surface areas are suitable materials for enzyme immobilization as they can enable high enzyme loadings. Nanoporous gold (NPG) is obtained by dealloying Ag-Au alloys in concentrated nitric acid. In the NPG layer the gold atoms assemble into a 3D-structure to form large surface area materials with tunable pore sizes ranging from a few nanometres to several microns in diameter. The desired pore diameter is achieved by varying the temperature or the time of the dealloying process. The surfaces of the pores can be easily modified and the NPG films have high electrical conductivity.

2. Results

Electron transfer between NPG electrodes and redox enzymes can be accomplished in two ways. Direct electron transfer (DET) was achieved between thiol-modified NPG electrodes and both cytochrome c and cellobiose dehydrogenase (Corynascus thermophilus) (Fig. 1). Mediated electron transfer (MET) was achieved using redox-active osmium polymers \([\text{Os}(2,2’-\text{bipyridine})_2(\text{polyvinylimidazole})_{10}\text{Cl}]^{2+/2-}\) as mediators that shuttle electrons between enzyme active site and the electrode. CDH (Corynascus thermophilus) in a hydrogel containing an osmium mediator and poly(ethylene glycol) diglycidyl ether as cross-linker was used to create a bioanode. CDH modified NPG electrodes were prepared which can act as efficient biosensors for lactose and as biocathodes in biofuel cells.

Figure 1. Cyclic voltammogram of Corynascus thermophilus cellobiose dehydrogenase at SH-C\(_6\)H-OH modified nanoporous gold electrodes; scan rate: 100 mV/s.

3. Conclusions

Mesoporous gold electrodes successfully created and characterised:
- high surface area, up to ~28
- exhibit large catalytic response for mediated electron transfer involving redox enzymes glucose oxidase (GOD), cellobiose dehydrogenase (CDH) and bilirubin oxidase (BOD)
- DET lactose biosensor with CDH achieved
- porous environment likely to improve the stability of resulting electrodes for MET and DET biosensors and bio-fuel cells
From Rose Petals to Lotus Leaves: The Effect of Surface Roughness on Superhydrophobic Surfaces

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Abstract
Superhydrophobicity can be seen in nature with varying degrees of wetting. Herein we describe how, with the use of evaporated metals, the hydrophobicity of carbon spheres which are intrinsically hydrophobic can be altered to biomimic different states of wetting as seen in nature. This includes hydrophobic “pinned” water droplets in rose petals to self-cleaning surfaces such as lotus leaves.

1. Introduction

The leaves of the lotus plant have long been identified for their superhydrophobic properties. Superhydrophobic surfaces have contact angles larger than 150° and their sliding angles are less than 10°. The basic ideas of superhydrophobicity were developed by Wenzel¹, and Cassie and Baxter² in the 1930’s and 1940’s respectively. This superhydrophobicity makes water droplets roll on the surface, thereby cleaning dirt particles that might be collected. The phenomenon was dubbed “the lotus effect”.

Figure 1: Different wetting states of Wenzel and Cassie-Baxter.

Water droplets can also be superhydrophobic without the self-cleaning effect of the water droplet rolling on the surface. Different from the lotus effect, the so-called petal effect describes the phenomenon that a water droplet on the petal surface of a red rose (rosa Rehd) “beads up”, but does not roll off even when the petal is turned upside down³. The diverse design in surface microstructure on rose petals results in different dynamic wetting from lotus leaves.

With the invention of the SEM it was seen that nanostructuring was responsible for hydrophobicity. Studies revealed that the surfaces, which appear to be macroscopically smooth, exhibit microscopic roughness on different scale lengths. It is therefore this hierarchical scale roughness that is responsible for the varying degrees of wetting.

2. Results

A colloidal approach has been developed with the carbonisation of squalane, a non-volatile, hydrocarbon solvent, in supercritical carbon dioxide (sc-CO₂) to form colloidal carbon spheres⁴. The spheres produced are of amorphous carbon and solid in nature. The inherent value of the spheres makes them hard wearing and durable while displaying hydrophobic properties with contact angles of θ = 140° observed. In order to increase the hydrophobicity of the spheres, a hierarchical roughness was applied to the surface.

Figure 2: SEM images of carbon spheres in a) as synthesized, b) 20nm layer of evaporated tin, c) 20nm layer of evaporated indium and d) contact angle of 170° displayed on layer of evaporated In on spheres.

Vacuum evaporation of metals (In and Sn) was used to impart surface roughness on the spheres. This increased the hierarchical roughness of the layer and decreased the surface area in contact with the water through the stranski krastanov island formation as seen in fig. 2b and c.

3. Conclusion

From the evaporation of 20-30nm rough layers of In and Sn the water contact angle was seen to increase from a hydrophobic state (140°) to a superhydrophobic state (170°). This surface roughness also altered the dynamic wetting and transformed the surface from petal state wetting to self-cleaning lotus-leaf-like wetting. These superhydrophobic self-cleaning surfaces have many applications in antifouling, self-cleaning and water resistant coatings.

3. References
A highly conserved detrimental gene associated with stress induction from R391, a promiscuous enteric Integrative Conjugative Element (ICE)

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Abstract

The integrative conjugative element R391 belongs to the IncI class of mobile genetic elements. ICEs integrate into the chromosome, site-specifically into the prfC gene. They are found in the chromosome of enteric pathogens such as Vibrio cholerae and have been implicated as contributors to host virulence as their presence has been detected in numerous new invasive sero-groups.

R391 has been sequenced and contains regions homologous to plasmids, bacteriophages and transposons, is 89kb and contains kanamycin and mercury resistance genes and genes involved in mutagenic DNA repair. Along with the advantages that R391/SXT like ICEs contribute to a host, certain disadvantages such as increased sensitivity to cell damaging agents are also known.

Recently a gene responsible for one of these detrimental effects has been determined. This gene is highly conserved (99%) across the R391/SXT group and is essential to the basic functionality of R391 type elements.

As ICEs are characterised as being highly mutable and diverse, it is unusual that this gene has remained so highly conserved across the R391/SXT group.

This study aims to examine possible reasons why a host would keep a harmful gene without selecting mutations to remove its negative effect.

8. References


Electrochemical and spectroscopic characterization of dye-sensitized solar cells

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Abstract

Dye-sensitized solar cells (DSSC) are the most promising alternative to Si-based photovoltaic devices. Over the past two decades many efforts have been made to improve the efficiency of DSSCs. Currently a maximum conversion efficiency of 12 % has been obtained for ruthenium sensitizer in combination with volatile liquid electrolytes. Ruthenium based sensitizers have some drawbacks as they are costly, have limited availability, factors which limit the practical application of DSSCs. Metal free organic dyes have received attention as they are relatively easy to synthesize, low in cost, and can be readily functionalised.

1. Introduction

In DSSC the photosensitiser absorbs an incident photon and gets excited from the ground state (S) to the excited state (S*). Injection of an electron into the CB of the TiO2 electrode results in oxidation of the sensitizer. Electrons diffuse towards the anode and reach the counter electrode through the external load. The oxidized dye (S+) recaptures electrons from iodide (I–) in the electrolyte, regenerating the ground state (S). I– is oxidised to triiodide (I3–) which then diffuses towards the counter electrode where it is reduced to I– iodide, thus generates power without any permanent chemical transformations.

Figure 1: Principle of operation and energy level scheme of a dye-sensitized solar cell.

2. Results

Figure 2: Raman spectrum of C212 derivative on TiO2

Table 1: Absorption, emission and electrochemical properties of the dyes.

<table>
<thead>
<tr>
<th>Dye</th>
<th>λabs,max (nm)</th>
<th>ε (M⁻¹cm⁻¹)</th>
<th>λem,max (nm)</th>
<th>E_Dd (V vs NHE)</th>
<th>E_ads (V)</th>
<th>E_LUMO (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C212 derivative</td>
<td>493</td>
<td>3700</td>
<td>654</td>
<td>1.13</td>
<td>2.17</td>
<td>-1.04</td>
</tr>
<tr>
<td>L0</td>
<td>400</td>
<td>15000</td>
<td>536</td>
<td>1.52</td>
<td>2.89</td>
<td>-1.37</td>
</tr>
<tr>
<td>PM-003</td>
<td>419</td>
<td>490000</td>
<td>659, 724</td>
<td>1.53</td>
<td>2.04</td>
<td>-0.51</td>
</tr>
</tbody>
</table>

Table 1: Absorption, emission and electrochemical properties of the dyes.

3. Conclusions

The dyes displayed maximum absorbance between 400-500 nm. ATR-FTIR and Raman spectra of the adsorbed dyes indicated that the dyes were adsorbed to the TiO2 surface via the carboxylate group. The HOMO energy levels of the dyes were (ca. 0.6 V) more positive than the redox potential of the iodide/triiodide couple (ca. 0.4 V vs NHE) indicating that the dyes can be regenerated by I– in the electrolyte to give efficient charge separation. The LUMO levels of the dye were more negative (ca. 0.5 V) than the conduction band edge (-0.5 V vs NHE) of TiO2, providing sufficient driving forces to inject electrons from the excited dye molecules to the conduction band of TiO2. The results show that these metal-free dyes fulfill the criteria for DSSC and are promising materials for the development of dye-sensitized solar cells.

4. References

FORMING CONDUCTING POLYMERS UTILISING ROOM TEMPERATURE IONIC LIQUIDS

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Abstract
Conducting polymer (CP) materials, in conjunction with room temperature ionic liquids (RTILs) were used to fabricate new energy-efficient electrochromic films. An electrochromic material is one where a reversible colour change takes place upon reduction (gain of electrons) or oxidation (loss of electrons), on passage of electrical current after the application of an appropriate electrode potential. A novel poly (2,3,5,6-tetrafluoroaniline) film has been synthesised and characterized using electrochemical and spectroscopic methods from aqueous solution. Electrochromic films of poly(2,3,5,6-tetrafluoroaniline) (PTFA) were formed on FTO substrates from aqueous solutions utilising perchloric acid (HClO₄) as dopant.

1. Introduction
This work involves poly(2,3,5,6-tetrafluoroaniline) (PTFA) films doped with anions (ClO₄⁻) that enter the film on oxidation and exit upon reduction.

2. Results and Discussion
The electroactive films were prepared using both cyclic voltammetry and chronoamperometry. The films were characterized using a range of spectroscopic, microscopic and electrochemical techniques. The poly-(2,3,5,6-tetrafluoroaniline) film deposited on FTO glass had an orange and pink colour in its oxidized and reduced forms, respectively. Relatively little change in the absorbance can be noticed in the region from 500 to 1000 nm. At 400 nm the absorbance increased as the potential decreased indicating electrochromic behaviour. Fluorine is improving the stability of the aniline conducting polymer and promising results were obtained for polymer formation from ionic liquids using a multiphase system. The films formed on FTO glass from aqueous electrolytes were stable under air conditions. Yellow films were formed from ionic liquids, but they were easily dissolved with deionized water.

3. Conclusions
• Spectroscopic characterization of novel PTFA compound indicated that around 400 nm the absorbance increased as the potential decreased indicating electrochromic behaviour.
• PTFA film was stable in air when formed in aqueous conditions on FTO.
• However the film was not stable when formed in BMIM TFMS on platinum surface.
• Demonstration of conducting polymer deposition from an immiscible two-phase system.
• Advantage of economic use of ionic liquids.

4. References
The Catalytic Conversion of Levulinic Acid Derived from Biomass to Fuels and Fuel Additives

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Abstract

Levulinic Acid has been shown to be a useful intermediate in fuel production. However most of the reactions which have been studied to date have been carried out without attention being given to optimising yields or to minimising waste by-products.

The objective of this project will be aimed at establishing catalytic routes based on the decarboxylation of levulinic acid. The conversions and selectivities will be optimized, thus, minimising the production of unwanted by products.

The main objective of the work is to develop novel active, selective and stable catalysts and to propose a new process for levulinic acid transformation to fuel additives by decarboxylation and decarboxylative coupling.

Introduction

In the current climate the over dependence on fossil fuels has lead to growing need for another cleaner source of energy. Levulinic acid, one of the top 10 platform chemicals can be produced cheaply and efficiently from lignocellulosic biomass due to the Biofine process and shows great potential for this purpose [1]. This is due to the reactive nature of its structural characteristics with both reactive carbonyl and carboxyl functional groups.

It has been shown that levulinic acid can be decarboxylated to form butanone in the presence of an appropriate catalyst [2]. If this reaction could be carried out with high conversions and selectivities, the butanone formed could then be hydrogenated to give 2-butanol thus, further improving the fuel properties. Also proposed is the process of decarboxylative coupling where two molecules of the keto acid can be coupled to give a tri-ketone which can be similarly hydrogenated to an alcohol.

The mentioned reactions correspond to the demands of “green chemistry” as giving high yields of valuable fuel additives and low-polluting by-products.

The project should lead to new catalytic processes based on decarboxylation or decarboxylative coupling of levulinic acid and a deep understanding of the factors which control activity and selectivity of these reactions.

Materials and Methods

The appropriate catalysts e.g. table 1 will be first synthesized by impregnation and coprecipitation and then used to examine the mentioned reactions using a 4598 Parr high temperature autoclave micro-reactor. The products are then condensed and analysed by means of a GC and GC-MS.

Table 1: A selection of catalysts for analyses

<table>
<thead>
<tr>
<th>Reaction</th>
<th>Active component</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decarboxylation</td>
<td>Cu</td>
<td>Faujasite, MCM-41, Al-MCM-41, ZSM-5, MgO</td>
</tr>
<tr>
<td>Decarboxylative Coupling</td>
<td>MnO2, CeO2</td>
<td>Al2O3, ZrO2 Al-MCM-41,</td>
</tr>
</tbody>
</table>

This process is used to screen the various catalysts, the most promising of which will undergo optimisation studies and then characterisation by various techniques such as chemisorption, XRD, Raman spectroscopy, XPS and HRTEM.

Acknowledgements

This study is funded by the Science Foundation of Ireland Research Frontiers Programme.

References


Development of amine solids for the capture of carbon dioxide from gaseous streams

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Abstract
This project studies the CO$_2$ adsorption capacities of amine-modified mesoporous solids. Such solids may eventually be placed in fossil fuel based power-plants, as nearly a third of all CO$_2$ emissions come from such sites.

1. Introduction
Climate change can be defined as “major changes in temperature, rainfall, snow or wind patterns lasting for decades or longer”. While the Earth has warmed and cooled many times in its history, it is argued that the rapid increase in warming seen today cannot be explained by natural forces alone [1]. Human activities in the form of burning fossil fuels are believed to be a contributing factor to the increase in atmospheric concentration of CO$_2$. Currently the CO$_2$ content of the atmosphere is rising by 2ppm per year [2]. With more energy demands expected from developing countries in the near future, this upward trend is likely to continue. Human dependence on fossil fuels for energy most likely will not be met by alternative sources of energy for the foreseeable future. This is why research into the capture of CO$_2$ from flue gases has attracted much attention. Amine absorbents are a potential way of capturing CO$_2$ post-combustion. The conventional way to remove CO$_2$ from flue gases has been through the use of a scrubber which uses an aqueous amine solution. However, large energy requirements are associated with this technology; also the liquid amine can break down and evaporate during the regeneration step. Corrosion is another potential issue.

A possible solution to some of these issues is to use amines immobilized on solid surfaces. The surface amines interact with CO$_2$ molecules forming ammonium carbamates when in anhydrous conditions and ammonium bicarbonate in the presence of water. The mechanism is similar to that of the liquid based system. The work reported here outlines some developments regarding the immobilization of amines on mesoporous silica and their performance for the capture of CO$_2$ from flue gas streams.

2. Methodology
2.1. SBA-15 and Al-SBA-15
Mesoporous silica, SBA-15 and mesoporous Al-SBA-15 were chosen as supports in this study because of their large, accessible surface area and large pores which allows for the grafting of amine molecules.

2.2. Modification of mesoporous solids
Both SBA-15 and Al-SBA-15 were modified with the amines; (tetraethylenepentamine (TEPA), 3-aminopropyltriethoxysilane (APTES) and polyethylenimine (PEI)) of varying loadings via wet impregnation or grafting.

2.3. Testing
Prepared samples were tested for CO$_2$ adsorption capacity using an on-line gas system with mass spectrometry detection. The uptake of CO$_2$ at 30°C (15% CO$_2$ in helium) was monitored and once saturated, the samples were heated in a linear fashion and desorption of CO$_2$ was recorded with temperature. In this way, the CO$_2$ capacity could be calculated and the temperature required for CO$_2$ desorption studied.

3. Results and Discussion
Fig 1 presents the amount of CO$_2$ desorbed from all the modified samples. Of the three amines, TEPA performed the best in terms of overall CO$_2$ adsorption capacity. As is also shown the higher loadings of amine contributed to less CO$_2$ adsorption. This may be due to pore blocking, thus limiting interaction with CO$_2$ molecules.

Fig 1. Summary of amine loadings with CO2 adsorption capacities

8. References
Amine Modified Y-Type Zeolites for Low Temperature CO₂ Capture

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Abstract

In this work, a CO₂ capture technology based on adsorption was investigated using economically viable materials, such as amine modified microporous zeolites, to test their potential versus comparable modified mesoporous solids such as MCM-41 and SBA-15. This study looks primarily at CO₂ adsorption from low temperature exhaust streams with two primary factors; CO₂ adsorption capacity and regeneration energy requirements.

1. Introduction

In conventional CO₂ capture technology, amines in aqueous solution are used for CO₂ adsorption from the gas phase with subsequent desorption at high temperature to regenerate the amine and produce an almost pure CO₂ stream. Disadvantages of this process include, large energy requirements during the amine-regenerating step, corrosion, amine degradation, foaming and amine loss due to evaporation.

Alternatively, amines can be supported on porous solids. The flue gas can be passed through the amine rich solid which adsorbs CO₂ from the gas stream. Once the solid is saturated, temperature swing methods can be applied to the solid to initiate a CO₂ desorption cycle. This solid amine system alleviates the problems associated with the conventional CO₂ capture technology.

In the adsorption process, carbamates are formed through reversible reactions of the free amine with CO₂ to form a bicarbonate ion (See Figure 1) [1].

![Fig. 1: Carbamate Formation](image)

2. Results

Table 1 is a summary of some of the more important results achieved so far in testing. The table includes the amine content of each sample in mmoles, the CO₂ adsorption in mg CO₂ g⁻¹ and finally the ratio of CO₂ adsorbed to amine used in the synthesis step.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Amines Content (nmols g⁻¹)</th>
<th>mg CO₂ g⁻¹</th>
<th>Adsorbed CO₂/Amine Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y-80/1A</td>
<td>2.5 mmoles APTES</td>
<td>31.3</td>
<td>0.22</td>
</tr>
<tr>
<td>Y-80/1A(1 × 2)</td>
<td>7.5 mmoles APTES</td>
<td>71.0</td>
<td>0.22</td>
</tr>
<tr>
<td>Y-80/1A(1 × 2)</td>
<td>7.5 mmoles APTES</td>
<td>37.0</td>
<td>0.19</td>
</tr>
<tr>
<td>Y-80/1A(2 × 2)</td>
<td>15 mmoles APTES</td>
<td>11.9</td>
<td>0.05</td>
</tr>
<tr>
<td>Y-80/1A(2 × 2)</td>
<td>15 mmoles APTES</td>
<td>25.9</td>
<td>0.16</td>
</tr>
<tr>
<td>Y-80/1A(2 × 2)</td>
<td>15 mmoles APTES</td>
<td>14.6</td>
<td>0.09</td>
</tr>
<tr>
<td>Y-80/1A(1 × 2)</td>
<td>3.5 mmoles TIPA</td>
<td>43.3</td>
<td>0.19</td>
</tr>
<tr>
<td>Y-80/1A(2 × 2)</td>
<td>3.5 mmoles TIPA</td>
<td>43.5</td>
<td>0.19</td>
</tr>
<tr>
<td>Y-80/1A(2 × 2)</td>
<td>11.1 mmoles TIPA</td>
<td>19.0</td>
<td>0.12</td>
</tr>
</tbody>
</table>

3. Discussion

The best adsorbent, using Y-zeolite as support, was Y-80 zeolite modified with APTES. This showed relatively high CO₂ capacity while also having a low CO₂ affinity with desorption occurring at 60°C.

The ratio of loaded amine to CO₂ adsorbed is an important factor. Ratios of up to 0.4 would suggest pore blocking or inaccessible adsorption sites in the hybrid solid. This would seem to suggest that control of loading of the amine is important, as overloading would result in reduced uptake of the CO₂ and inefficient use of the amine.

4. Conclusions

Microporous solids combine good adsorption capacities with low energy regeneration requirements, while also being relatively inexpensive to produce compared with more expensive mesoporous solids.

5. Acknowledgements

This material is based upon works supported by Science Foundation Ireland with the Solar Energy Conversion Strategic Research Cluster [07/SRC/B1160]; The Department of Chemical and Environmental Sciences, University of Limerick.

6. References

Moiré Pattern Revealed in Semiconductor Nanorods Superlattice

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Abstract

Here we present the formation of an array of complex Moiré interference patterns from self-assembled semiconductor nanorods, demonstrating the extraordinary order attainable with these materials. The Moiré patterns are uniquely characterized by angular dark-field STEM (DF-STEM) and referenced against SAED, HRTEM, and HRSEM for comparison. Six distinct patterns are observed and are indexed to an angular rotation between underlying sheets, allowing the three-dimensional architecture to be accurately determined. The interpretation of additional lateral stacking faults and defects owing to random tetrapod distribution offers a critical depth of understanding necessary for next-generation applications incorporating orthogonal rod assembly.

1. Introduction

Moiré interference patterns occur when two lattices overlap with a rotational misorientation and are independent of length scale once the effect is observable to the eye.1 These patterns, initially only of aesthetic interest, are now finding important applications for characterizing the three-dimensional architecture of layered nanomaterials. As these materials can be imaged in transmission mode (TEM, STEM, or STM), sequential layers that have an angular offset generate Moiré patterns in the upscaled images, allowing three-dimensional structural determination in both crystalline (e.g., anodic alumina) and noncrystalline materials (e.g., self-patterned block copolymers). Moiré patterns have particular importance in the area of nanocrystal assembly, as the interparticle length scales (1–10 nm) allow manifestation of interference patterns that allow detailed interpretation of the three-dimensional structure.2,3

2. Results

Colloidal II–VI nanorods have a permanent dipole moment and a net charge that varies, primarily as a function of ligand. We have recently shown that the simplest method to achieve a perpendicular assembly in solution is to direct the total energy considerations such that attractive interactions (dipole–dipole) slightly outweigh repulsive interactions (Coulombic) to allow supercrystallization.4,5 Nucleation of assembly thereby has a distance and hence concentration dependence that when suboptimal will result in random rod alignment, as highlighted in Figure 1a, and when optimized allows formation of a perfect 2D supercrystal layer that forms on the surface after sedimentation from solution, (Figure 1b). The 2D sheets can be deposited sequentially, forming multilayer arrays, as shown in the SEM image in Figure 1c, when the rate of evaporation of the solvent is controlled. Imaging these multilayer assemblies in transmission mode (TEM, STEM) results in characteristic Moiré interference patterns, Figure 1d that vary depending on the number of monolayers.

Figure 1: Figure 1. (a) TEM image showing randomly lying CdS nanorods (7× 30 nm). (b) HRTEM showing top-down image of vertically oriented close-packed CdS nanorods. (c) SEM image showing the multilayer, vertical assembly of nanorod superstructures. (d) TEM image showing different Moiré patterns revealed in CdS nanorod superstructures.

3. References

**Abstract**

*Ralstonia pickettii* has been identified as an emerging cause of infection and death among immunocompromised patients. It has been demonstrated to form acylhomo-serine lactones which are known signalling chemicals involved in biofilm formation. *R. pickettii* also has a select antibiotic persistence profile. Persisters are considered to be important in bacterial contamination of high purity water. Persisters are phenotypic variants of the wild type and are largely responsible for multiple drug tolerance of biofilms and stationary populations. The hipBA toxin/antitoxin locus has recently been identified as part of the multi drug tolerance mechanism in *Escherichia coli*.

We have identified a hipBA locus from the sequence of *R. pickettii* 12J. HipA & hipB were both cloned and hipA was expressed and purified for crystallisation and structural determination.

1. **Introduction**

Persisters cell is one of the well-recognized puzzles in microbiology. [1] It can be hypothesised that *R. pickettii* survives nutrient deprived conditions of high purity water through formation of biofilm communities. That the ability to survive in the biofilm community may be due to persister cells.

In order to elucidate the mechanism by which HipA and HipB contribute to multiple drug tolerance, Lewis and co-workers [3] carried out biochemical and structural analysis of HipA as well as the HipA-HipB-DNA complex. HipA mediates persistent by phosphorylating target proteins. It was identified that HipB forms a compact dimer which interacts with DNA via contacts through the major grooves in which two HipA molecules sandwich the HipB-DNA complex by stabilising contacts through the sides of the HipB-dimer. [3] We identified and cloned HipA and HipB, expressed and purified hipA.

2. **Results**

**Cloning result of hipA in pETDuet-1**

Fig. 2: 1% Agrose gel of digestion of pETDuet-1/ hipA
M: DNA Marker HypeLadder I
1: digested constructed plasmid pETDuet-1/hipA
2: digested constructed plasmid pETDuet-1/hipA

**IPTG-induce expression of HipA**

Fig. 3: Western blot of IPTG-induce expression HipA constructed into pETDuet-1 transformed into BL21 Codon Plus expression strain Conditions: 25 °C, 220rpm, 1mM IPTG Media: LB broth Induction at OD600 = 0.7
M: protein marker lane
2: 0.1 mM IPTG induced for 2 hours
4: 0.1 mM IPTG induced for 3 hours
5: 0.1 mM IPTG induced for 5 hours
8: 0.5 mM IPTG induced for 2 hours
10: 0.5 mM IPTG induced for 3 hours
12: 0.5 mM IPTG induced for 5 hours

HipA was expressed and extracted from BL21 Codon Plus cells. Protease inhibitor was added in the lysis buffer but HipA degraded during the expression. HipA protein was purified by IMAC.

3. **References**


Growth and Characterization of Unseeded Ge NWs

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Abstract

High density, crystalline Ge nanowires (NWs) were grown on pyrex, quartz and indium tin oxide (ITO) substrates using a thermolytic, organometallic precursor decomposition method. The NWs were synthesized without the need for the metal catalyst particles typically associated with group IV NW growth. Perpendicular alignment of the NWs was confirmed by Scanning Electron Microscopy (SEM). Further characterization of the NWs was conducted through the use of Transmission Electron Microscopy (TEM). A temperature related increase in NW tortuosity and defect density was identified and additional TEM characterization was used to identify the defects and growth directional changes which determined the morphology of the NWs.

Detail

Ge NW growth has been successfully achieved using a variety of methods including chemical vapour deposition, laser ablation and numerous solution based methods. A common vein through this area is the need for metal catalysis to induce nucleation and growth of the NWs. Catalyst free, organic solvent based approaches have been successful in a small number of studies.1,2 To date these attempts have focused on material grown in solution and have not examined vapour phase growth within an organic medium. Metal nanoparticle catalyzed routes have been widely successful in allowing location specific, NW growth on substrates. While these approaches benefit from the ability to define the location of the NWs, inherent metal contamination of the resultant structures is known to limit potential device efficiency. As a result, metal free routes facilitating the growth of crystalline Ge NWs are needed.

Here we present the high density growth of Ge NWs on pyrex, quartz and indium tin oxide (ITO) substrates.3 The NW growth is conducted without the need for metal catalyst particles and allows the formation of highly dense, perpendicularly grown mats of Ge NWs on the substrate. The work is conducted in Pyrex glassware using a high boiling point organic solvent and the widely used Ge precursor diphenylgermane. The NW growth occurs solely within the vapour phase of the system. The refluxing solvent has dual functionality insofar as it acts as the site for precursor decomposition and also serves as the carrier medium for the gaseous Ge monomer supply. NW growth occurs only in heated areas of the system and placement of substrates in the appropriate zone of the reaction flask allows widespread growth on the material. The elevated temperature at the substrate or NW growth vessel is crucial in overcoming the barrier to NW nucleation as evidenced by the lack of growth in the solution part of the system. TEM analysis shows the NWs exhibit sub 25 nm diameters and lengths often in the order of tens of microns while SEM analysis provides evidence of directional growth from the substrate.

An in-depth study detailing the morphology of the Ge NWs grown via this method is also presented here.4 Using high resolution TEM and SEM, the roles of preferred growth directions and defects in the formation of kinked and wormlike, crystalline germanium nanowires (NWs) were examined. Examples of, and reasoning for, lateral, longitudinal, and more complex faults seen in the NWs are presented, and an increase in their relative frequency as a function of reaction temperature and solvent is detailed. Tortuous NWs are examined and NW kinking is found to originate from interplay between NWs tending to grow along preferred crystallographic axes and NW defects being perpendicular to the NW growth direction. The study provides insight into the impact of growth direction changes and defect formation on the morphology of unseeded Ge NWs.

References

Air blown gasification of Miscanthus x giganteus

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Abstract
Gasification is a competitive way to convert diverse biomass to syngas for combined heat and power generation with low environmental impact. Gasification of Miscanthus in an air blown fluidized bed was undertaken. The product gas can be utilized as a fuel or co-processed fuel for heat production in gas boilers or in an internal combustion engine to produce electricity.

1. Introduction
Biomass gasification is a promising technology with high potential in order to reduce greenhouse gas emissions. It is regarded as the main and effective future technology for the thermochemical conversion of biomass to fuel gas or synthesis gas[1]. Gasification has several advantages over combustion since it allows limited formation of nitrous and sulphur oxides, a strong reduction of the process gas volume, the production of an energy carrier that can be utilized in gas turbines and engines [2].

2. Experimental
Experiments were conducted in fluidized bed reactor which was heated to reaction temperature by a set of electrical furnaces. The gas generated in the reactor was sent to cyclones where ash and elutriated solid were collected. The gas was cooled in a heat exchanger and any tar was collected in a tar trap. The residual fly ash was collected in filters which are located before the mass flow meter. The composition of the product gas was analyzed by means of micro-GC.

Biomass was fed through a system of screw augers into the fluidized bed reactor. Gasifying agents (air) was heated up to 550°C before entering the base of the fluidized bed reactor.

Two different bed materials were used in gasification tests: silica sand and calcined olivine (MgFe)2SiO4.

3. Materials
The biomass feedstock used in this study was Miscanthus x giganteus with particle size between 200 μm -1.5mm, bulk density of 120kg/m3 and moisture content of 10.5%. Flow rate of biomass was 2kg/h.

4. Scope of the study
The objective of the study was to investigate the impact of bed material and the amount of gasifying air on the heating value and composition of produced gas.

5. Results and discussion
Gasification experiments with silica sand as bed material were conducted at 700°C with an equivalence ratio (ER) of 0.37 which means that 37% of the air which is required for stoichiometric combustion of biomass was used for gasification. The composition of the product gas was following: H2-9.8%, CO-12%, CO2-20%, CH4-4.5%, C2H6-1.48%, N2-57%. Higher heating value of the product gas was 5.5 MJ/Nm3, tar content was 3%, C conversion 88% and H conversion 56%.

Experiments with olivine as the bed material were conducted for different ER 0.28-0.3 and gasification temperatures 670 and 700°C. The composition of the product gas for gasification at 670°C with ER= 0.28 was following: H2-11%, CO-14.2%, CO2-19.4%, CH4-5.4%, C2H6-1.64%, N2-48%. Higher heating value of the product gas was 6.4 MJ/Nm3, tar content was 4.6%, C conversion 76% and H conversion 52%.

The higher the ER the more combustion reaction occurs in the reactor therefore the CO2 content in the product gas is higher and carbon and hydrogen conversion are also higher. However high ER causes decrease in heating value of the product gas.

Bed material in fluidized gasifiers can act as heat transfer medium but their major role involves in tar cracking. The catalytic activity of olivine has been attributed to the presence of Fe. It is necessary to calcine olivine at 900°C and reduced it for high activity in conversion of tars. For the studied range of operating parameter olivine did not show catalytic activity towards tar. This means that in-situ reduction of iron oxides was not completed within 3 hours of gasification experiments. Gasification tests at higher temperature 750-800°C are necessary in order to reduce calcined olivine.

6. Conclusions
Fluidized bed gasification of Miscanthus produces gas with desire composition for the use in internal combustion engine but tar content in the gas is too high. Gasification tests at higher temperature are necessary in order to reduce calcined olivine for high activity in conversion of tars.

7. References
Improved Catalytic Hydrogen Production from Formic Acid Decomposition
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 b Materials & Surface Science Institute, University of Limerick, Limerick, Ireland.

Abstract
Vapor phase formic acid decomposition was investigated to produce hydrogen at low temperature (<400 K) with doped and undoped catalyst Pd/C. The activity was improved significantly by doping Pd/C with Potassium with the reaction rates increased by 1-2 orders of magnitude. Surface potassium formate and/or bicarbonate species could be involved in this reaction.

1. Introduction
Formic acid decomposition has been used as a model reaction to investigate the catalytic mechanism since at least a century ago. Nowadays, as a product of formic acid decomposition, hydrogen is considered as an alternative clean secondary energy resource. More and more researchers are focusing on the hydrogen production from this reaction, as formic acid is one of the main productions by biomass Biofine process [1].

In previous work [2, 3], Pd/C catalysts were found to be quite active for the decomposition of formic acid at low temperature giving hydrogen with high selectivity. Here, we modified Pd/C with potassium here in order to get higher catalytic activity.

2. Experiment
K2CO3 (Sigma-Aldrich) solution were dropped into 1 wt.% Pd/C (Sigma-Aldrich) in beaker, followed by Ultrasonic for 4 hours, dry at room temperature for 12 hours and 105°C for 12 hours in oven to get 10:1 K-Pd/C. Reduction process was needed before reaction.

Pd/C (68 mg) and K-Pd/C (75 mg) were placed in a quartz tubular reactor of 4 mm internal diameter. 2 vol. % vapor phase formic acid/He with a total flow rate of 51 cm3 (STP) min-1 was introduced into the flow reactor. The reactants and products were analyzed by a gas chromatograph (HP-5890) fitted with a Porapak-Q column and TCD detector.

BET, TEM, EDS, XPS, XRD and Chemisorption were used to characterize the properties of catalysts.

3. Results and discussion
Improvement catalytic activity of catalysts in formic acid decomposition was obtained by doping Pd/C with Potassium.

Fig. 1 shows Arrhenius plots for the reaction rates in the formic acid decomposition on the 1 wt.% Pd/C catalyst with and without addition of 10 wt.% of K [4].

for the undoped and doped Pd/C samples. For example, the rates increased by a factor of 25 at 343 K and the activation energies (Ea) for the undoped and doped samples were 65 and 97 kJ mol-1, respectively.

4. Conclusion
Modified catalyst K-Pd/C was prepared by impregnation method. Significant improvement of catalytic activity and selectivity was obtained by the doping with Potassium.

5. References
Influence of the Pig Manure Separation System and Pyrolysis Temperature on Biochar Sorption Properties

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Abstract
The sorption of Cr(III) ions on various pig manure biochar (BC) samples was investigated to determine the effect of operation conditions (initial pH, sorbate and sorbent concentrations) on sorptive capacity. The data indicate that the technology used for separation of the manure and pyrolysis temperature had a significant influence on the physical and chemical properties of the BC and affected it’s sorption capacity. The maximum Cr(III) uptake of 102mg/g for the BC sample was achieved at C0 = 300 mg/dm³ and pH = 5. It was also found that for the same sample and at the same sorption conditions the maximum Zn(II) ions uptake was 33 mg/g. The BC samples with higher sorption capacity were rich in alkaline metals that was measured by ICP-OES and high surface area.

1. Introduction
Pig manure can be converted into gas, vapours (which condense to crude oil) and char (biochar). The biochar (BC) is usually a highly porous solid material, with a high mineral matter and ash content [1]. Both the structure and ash content make the BC a material with good sorptive properties for heavy metal ion removal from solution. The BC structure and ash content are influenced by many factors related to the nature of the mainly to the different separation process used and pyrolysis conditions used, especially the temperature. The nutrient-rich solid fractions from several different separation technologies were applied in this study: chemically pre-treated slurry with subsequent mechanical pressing (KEM), anaerobically-digested slurry separated using a decanter centrifuge (DEC) and simple mechanical separation (MEC). All the aforementioned technologies affect feedstock properties. Moreover, the process of heavy metal sorption on the BC can be influenced by the biochar morphology, sorption conditions (pH, temperature) sorbate type and its concentration.

2. Cr(III) sorption on biochar
Experiments were undertaken to determine the effect of separation technology and pyrolysis process condition on the morphology of pig manure biochar. The effect of pH, ion concentration and pyrolysis temperature on the sorption of Cr(III) ions on various BC samples, was investigated. Due to its high mineral content and the possibility to adsorb or desorb desirable/undesirable ions, the pig manure BC is a potentially good fertilizer and/or sorbent. The experimental data indicate that the separation technology and pyrolysis temperature had a considerable influence on the sorption capacity. The influence of the different separation system for BC produced at 400 and 600°C on the maximum sorption capacity of Cr(III) is reported (Table 1).

Table 1. BC properties and maximum sorption capacity for different separation technologies and pyrolysis temperature

<table>
<thead>
<tr>
<th>BC sample</th>
<th>DEC6</th>
<th>KEM6</th>
<th>MEC6</th>
<th>MEC4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature,°C</td>
<td>600</td>
<td>600</td>
<td>600</td>
<td>400</td>
</tr>
<tr>
<td>Ash content wt.%</td>
<td>55.5</td>
<td>52.4</td>
<td>31.8</td>
<td>30.3</td>
</tr>
<tr>
<td>Surface area, m²/g</td>
<td>35.7</td>
<td>53.2</td>
<td>22.9</td>
<td>21.1</td>
</tr>
<tr>
<td>Max. sorption capacity, mg/g</td>
<td>102</td>
<td>40.0</td>
<td>25.9</td>
<td>18.7</td>
</tr>
</tbody>
</table>

3. Conclusions
Application of various pig manure pre-treatment methods influences the properties of BC’s. The BC samples derived from the chemical (KEM) or biological (DEC) pre-treated pig manure samples have better sorptive properties compared with the BC obtained from simple mechanical separation (MEC). These samples had also higher mineral matter content and surface area when compared to the just simple mechanical pretreatment. The BC obtained at higher pyrolysis temperature had higher sorption capacity under the same conditions. The BC has a considerable capacity for Cr(III) and Zn(II) sorption.

4. Acknowledgment
This research was partially supported by The Danish Council for Strategic Research, Danish Ministry of Science, Technology and Innovation, the program for sustainable energy and environment the project CLEANWASTE (Project no. J. nr. 2104-09-0056).

5. References
Autothermal Performic Acid Pretreatment for Rapid Fractionation of Biomass

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Abstract
A novel approach to the performic acid pulping of biomass enables effective delignification and fractionation in a short time. A concentrated caustic solution initiated the autothermal decomposition reaction of hydrogen peroxide in a formic acid solution containing lignocellulosic biomass (i.e. Miscanthus x giganteus, sugarcane bagasse). The exothermic reaction of the peroxy-compounds resulted in temperatures of 50 to 180°C and pressures of 0.5 to 7 MPa. These conditions observed during the treatment depended on the concentration of hydrogen peroxide (2.5-7.5 wt% H2O2) during the experiments. Analysis on the solvent and the final cellulosic pulp was carried out. When the highest hydrogen peroxide concentrations were utilized, the removal of lignin and hemicellulose from the biomass was higher than 85%.

1. Introduction
Although lignocellulosic biomass have a great potential as a transitional fuel source and platform chemicals feedstock, the sustainability of these technologies rely on the versatile use of its components. The approach presented in this study is intended to provide an alternative method for the pretreatment of biomass. Additionally this alternative offers a relevant advantage related to the short time-frame of the process and the energy supplied by the exothermic decomposition of the hydrogen peroxide.

2. Experimental work
A closed reaction vessel of 8-L was used for the experiments. The sample of biomass (150-300 g), i.e. Miscanthus and sugarcane bagasse – SCB, was placed in the vessel with a solution of hydrogen peroxide in aqueous formic acid (2.5-7.5 wt% H2O2; 70-75% formic acid). The mixture was thoroughly stirred. An initial sample was taken and 125 ml of 4M NaOH solution was injected to the system. Samples were taken at different times and analyzed to determine the composition of the liquor throughout the experiment. After reaching the maximum temperature, the system was left to cool until room temperature. The mixture was then filtered to recover the liquid stream (in which the lignin was dissolved), while the solid fraction was further washed and dried. The untreated biomass and the treated pulps were analysed for carbohydrates and lignin content following a standardized method developed by the National Renewable Energy Laboratory [1].

3. Results
A steady increase in temperature and pressure was observed once the solution of sodium hydroxide was injected into the system and the decomposition of H2O2 was initiated. The maximum temperature and pressure were proportional to the energy stored in the H2O2 content in each of the experiments.

The response variables studied were the solid yield (SY%), the delignification yield (LR%), the hemicellulose removal (HCR%) and glucan removal (GR%). All these variables were measured by comparing the carbohydrates and lignin content in the initial feedstock and the treated pulps. An extensive delignification was observed for both feedstocks and up to 90% and 96% of lignin was removed from Miscanthus and SCB, respectively. Hemicellulose (HC) fraction in both feedstocks was fully removed (90-98% of the initial HC) under the treatment conditions studied in this work.

Figure 1 – Comparison of the pretreatment at different hydrogen peroxide concentration for Miscanthus x giganteus and SCB.

3. Future work
Further experimental work is being carried out to evaluate the effect of other parameters, such as the biomass loading, on the reaction rate and delignification yield during the treatment. Additional work will include the study of the mechanism of reaction of the peroxy-radicals during the catalytic decomposition. This will be assessed through the analysis of the gas formed during the reaction and the analysis of the degraded lignin compounds.

8. References
Groundwater as a Drinking water supply; an assessment of the effect of geological features on the prevalence of microbiological and chemical pollution.

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Abstract

This project aims to investigate the relationship between the geology and hydrology of different aquifer types and the subsurface transport of pollutants. Groundwater samples from domestic private well water supplies are taken in areas with varying geological properties. The samples are then tested for both chemical and microbiological indicators of anthropogenic pollution. The data obtained will provide insight into the spatial distribution of areas with ‘poor’ groundwater status as defined in the Water Framework Directive (2000/60/EC). It will highlight areas of environmental health concerns in relation to the abstraction of groundwater for drinking water purposes.

Introduction

Some 7% of the population of Ireland derives their potable water from over an estimated 191,799 private supplies. The majority of these are very small domestic supplies serving a single property (PWS) or a small group of properties as in a private group water Scheme (pGWS). Treatment for such supplies is rudimentary or most often non-existent and their microbiological and chemical quality has been shown repeatedly to be in breach of the European Communities (No.2) regulations, 2007. Public Health authorities, in both developed and undeveloped countries rely on the use of sanitary set back distances between animal and human waste disposal sites and drinking water wells, with the intent of protecting human health(Berger 2008). Unfortunately, in Ireland these distances are not based on the unique hydrogeological properties of the area, despite the well documented knowledge that the risk of faecal contamination varies greatly in different aquifer types. The sensitivity of the aquifer is paramount to the risk of contamination. Approximately 26 per cent of the public and private drinking water supply in Ireland is provided by groundwater or spring sources (EPA, 2008a) .Accredited to the decentralisation of rural Ireland, the majority of small Private Water Supplies and small private group schemes are reliant on solely on the abstraction of groundwater which often have inadequate treatment, and in many cases, no treatment at all. This lack of supportive infrastructure heightens the need for source protection, pollution prevention and the implementation of singular or group treating regimes to ensure that the quality of the drinking water conforms to the Drinking Water Regulations (S.I.278 of 2007).

Methodology

All samples were tested in accordance with the Wealth Health Organisation Guidelines for Drinking Water Quality, Third Edition (WHO 2008).

Results:

To date, the focus has been on the microbiological quality of groundwater. 27 samples were taken from different geological locations across Munster. They were analysed using the IDEXX Coliert 24 system for the presence of Total and Faecal Coliforms (E.coli) in accordance with ISO 9308-1. The results are shown in Table 1.

<table>
<thead>
<tr>
<th>Indicator Microorganisms in Irish Groundwater</th>
<th>Indicator Organism</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TotalColiforms</td>
<td>E.coli</td>
<td></td>
</tr>
<tr>
<td>Limerick</td>
<td>6(100%)</td>
<td>3 (50%)</td>
<td></td>
</tr>
<tr>
<td>Clare</td>
<td>8 (100%)</td>
<td>5 (62.5%)</td>
<td></td>
</tr>
<tr>
<td>Cork</td>
<td>5 (42%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19 (70.3%)</td>
<td>8 (29.6%)</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Number and % of Groundwater supplies with Total Coliforms and E.coli.

Conclusions

The prevalence of E.coli across Munster, which in some areas has shown to be as high as 62.5% is a major concern for public health. Further research hopes to quantify the risk of Faecal contamination as a function of aquifer type. The presence of chemical pollutants will also be examined over the course of this study.

References:


Abstract

Analytical pyrolysis-gas chromatography/mass spectroscopy (Py-GC/MS) combined with a separate catalyst reactor was used to carry out fast pyrolysis of Miscanthus x giganteus and on-line analysis of the product vapours. Pyrolysis was carried out in a highly reducing atmosphere of H₂.

1. Introduction

Bio-oil, an important product from biomass pyrolysis, can be regarded as a low grade fuel in its crude state. Many pyrolysis process parameters, such as temperature, pressure, heating rate, reactor configuration, biomass type and particle size have been extensively studied [1 & 2]. The crude bio-oil possesses many unfavourable properties, such as high acidity, high aromaticity, high viscosity and are chemically unstable, thus has very limited use. In order to create a fungible fuel from this process the bio-oil must undergo an expensive upgrading process, which is not economical.

The problems with bio-oil largely stem from the high oxygen content and a low effective H/C ratio. In order to overcome these issues, pyrolysis can be carried out in a hydrogen atmosphere. Hydro-pyrolysis rapidly adds hydrogen to the biomass fragments, removes oxygen and caps free radicals, as soon as the biomass devolatilizes. Oxygen removal is rapid, particularly at elevated hydrogen pressure and with the help of an effective catalyst. This will result in the formation of a hydrocarbon rich oil with a significant reduction in oxygenates.

2. Experimental

Hydro-Pyrolysis was carried out using a CDS Analytical 5200 pyroprobe. This instrument contains two separate reactors, the first of which is for pyrolysis, the second is a catalyst reactor. For all experiments 1.5 mg (± 0.01mg) of Miscanthus x giganteus (M) was used. The heating rate for pyrolysis was 20°C/ms and the biomass was then held at 600°C for 20 s. After pyrolysis the vapours passed through the catalyst reactor held at 300°C. The catalysts used during the study were Ni (2.5 & 10 wt%) supported on ZSM-5 and MCM-41.

3. Results/Discussion

The low pH, from the presence of carboxylic acids, and in particular ethanoic acid in oils is a major concern. Carboxylic acids make the oils corrosive and also promote many undesirable reactions during storage. Therefore it is important that any bio-oil upgrading method should decrease the amount of ethanoic acid. Figure 1 shows that all catalysts lowered the ethanoic acid content, the effect was greatest for 10%Ni on MCM-41 and ZSM-5. With the introduction of H₂ as the carried gas, even when no catalyst was applied, there was about a 20% decrease in the ethanoic acid concentration.

Figure 1. Effect of selected catalysts on ethanoic acid concentration.

Deoxygenation of ethanoic acid occurs mainly via a decarboxylation reaction pathway, and to a much lesser extent by dehydration [3]. The primary degradation products from ethanoic acid in the presence of both H₂ and the catalysts was CO₂, and lighter components which could not be detected.

Other results from this study show a significant decrease in high molecular weight compounds, particularly large phenolic molecules, which will lower the viscosity of the bio-oil. A large improvement in the level of hydrocarbons was also observed. All results indicate that both hydrogen and the catalysts play an important role in the formation of a high quality bio-oil.

4. References

Torrefaction of Miscanthus x giganteus.

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Abstract
Torrefaction of Miscanthus has been performed to investigate the effects of process variables on the properties of the fuel. The torrefied MxG has favorable properties compared to the raw material.

1. Introduction
Torrefaction is a thermal pre-treatment process that involves heating biomass to moderate temperatures between 200°C and 300°C under an inert atmosphere [1]. It is an effective method to improve energy density, grind ability and hydrophobicity of biomass.

Miscanthus x giganteus (MxG) is considered as a promising energy crop cultivated widely across Europe, due to its rapid growth, low mineral content, high biomass yield and favorable carbon balance [2]. However raw MxG shares the same weaknesses as other biomass, such as low bulk density, low energy density and non uniform physical and chemical properties, which result in storage complications, lower thermal-conversion efficiency and utilization limitations. In order to facilitate the utilization of MxG, its properties need to be modified.

2. Experiment
Torrefaction experiments were undertaken both in a horizontal furnace as well as using thermogravimetry. Thermogravimetric analysis (TGA) was carried out to illustrate the changes in chemical composition of MxG under torrefaction conditions. The horizontal furnace was used to prepare more materials for further analysis. MxG was torrefied at four different temperatures: 230, 250, 270 and 290°C for 10 and 30 minutes in a purge of N₂. Physical and chemical properties of raw and torrefied biomass were analyzed and mass and energy yield was calculated. Analysis included: moisture, ash and volatile matter content, fixed carbon as well as the C, H, N and S content, heating value, chemical composition, contact angle and concentration of elements in the ash.

3. Material
The biomass feedstock used in the study was Miscanthus x giganteus with particle size between 200μm-1.5 mm.

4. Scope of the study
The objective of this study was to investigate the impact of torrefaction temperature and residence time on the fuel properties of Miscanthus x giganteus.

5. Results and discussion
The content of hemicellulose in torrefied biomass decreased with the increase of temperature and residence time. The hemicellulose was completely decomposed during the most severe torrefaction conditions. The cellulose and lignin underwent limited decomposition reactions at torrefaction temperatures below 270°C.

The moisture content of torrefied MxG decreased significantly (varying from 1.39 to 2.9%) compared to that of raw material (9.69%). The volatile matter content decreased from 80.60 to 32.45% and the fixed carbon content increased correspondingly from 13.07 to 57.82% comparing to 3.94% (raw) and it was closely related to the intensity of torrefaction. The ash content increased (varying from 4.26 to 9.37%) compared to that of raw material (4.04%). The relative concentration of most elements/minerals in the ash slightly increased except the chlorine content which falls after torrefaction and this may have benefits for thermo-chemical conversion processes.

The heating value of torrefied MxG was higher than that of raw material (18.360 MJ/kg) between 19.10 and 26.59 MJ/kg. Contact angle increases with an increase in torrefaction temperature and is greater than 90°, suggesting that torrefied biomass is more hydrophobic.

The raw MxG is characterized by high oxygen content (45.54%) and relatively low carbon (47.63%) and hydrogen content (6.19%); from this perspective it can be classified as a low heating value biomass. After thermal pretreatment O/C and H/C ratio decreased and properties of torrefied MxG were similar to peat in terms of its fuel classification.

6. Conclusion
From the analysis of fuel properties it can be concluded that the optimal process conditions for torrefaction of Miscanthus x giganteus are: 250°C and 30 min. The mass and energy yield for these conditions were 71.6% and 85.1% respectively.

7. Reference
Controlled Growth of Si Nanowires using a Simple Solution Based Approach

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Abstract
Herein, we present the growth of Si nanowires (NWs) using a newly developed, high boiling point organic solvent synthetic system. The NWs were formed in high density on a variety of substrates through the use of In catalysis. The NWs show excellent potential for Li ion cell anodes due to the high capacity of both Si and In.

1. Introduction
Si NWs have attracted a huge amount of research interest due to their potential in devices ranging from transistors to photovoltaics and lithium ion storage components. The majority of solution based, Si NW growth methods require temperatures which are not easily attainable in conventional organic solvents, to allow decomposition of organometallic precursors. As a result, typically used approaches require supercritical media which are not suited to NW growth directly on substrates. The development of alternative, cost effective growth methods which allow the growth of Si NWs on substrates is crucial if Si NW based devices are to reach their full potential.

2. Results
We have recently developed a Ge NW growth system within a high boiling point organic solvent medium. The method allowed the formation of high density Ge NWs on various substrates using a simple glassware based system. Here, we show that this HBS system can be extended to the growth of crystalline Si NWs by choosing the appropriate reaction conditions, catalyst material and organometallic precursor (Figure 1 a). The NWs were characterized using electron microscopy and the relationship between the catalyst seeds and the NWs was identified.

Figure 1: Schematic of In catalyzed Si NW growth.

The NWs were formed in high density on a variety of substrates (Figure 1 b). TEM analysis was used to investigate the role of the In catalyst (Figure 1 c) in allowing the growth of crystalline Si NWs (Figure 1 d). Cyclic voltammetric measurements on the NWs showed that both the Si NWs and In catalyst particle were involved in alloying and dealloying with Li, indicating their potential for use in Li ion cells.

3. References
Synthesis of Ternary and Quaternary I-III-VI$_2$ Semiconductor Nanocrystals for Integration into Low-Cost Solar Cells

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Abstract
Copper-based ternary and quaternary chalcogenides, namely CuInS$_2$ and CuIn$_x$Ga$_{1-x}$S$_2$ (CIGS), have recently attracted a great deal of attention as direct band gap materials for the fabrication of high-efficiency thin film photovoltaic devices. Herein, we present the growth of monodisperse wurtzite CuInS$_2$ and CuIn$_x$Ga$_{1-x}$S$_2$ (CIGS) in size-controlled nanorod form using a facile solution-based method. The nanorods were subsequently assembled by solvent evaporation methods and align perpendicular to the substrate, which is the most viable architecture for functional application of nanorod assemblies.

1. Introduction
The application of ternary and quaternary I-III-VI$_2$ semiconductors in thin-film solar cells is readily appreciated due to their high optical absorption coefficients, high energy conversion efficiencies, good photostability against long-term radiation and desirable band gap which matches well with the solar spectrum.\textsuperscript{1-3} In state of the art devices, CIGS layers are deposited by sputtering or multistage coevaporation techniques – processes which are expensive, time consuming and yield uncontrolled stoichiometry over large device areas.\textsuperscript{4} Advances in colloidal nanocrystal chemistry are paving the way for new routes to ternary and quaternary semiconductor materials, with significant potential for low-cost, solution processable solar cells. Extending nanocrystal synthesis to rod formation has several critical advantages, with their subsequent assembly resulting in elevated efficiencies of current nanocrystal-based photovoltaics.

2. Results
By manipulating reaction conditions, we have successfully synthesized high quality, monodisperse CuInS$_2$ and CuIn$_{0.75}$Ga$_{0.25}$S$_2$ (CIGS) nanocrystals in size-controlled nanorod form. These nanocrystals crystallize in the hexagonal wurtzite phase which is not just attractive for shape control, but also allows wide range tuning of the band gap. The high degree of monodispersity and absence of branching in these nanocrystals allows their subsequent assembly into perpendicular superlattices (Fig 1a,c) by a solvent evaporation technique. The top down TEM view (Fig 1b) shows that the nanorods are azimuthally aligned along their crystal facets and are spaced by interdigitation of the long chain alkyl ligands. The HRTEM image (Fig 1d) shows lattice fringes with a spacing of d=0.317nm, which corresponds with the (002) lattice plane of the wurtzite CIGS structure.

Figure 1. TEM images of CuInS$_2$ and CuIn$_{0.75}$Ga$_{0.25}$S$_2$ nanorod assemblies. (a) Large scale assembly of CuInS$_2$ nanorods. The inset shows the corresponding SAED pattern. (b) HRTEM image of a; (c) Large scale assembly of CuIn$_{0.75}$Ga$_{0.25}$S$_2$ nanorods; (d) HRTEM image of c.

3. References
Methods for evaluating sustainability policies in small Irish settlements
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Abstract
There is a strong political desire for the comprehensive assessment of changes in economic, environmental, and social conditions, but this has proved difficult because of competing characterisations of sustainability and a lack of hard evidence [1]. It is vital that we are able to measure sustainability in order to check whether a new policy, decision or technical innovation is making things better or worse [2]. Put simply, what gets measured gets done: if it cannot be measured it cannot be managed. This research reports a method for the evaluation of policies to enhance urban sustainability, using a metric, which is designed to be policy-relevant in that it is both quantitative and usable by decision makers.

1. Introduction
Approximately 75% of green house gases (GHG) are associated with lifestyle choices, with transport and household based consumption being responsible for the largest shares, concentrated in urban areas [3][4]. This consumption is important in national and local scale policy development for reducing GHG emissions. It has been difficult to prioritise urban sustainability policy roll out as it has not been possible to estimate sustainability savings associated with candidate policies. The Sustainability Evaluation Metric for Policy Recommendation (SEMPRe) approach [5] outlined in this research seeks to address gaps in our knowledge by developing a method and metric based in multiple indices, with the ability to evaluate sustainability policies and inform policy decisions at both a specific and broad level.

2. Method
Within this method Irish urban areas are characterised through a set of environmental, social and economic indicators measured using an existing database of c300 pieces of information for 79 urban areas studied [6]. SEMPRe is based in 40 sustainability indicators, grouped under the 4 policy areas of environment, quality of life, socio-economic and transport. This range of information is used in calculations of the likely impacts of policy implementation.

Following modeling through SEMPRe the selected policies are feasibility tested to identify where cumulative sustainability gains are greatest in determining policies to select for bundling. This may also assist in the identification and avoidance of policy implementation which results in overall reduction in sustainability through exploring rebound and backfire effects, as described by Druckman et al. [7].

3. Conclusion
This research provides results which facilitate comparisons between the likely impacts of the implementation of policies. Fresh insights have emerged. It is clear that some policies will have greater impact in some settlements, and less in others (resulting from e.g. differences in population and location). This allows identification of two sets of policies: those with more or less universal application, and those which are appropriate in only some types of settlement. Tailoring policy implementation to settlement attributes increases the chances of achieving sustainability goals.

The method has wide application and is adaptable: sustainability indicators within SEMPRe can be changed for more specialised testing. While developed to date using Irish urban data, the method and metric has international application. The method is not claimed to be foolproof but it is much more likely to provide decision makers with evidence to promote innovation than the current situation where decision makers are making policy decisions with little quantitative evidence to support or inform decisions.

4. References
Has the Use of Biocides in Dairy Farming Contributed to the Development and Spread of Antibiotic Resistance in Microorganisms?

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Abstract
The increase and spread of resistance to antibiotics linked to reports of co- and cross-resistance between antibiotics and biocides raised speculations on potential hazard of biocide use. Biocides are antimicrobial agents that have been in use for hundreds of years for disinfection, antisepsis and preservation. They are used in all areas of the food industry and are widely available in household products for cleaning purposes and play a key role in animal husbandry. Despite this widespread use most fungal and bacterial species remain susceptible to biocides. However over-reliance and inappropriate use of biocides has led to the emergence of biocide tolerant pathogens. Biocide tolerance has been reported in common foodborne pathogens, such as E. coli and Salmonella spp. This resistance could be linked to cross-resistance to antibiotics and a potential public health risk.

1. Introduction
Over recent years unquantifiable amounts of biocides and antibiotics have been released into the environment. The scientific committee SCHENIHR documented that it was not possible to obtain any tonnage information on the dissemination of biocides (E.C., 2009). However little is known about the effects of these chemicals on bacteria found naturally in the environment. Furthermore, water sources, sewage and other wastes have been polluted with sub-lethal concentrations of biocides and antibiotics. This sub-lethal application could lead natural microbial populations developing a new resistance. To prevent biocide and antibiotic resistance it is important to incorporate best practice, this includes ensuring disinfection and environmental guidelines are in place. This is especially relevant in the farming sector where significant quantities of disinfectant are used daily under varying conditions. Increased awareness and improved farming practice could lead to better hygiene and therefore minimise antibiotic resistance spread.

It is predicted that the biocide industry is expected to grow up to 4-5% over the next few years, with the growing usage in developing nations to improve hygiene. This had led to biocide regulations being reviewed worldwide. These regulations would harmonise biocidal products and there active substance. Biocides are frequently used for the disinfection of surfaces and play a key role in the elimination of pathogens. There are a number of disinfectants used in industrial and institutional use, with the most common being Quaternary Ammonium compounds; this is due to their stability and toxicology (Johansson and Somasundaran, 2007).

However, resistance has been reported against different type of biocides. This resistance could lead to co- and cross-resistance between antibiotics and biocides.

Bacteria have many bacterial resistance mechanisms to prevent the effect of biocides on a bacterial cell. These mechanisms include antibiotic efflux pump, antibiotic- degrading and altering enzymes and antibiotic genes, these mechanisms usually work in combination to lead to antibiotic resistance (Poole, 2002).

2. Methodology
Throughput screening of strains not resistance to antibiotics will be used for exposure testing and kill experiments. Phenotypic screening for reduced susceptibility to biocides, detection of novel resistance genes and mobile elements, and screening for their molecular epidemiology and metagenomics will be accompanied by methodological innovation for testing, risk evaluation and registration of biocides. Hygiene monitoring of dairy farms will be carried out to quantify potential outbreaks and examine the use of biocides in a dairy farm setting.

3. Discussion
This project will develop (a) standard protocol(s) for the quantitative assessment of biocide induced resistance and cross-resistance.

4. References


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A Roadmap for Navigating the Life Sciences Linked Open Data Cloud

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Abstract
Life Sciences Linked Open Data (LOD) Cloud currently comprises multiple datasets that add high value to biomedical research. The ability to navigate through these datasets in order to derive and discover new meaningful biological correlations is considered one of the most relevant resources for the future of personalized medicine and the discovery of biological correlations in general. However, navigating these multiple datasets is not easy as most of them are available only as isolated SPARQL endpoints. There is an utmost desire by the researchers, practitioners and pharmaceutical industry workers to make use of these linked datasets to improve the drug discovery and development process. With the standardization of SPARQL 1.1, and its support for federated queries, it became possible to assemble queries that retrieve data from multiple SPARQL endpoints simultaneously. However, in order to match data from multiple endpoints, it is first necessary to understand which data exist in each endpoint and how that data can be queried.

We have devised an active roadmap for navigating the linked life sciences cloud that illustrates all the possible “roads” or “links” between concepts in the LOD cloud. The methodology for roadmap identification relied on retrieving all “types” (concepts) and properties associated with concepts from六十 Life Sciences related SPARQL endpoints and all properties associated with instances of each of those types. The entities collected (query elements) were then weaved together using three different approaches for concept and property matching: syntactic matching, semantic matching and domain matching. Our approach, if generalized to encompass other domains, can be used for road-mapping the entire LOD cloud.

1. Introduction
It is not uncommon for semantic web experts to publish datasets using their own vocabularies and terminologies without publication or reuse of ontologies. Although the publication of datasets as RDF is a necessary step towards achieving integration of biological datasets, we argue that it is not enough since it solves only the syntactic interoperability problem without addressing the “semantic” interoperability problem.

2. Methodology
Our methodology consists of two phases. During first phase we retrieved data from remote SPARQL endpoints. A method was devised to retrieve all classes (concepts) and associated properties (attributes) available through any particular endpoint by probing data instances. It is worth noticing that the number of classes per endpoint varied from a single class to a few hundred thousand classes in the case of one of the endpoints (http://miuras.inf.um.es/sparql/). Our ultimate goal was to create links between different similar concepts and properties to facilitate the navigation in Life Science LOD. During second stage following three approaches were used for matching and linking concepts:

- **Syntactic Matching**: Matching the labels using simple and advance string operations. For example Compound, Compounds and Chemical compound are classified as same concept. It is also termed as naïve approach.
- **Semantic Matching**: UMLS [1][2] vocabulary was used to classify concepts and properties based on similarity and relatedness. For example Drugs, Compounds and Molecules are termed as related concepts.
- **Domain matching**: It relied on identifying properties and concepts that uniquely identify concepts. For example, a SMILES [3] string uniquely identifies an instance of molecule. Whenever a concept is discovered with that property, was classified as a “Molecule”.

![Roadmap for Navigating Life Sciences (LOD)](image)

3. Conclusion
Our preliminary analysis of existing SPARQL endpoint reveals that most bio-available data cannot be easily mapped together. In fact, in the majority of cases, there is very little ontology and URI reuse. Furthermore, many datasets include orphan URI - instances that have no “type”; and multiple URI that cannot be dereference. Rather than exposing these, our roadmap is a step towards linking the Life Science LOD through different techniques including syntactic and semantic matching in case of reference able URI whereas domain matching and regular expression matching in case of non-dereference able URI.

4. References
[3]: Gerhard Kremer, Stefanie Anstein and Uwe Reyle, Analysing and Classifying Names of Chemical Compounds with CHEMorph
Enabling the next generation of personalisation applications

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Abstract

Personalisation on structured data faces new challenges, due to the increasing user expectations and newly available structured data about user interests from different sources and domains. We have identified the components required to leverage the Web of Data for personalisation, we propose an algorithm to exploit the available structured data for personalisation, and we suggest an architecture for reconciling user privacy with personalisation in federated eco-systems.

1. Motivation

Users have come to expect personalised experiences on major social web sites such as Facebook and Twitter. At the same time the amount of structured data, which is published on the Web, is constantly increasing. Major search engines such as Google, Yahoo and Bing already support such structured data.

2. Problem statement

How can applications take advantage of this new environment? We propose three related approaches for applications to provide personalisation using structured data.

3. Conceptual architecture for personalisation applications on the Web of Data [1]

Our conceptual architecture provides the fundamental building blocks for applications on the Web of Data by summarizing the state of the art. It is based on an empirical analysis of 124 Semantic Web applications over a decade.

Out empirical analysis indicates that FOAF, DC and SIOC are the most popular SemWeb vocabularies, RDF, OWL and SPARQL are the most popular standards.

We describe the following components: RDF store, graph access layer, data discovery service, data homogenisation service, graph query language service, graph-based navigation service, application logic, structured data authoring interface. In addition we identify the main implementation challenges, and suggest approaches for simplifying development of Semantic Web applications.


As data sources become increasingly more connected, an algorithm for leveraging linked open data for recommendations is required. The novel benefits of such a recommendation algorithm are two-fold: First it can provide recommendations using data from multiple sources, secondly it can take interests from many different domains into account.

As a first candidate approach, we have evaluated an extension of collaborative filtering for Linked Open Data. We were able to improve the precision by 12% and the recall by 26%, compared to a system which only uses closed data for the recommendation.

5. Architecture for federated, privacy-enabled personalisation [3]

The increasing expectation of personalisation on social web sites clashes with the user need for privacy. As there are different parties involved, which consume and publish information, an architectural approach is required in order to give back control to the user.

We propose to express profiles with Semantic Web vocabularies RDF and FOAF. For the purpose of authentication and authorisation we propose using WebID, an emerging standard for tying SSL keys to FOAF profiles.

In addition, our architecture prescribes a communication pattern between the different participants of the architecture. Our architecture can provide the foundation for a universal, user-centric ecosystem which will allow data sharing for personalisation while maintaining the privacy of the user at the same time.

6. Future work

We are currently in the process of implementing spreading activation as an algorithm to generate multi-source and cross-domain recommendations. We plan on evaluating the algorithm using DBpedia and publicly available social networking data.

6. Acknowledgements

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8. References

Finding Information Through Ad-Hoc Collaboration in the Virtual and Physical World

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I. MOTIVATION: THE BIG PICTURE

The Internet has become the largest and most popular source of information, and it is continuously growing. The demand for quickly finding the right information on the Web has spurred (and still spurs) the success of web search engines that apply sophisticated algorithms to crawl and analyze the Web. However, there are various common information needs that cannot be satisfied by using such search engines:

1) Complex information. Often the required information covers a broad spectrum, with all relevant pieces unlikely to be found on a single web page. Getting the full picture may quickly result in a lengthy process. Collaborating with like-minded people pursuing similar goals has the potential to speed up this process significantly. However, browsing and searching the Web is still mainly a single-user task.

2) Tacit knowledge. Tacit knowledge refers to one’s personal knowledge embedded in the person’s experience and involves less tangible factors (e.g., beliefs, intuitions, perceptions, etc.). By definition, tacit knowledge is very hard to convey by, e.g., verbalizing or writing it down en bloc. However, such knowledge may naturally elicit in more collaborative environments, like in a discussion between people.

3) Location- and time-specific information. Various information needs of users refer to both a specific location and specific, often short-term, time span. (e.g., “Is the advertised bargain still available that shop?”). In general, the answers to such questions are too specific and the time frame for their validity is too short to be put and maintained on a web page. Here, the best answers can give people that are currently on-site, intend to go or were (quite recently) there.

A first step towards finding information in a more collaborative way was to harness the “wisdom of crowds”. Online fora or Q&A systems, but also commenting sections on web pages allow users to share information. However, the communication in online fora and Q&A systems is asynchronous, and users typically have to wait for a reply. Thus, the degree of collaboration is still rather limited, which is particularly pronounced for questions requiring a quick answer. Furthermore, communities in such systems form in a rather explicit fashion. For example, users have to join a typically topic-specific online forum, or have to create and maintain a personal profile that reflects their interests, likings, expertises or (social) relationships. This rather static group formation does not reflect the varying information needs of a user.

II. SOLUTION OUTLINE

We propose the concept of presence as a means to allow users to collaborate with others in an ad-hoc manner. The intuition is that two users browsing the same page (or similar pages) at the same time share either common interests or looking for the same information. Our approach enables users (a) to be aware of each others presence and (b) to provide them with basic means to get in contact. To accomplish this, in a nutshell, we define the concept of a virtual location – as counterpart to a physical location – where users, if being at the same virtual location, are aware of each others presence. The definition of virtual locations is not obvious since the naive approach to assign a location to each URL is, in general, not reasonable, but calls for an intelligent grouping of pages to locations.

To push this idea even further, we aim to merge the concepts of presence in the physical and virtual space, exploiting the advances in mobile technologies to connect to the Internet from almost everywhere. Sharing the presence of people across the virtual and physical space enables entirely new ways to establish interactions between them. Given their different characteristics, fusing the virtual and physical space is challenging. While mapping, e.g., the website of a shop to its physical location is straightforward, we also envision more elaborate schemes that allow, e.g., users watching a clip about Galway on YouTube to get in contact with people currently visiting Galway. To establish such mappings sophisticated techniques are required, e.g., (semi-)automated processes based on folksonomies or letting users directly create links between virtual and physical locations.

III. CURRENT SYSTEM ARCHITECTURE

To demonstrate our ideas we already feature a prototypical system implementation. As front end, we provide (a) a web browser add-on for the seamless integration of presence mechanisms into the normal browsing experience of users, and (b) a mobile application for Android devices. These tools enable both Internet and mobile users to be aware of and talk to others close by regarding both physical and virtual locations. The core of the back end comprises a knowledge base for the mapping between virtual and physical locations. For the time being, the knowledge base features information about the websites and respective physical locations of public facilities (e.g., bars, hotels, shops, etc.) in County Galway.

1 Screenshots available on http://vmusm02.deri.ie/presence
A Citizen Sensing Platform for Monitoring Traffic
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Abstract
Citizen Sensing comprises the three entities of the Social, Mobile and Semantic Web and through implementing technologies from these three fields tries to add meaning to social media posts. By harnessing, the power of services like Twitter, Semantic Web standards like SIOC and the SSN ontologies, then by combining these with sensor/multi-sensor data from mobile devices, this work aims to create citizen-sensor-networks often where large sensor networks are not currently feasible. Currently this work is related to Galway City traffic reporting using mobile applications.

1. Introduction
Neil Gross in 1999 foresaw that “In the next century, planet earth will don an electronic skin. It will use the Internet as a scaffold to support and transmit its sensations” [1]. This view of sensors as ubiquitous and being embedded into our everyday environment can be seen as an accurate description of human-sensor interaction today with the advancements in wireless sensor networks and with the huge growth in the use of mobile devices which contain multiple sensors. Furthermore, social media can provide an important insight into people’s lives, lives in this instance can describe both offline and online and the combination of online and offline. It is in this combination of social media data and sensor data can help users get involved in participatory or citizen sensing [2] projects.

2. Mobile Sensing
Mobile devices commonly contain many sensor formats that support information like location through GPS or cell location to create/add context to Microposts, which companies like Foursquare use to create a geo-social gaming/marketing platform. Implementing mobile device systems to collect user situational data is labeled as either participatory/citizen sensing, which requires explicit user actions to share sensor data, or as opportunist sensing where the mobile sensing application collects and shares data without user involvement [3].

4. Social Web
The growth in popularity and usage of microblog publishing services has led to a surge in data created by users; these low-effort formats have removed some of the barriers for users to post to the Web. As microblogging lends itself to almost instantaneous updates, creation of data related to events, in this case traffic events, around the world is posted before it is reported on by traditional media and even by blog or blog-like services.

5. Semantic Web
SIOC allows the semantic interlinking of content items from forums, blogs and other social websites, and aims to enable the integration of online community information. SIOC provides a Semantic Web ontology for representing rich data from the Social Web using the Resource Description Framework (RDF). By describing the social data contained within online communities (powered by blogs, wikis, and forums) using semantic technologies, SIOC enables this data to become a “Social Web of Data”. The combination of the SIOC and the SSN ontology and creating an alignment between the two allows for enriching of social data with sensor data/metadata [4].

7. Proposed Solution/Conclusion
Citizen Sensing is an emergent field combining different aspects of the Social Web, Semantic Web and sensor networks, where mobile devices controlled by human members of the network from the sensor networks. The aim of this work is to make data relevant to Galway road users accessible, relevant and timely and to provide feedback to the user while driving and allow posting of this data to a discussion forum.

8. References
Evolutionary clustering and analysis of user behaviour in online forums

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1. INTRODUCTION

We use evolutionary clustering to group users of online forums into behavioural roles from their egocentric reply-graph and then analyse changes in the role membership of the users over time, the change in role composition of forums over time and examine the differences between forums in terms of role composition.

2. METHODOLOGY

We analysed 200 forums from Boards.ie and 14 forums from the SAP Community Network. Ten reply-graph features were extracted from each forum using pre-selected window sizes (seven, 15 and 30 days). Next, for each forum, users were clustered using an evolutionary extension to K-means. Finally, at each time step, behavioural roles defined in Table I are mapped to the clusters using the following decision rule.

Algorithm 1 Role labelling decision rule.

Input: Set of $K$ clusters $C$ with centroid means $\{ppr, inex, outex\}$

Output: Set of $K$ labels $L$

1. $\text{supporter} \leftarrow \{ c \in C : \text{argmax}_{c} (ppr_{c} + \text{inex}_{c} + \text{outex}_{c})\}$
2. $\text{ignored} \leftarrow \{ c \in C : \text{argmax}_{c} (1-\text{inex}_{c}) + \text{outex}_{c}\}$
3. $\text{grunt} \leftarrow \{ c \in C : \text{argmax}_{c} ((1-\text{outex}_{c}) + (1-|\text{inex}_{c} - \text{outex}_{c}|))\}$
4. $\text{elitist} \leftarrow \{ c \in C \}$
5. $L \leftarrow \{\text{supporter}, \text{ignored}, \text{grunt}, \text{elitist}\}$

3. RESULTS AND DISCUSSION

We found that certain roles were more stable between window sizes than others (Supporter, Ignored, Grunt users for the Boards.ie dataset and Supporters for the SAP dataset). Forums with higher activity (number of users) generally had better stability between window sizes. In some forums, considerable fractions of users maintain their roles over long periods. It was also observed that in some high activity forums, small groups of users, usually Grunts, maintained their behaviour for the entire analysis period. In other forums, such as Helpdesk or Soccer Access Requests, users rarely maintain their role for more than one time step due to the nature of the activity in the forum. Grunt users, defined as those users who communicate with few other users, were seen to be the most dominant role throughout most of the forums, especially in those that were more active, a finding supported by [1]. Only a handful of the analysed forums, particularly the high activity forums (e.g. Motors), showed stable role compositions over time. Other forums (e.g. SAP BO Core) had compositions that changed slowly and steadily over time. We found that generally the most active forums have similar compositions, however, some forums have very different compositions to the others (e.g. Soccer versus Soccer Access Requests) and can be explained by their nature which in turn governs the user behaviour.

Table I

<table>
<thead>
<tr>
<th>Role label</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supporter</td>
<td>Stable backbone of the forum; contributes useful content that yields replies</td>
</tr>
<tr>
<td>Ignored</td>
<td>Generally ignored by other users; in unmoderated forums spammers would fall into this role</td>
</tr>
<tr>
<td>Grunt</td>
<td>Communication with few users</td>
</tr>
<tr>
<td>Elitist</td>
<td>High communication with few users</td>
</tr>
</tbody>
</table>

Fig. 1. Evolutionary clustering of the After Hours forum from the Boards.ie dataset. The role heatmap (left) shows the behavioural role of each user at each time step and the area plot (right) shows the role composition (number of users) over time.
Reconstruction of Threaded Conversations in Online Discussion Forums

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1. What are we doing?
When acquiring online forum data for scientific or commercial purpose, the relations between forum posts are often not available. But in order to understand the context of the messages that belong to a conversation, the inter-message relations are needed.

We investigate how we can recover these relations in forum threads, such that it is clear which message is the reply to which previous message. In other words, we learn who replies to whom. Figure 1 illustrates this research problem in a nutshell. We take an unordered set of messages that belong to a thread (e.g. by scraping a page of a forum), and recreate the reply links between them. Therefore, we incorporate a machine learning classifier, whose task is to distinguish between replies and non-replies.

![Figure 1: Thread Reconstruction](image)

2. Why are we doing this?
There are a lot of social media platforms out there, such as blogs, microblogs, social networks and online forums. They are not (yet) as intuitive as face-to-face communication, so researchers study these platforms in order to improve their usability. For example, they investigate the interactions between users. Specifically, the users’ interaction in communities, their roles within the community, and how the information flows between the users. In order to investigate interactions, one needs to know the links between the people: It is vitally important to know who talks to whom.

From the different social media platforms we focus on recovering reply structures in online forums. Forums are an important part of the Internet, they contain archived knowledge about every kind of topic and provide a platform for people to exchange opinions. However, our method is not only applicable to forums, but can be extended to recover structures in other kinds of communication platforms as well.

3. How do we recover reply relations?
The reply relation between a pair of posts can be expressed by a number of properties, such as the time until the reply arrives, or the lexical similarity between the two contents. These properties are described as so called features. Figure 2 illustrates this scenario.

![Figure 2: Features describe reply relation](image)

4. How does the method perform?
We evaluated our method on the two forums Boards.ie and SAP Community Network, as well as on the mailing list TiddlyWiki. Figure 4 shows very good results for two of the datasets and a good result on the third one. The best result for the datasets was achieved by a different combination of features each.

![Figure 4: Classification accuracy](image)

5. What are our findings?
The results show a number of things: 1) Our method is applicable to mailing lists. That means that our method is not restricted to forums but, essentially, can be applied to various communication platforms; 2) The different numbers of accuracy indicate that there are different types of forums where our features are more or less effective; 3) Different features are required in order to achieve the best results on different types of forums.

The findings 2 and 3 lead to the conclusion that a selection of best training data and best combination of features is necessary for optimal results. Part of our future work is to investigate how to perform the selection for new forums.
Exploring Trends and Behaviours over Online Communities

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1. Introduction

Today’s Internet social media technologies have enabled very rich online communities. Community analysis is being done where interesting metrics like user/topics popularity or conversation dynamics can be obtained to better understand how they behave, evolve over time, churn, etc. We propose a framework to compute a number of user feature metrics over online forum-like communities. More important, this allows us to apply methods to enable comparisons between completely different metrics, and even across communities. Also we developed a visualization tool to interactively explore the resulting indicators.

2. Proposed Computation Framework

A linear processing architecture is proposed, working from the community raw data up to a final user feature metric value, as shown in figure 1. This approach works by applying three different functions inside the computation chain. A User Feature function computes the raw user features from the community data into a vector of values (each element corresponds to a user). Then, an Aggregation function is responsible for summarizing the vector and generalizing it into representative, smaller, values. For example, this function may compute histograms, means, variances, and other statistics. Finally, the Consolidation function transforms the summarized data into the final metric value, usually with a standardized semantic, and to perform value normalization (as explained in section 3).

![Figure 1: Proposed computation architecture](image)

Important challenges for such a processing scheme are: 1) communities datasets can be very large and 2), feature metrics have many different ranges and meanings. This architecture allows a great degree of function combinations, making it perfect for researching suitable normalization approaches. In addition, the processing can be done in parallel because the input data is easily separable into independent chunks.

3. Application Use Case

We choose three forum-like online communities: the TiddlyWiki development mailing list, SAP Community Network private forums and Boards.ie public forums. The User Feature metrics we implemented are: user in/out-degree, user popularity, reciprocity and forum activity as described in [1]. Those have very different output ranges and semantics.

The key for enabling feature comparison lies in the combination of the aggregation/consolidation functions applied. Aggregations chosen for the use case were different statistics indicators. The consolidation function is then a shaping process (see figure 2) which, together with a reference parameter, normalizes the final output value into a standard range/direction. All of this combined allows us to have uniform scaling and semantic across all metrics.

![Figure 2: Shape functions for consolidation](image)

We applied the above into a moving time window analysis to obtain charts similar to the one shown in figure 3.

![Figure 3: Multiple user features compared in time](image)

All metrics are normalized to the [0,1] output range, and oriented to have a “higher is better” direction. Because of this, some trends can be more clearly visible. For example, the user popularities remain almost the same (light blue line) while a drop of reciprocity (green line) can be appreciated. Those metrics originally had different ranges and opposite curve direction meanings.

4. Ongoing and Planned Work

This framework is still experimental. We are researching more advanced normalization approaches and also the ability to automatically compute the user-defined parameters for them, along with methods to adapt the framework to process online streams data (i.e.: Twitter and Facebook), with the aim towards community recommendation and attention management.

5. References

An Eigenvalue-Based Measure for Word-Sense Disambiguation
Ioana Hulpuș, Conor Hayes, Marcel Karnstedt, Derek Greene

Abstract

Current approaches for word-sense disambiguation (WSD) try to relate the senses of the target words by optimizing a score for each sense in the context of all other words’ senses. However, by scoring each sense separately, they often fail to optimize the relations between the resulting senses. We address this problem by proposing a HITS-inspired method that attempts to optimize the score for the entire sense combination rather than one-word-at-a-time. We also exploit word-sense disambiguation via topic-models, when retrieving senses from heterogeneous sense inventories. Although this entails the relaxation of several assumptions behind current WSD algorithms, we show that our proposed method E-WSD achieves better results than current state-of-the-art approaches, without the need for additional background knowledge.

1. Introduction

Word-sense disambiguation (WSD) chooses the correct sense of a word from a set of different possible senses. The set of possible senses are hereby usually obtained from one knowledge base, and the choice of the right sense is based on the observed context of the word. WSD plays an important role for a wide set of applications, such as information retrieval & Web search, entity resolution, concept recognition, etc. WSD is formally defined as follows. Given a set of related words, called target words, each target word has several possible senses. The problem is to find, for each target word, the appropriate sense in the context of all the other target words. This general WSD problem is usually extended by assuming that for each sense, we also have a bag of auxiliary related words.

Current WSD algorithms agree upon the intuition that, for a particular context, the correct senses of all target words should be related. The sense of a target word is usually chosen based on the connectivity of that sense to all the possible senses of all other target words and no measure of relatedness among the final chosen senses is computed. As we illustrate in this work, this results in problems in certain cases. In addition, modern web technologies make more and more heterogeneous sense inventories publicly available. This availability of diverse background knowledge is not exploited by most WSD algorithms that are highly-tailored for single inventories.

2. Our Approach

The contribution of our work is three-fold. First, we propose an eigenvalue-based measure, E-WSD, inspired by HITS (Hubs and Authorities) algorithm, which computes the relatedness within combinations of word senses to overcome the aforementioned drawbacks. We show that this method is suited to identify the optimal combination of senses without the need for any additional background knowledge. This results in an improved accuracy of WSD compared to current state of the art algorithms that rely on similar background knowledge, but select the right sense for one word at a time. Second, we base our approach for WSD on two different inventories: WordNet and DBPedia. We show that the inclusion of DBPedia results in a significant gain in accuracy compared to the traditionally exclusively used WordNet.

The third novel aspect of our work is that we exploit word-sense disambiguation via topic-models. This helps to reduce the complexity of WSD tasks for large text corpora. Although topic models have been used for document representation and extraction of related words for many years, word-sense disambiguation focuses mainly on disambiguation of words in the context of phrases. We show that the context created by a topic can be used to improve disambiguation performance, by amplifying the relatedness between target words appearing in the same context. The use of topics and heterogeneous sense sources entails the relaxation of several assumptions behind current WSD algorithms, and consequently the emergence of new challenges. First, there is no unified structure to connect the senses. Second, within topics it is not clear what part of speech the words have been used with. Third, the sense source might be intractable or require many resources for pre-processing. We believe that these challenges have to be faced by modern WSD algorithms in the current text, where more and more data and data sources are made available.

3. Results and Conclusion

Figure 1 presents the results we obtained after a comparative evaluation. The ground truth data was collected during a two week crowd sourcing experiment.

As seen in the figure, our algorithm E-WSD achieves a significantly better word sense disambiguation accuracy.
Rule Modeling for a Context-Aware Environment

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Abstract

In this abstract paper, we describe how we can achieve context-aware recommendation and task automation in the di.me project. We discuss how the di.me Rule Management Ontology (DRMO) and the system Context Listener will help us in this regard.

1. Introduction

Pervasive computing has been around quite some time and with smart devices nowadays, effort is being directed in creating solutions based on context-aware environments. One of the objectives in di.me is to learn about the user’s context through their personal devices and other online sources, and to provide context-aware recommendations and automation of tasks. In this paper we will briefly discuss how users are able to define and manage rules in di.me to reach the mentioned objective.

2. Aims and Objectives

This work aims (i) to create a rule definition model, and (ii) to show how this model will be integrated within the system to provide context-aware recommendations and automation.

The objectives which should be achieved in our work are (i) to allow the users to define and manage rules in the system to create automation of their repeated day to day tasks and situations, such as changing the state of a device when in a particular situation and (ii) to create a context listener which will detect any changes to the user’s Personal Information Model (PIM) and triggers a satisfied defined rule.

3. Approach

In di.me we introduce the di.me Rule Management Ontology (DRMO). Similar to work in rule modeling [1,2], this ontology supports rules based on the event-condition-action pattern

\[
\text{if } E[c_1 \ldots , c_m] \Rightarrow [a_1, \ldots , a_n]\text{,}
\]

where \(E\) consist of a chained combination of condition blocks which could trigger one or more actions. The condition blocks in a rule can be negated (not). Two or more conditions can be composed together using simple logic operators (and, or) and also ordered (succeeds, precedes).

In the DRMO model, rules can be constructed by (i) information elements from the NIE such as receiving an email, (ii) presence elements such as current device mode, and (iii) stored situations PIM. These rules will be stored in the PIM and used in the context listener to match any saved rule with the perceived context and thus triggering some action.

The approach we will take for our context listener is similar to the work in [1], where an ontology model is used as the backbone of a rule monitor. In the monitor, a controller inspects the perceived context data and checks for any rule which could be triggered. A notifier is notified by these rules that are satisfied and their action is triggered.

Our context listener will be monitoring for any events which cause changes to the user’s PIM. These events could be (i) the addition of new PIM items (such as receive a new email), (ii) a change in the PIM with regard to the user’s current environment, (in di.me we refer to them as presence elements, such as changing the state of a device), and (iii) switching to a different user-saved situation. In di.me a user-saved situation is a snapshot of the live-context. Situations are saved in the PIM and reflect a user's situation such as “at work”. Our context listener will subscribe to these events, and when one of them is triggered, it will check for any matching rule-block. If a match is found, then the event is pushed on a queue. An event remains on the queue until either (a) the queued presence element is changed by another one, or (b) a pre-set time window has passed. If at any point, the listener matches a rule, then that rule’s action is triggered and automation or a recommendation are given to the user. When a rule is triggered, the order of the events pushed into the queue becomes important when ordering-operators (‘succeeds’, ‘precedes’) are defined in the rule. On the other hand when the logical operators (‘and’, ‘or’, ‘not’) are used, the order is not considered as being important.

4. References


Acknowledgments

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1 http://dime-project.eu
2 http://www.semanticdesktop.org/ontologies/nie/
Turning dissenting opinions into networked knowledge

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Abstract

Although the Web enables large-scale collaboration, making sense of contentious issues remains challenging. Our research addresses the problem of turning dissenting opinions into actionable information. Using techniques from argumentation, knowledge representation, and social media mining, we analyse, extract, and represent disagreement in purposeful social web conversations, in order to support individual sensemaking and group decision-making.

1. Introduction

Although the Web enables large-scale collaboration, making sense of contentious issues remains challenging. Within organizations, a common complaint is that “we don't know what we know”. In Web-based organizations, the lack of integrated knowledge is an even larger and more pressing problem. Up to now, this has been partly addressed by aggregation, for instance to show the most popular products. Yet making sense of contentious issues remains challenging since the most popular choice is not necessarily best. Our goal, part of a new research area known as ‘competitive collective intelligence’, is to turn dissenting opinions into actionable information.

2. Approaches

Using techniques from argumentation, knowledge representation, and social media mining, we analyse, extract, and represent disagreement in purposeful social web conversations, in order to support individual sensemaking and group decision-making.

2.1. Argumentation

For opinions, the two most important types of dialogue [3] are persuasion—where the goal is to persuade a single person—and deliberation, where the goal is for a group to come to agreement. We argue that for reusing opinionated conversations, the dialogue type can provide valuable contextual information [2].

2.2. Knowledge Representation

We have described a knowledge representation to capture opinions and justifications that have been presented on the social web [1]. We can construct such a knowledge representation by hand, by finding opinions and representing the relationships between them. Aggregating over multiple peoples' viewpoints then yields a Viewpoint Web.

A Viewpoint Web can be used in multiple ways: for instance, to query for all opinions that give a supporting reason and that disagree with your current position; or as a knowledge base for an argumentative chatbot.

2.3. Social Media Mining

Contextual information helps us process conversations more quickly. With social media mining we want to extract certain key information about a conversation—who is involved, what is being discussed, when and where the conversation took place, and why (e.g. dialogue type) [3].

3. Sense-Making from Product Reviews

Reviews can be seen as persuasion dialogues, in order to convince a potential buyer to choose (or reject) a particular product. Using a domain ontology and discourse connectives, we are trying to automate the extraction of arguments, so we could create a Viewpoint Web automatically.


Wikipedia's decision-making uses consensus-driven deliberation. We have analysed a corpus of discussions based on several argumentative theories, to understand how dissenting opinions are synthesised.

5. Acknowledgements

SFI/08/CE/11380 and COST ICO801 STSM 1868.

6. References


Situation Matching for User Context

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Abstract
This effort is part of the di.me\(^1\) project and targets the development of an ontology-based context-aware information system that to automatically recognize any recurring situation the user finds herself in. A hybrid approach implementing syntactic and/or semantic matching on top of structural graph matching is proposed.

1. Introduction
The pervasive use of multiple devices such as laptops, smartphones and tablets is becoming more and more frequent in day-to-day life. Thus these devices contain data that is a very good indication of situations the user frequently finds herself in. Our aim is to gather and interpret this data with the intent of automatically recognizing recurring situations that are of importance to the user.

2. Aims and Objectives
Personal devices can record any activities carried out by the user such as current status and active file, as well as other environment data such as temperature and location. This data makes up the user’s live-context which, as defined by Dey, is any kind of information that can be used to characterize the situation of the user as an entity [1]. The live-context can then be saved at any point in time as a situation. A situation can occur multiple times and can be defined as a particular user circumstance (e.g. Attending a meeting).

The main objective is to automatically recognize recurring situations by comparing the live-context representation with that of the saved situations. When a match is found this will signify that the saved situation is recurring. The continuous changing of the user’s live-context, along with the continuous matching to stored situations, raises obvious performance issues that play a crucial role in such a scenario. Therefore we aim to find a balance between scalability and meaningful results.

3. Proposed Approach
The live-context and the saved situations are represented as named graphs using the DCON and the DPO ontologies from the di.me project. The DCON ontology is used to represent an entity’s context as can be extracted through device sensors and sharing activities while the DPO ontology is used to attach a richer meaning to contextual information streaming from device sensors and other information that can be extracted from the user’s social sharing activities.

Our problem is essentially a graph-matching one. Authors of similar work [2,3,4,5] tackle the graph-matching problem at both the schema and data levels, considering structural, syntactic and also semantic similarities. To achieve the required objectives, we will adopt a hybrid approach towards matching the graphs and implement syntactic and/or semantic matching on top of structural graph matching.

Since the live-context and the situations do not necessarily share the same structure, we require finding the largest common sub-graph, which is a case of a sub-graph isomorphism problem [2]. Our technique will be based on earlier efforts [3,4], however we will also implement a weighted system where the user can enhance specific contextual aspects and/or elements. This will eventually aid the matching process.

Once a common sub-graph is identified, we will focus on finding the degree of similarity at the data level. Our approach will involve the mixed use of syntactic and semantic techniques at the contextual element level [5]. This enables us to consider not only the syntactic similarity between nodes, but also any degree of similarity between the background semantic knowledge at the schema level.

Once the structural, semantic and syntactic matching techniques are implemented, the next challenge is to identify a score function that considers the matches at the various levels, as well as any user-given bias towards particular aspects and elements.

4. References

\(^{1}\) http://dime-project.eu

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Semantic Integration of Heterogeneous Online User Profiles
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Abstract
Users are currently required to create and separately manage duplicated personal data in numerous, heterogeneous online accounts. Our approach targets the retrieval and integration of this data, based on a comprehensive ontology framework which serves as a standard format. The main challenge faced by this approach is the detection of semantic equivalence between contacts described in online profiles, their attributes and shared posts. Contacts found to be semantically equivalent to persons that are already represented within the user’s personal information model are linked together.

1. Introduction
Currently, the typical computer literate user is forced to create a personal profile for each online account they would like to use. Popular online accounts now vary from general social networking platforms to specific email, instant messaging, calendaring, task management and file-sharing services as well as business-oriented customer management services. Personal data in these accounts ranges from the more static identity-related information, to more dynamic information about one's social network as well as physical and online presence. This situation results in personal data being unnecessarily duplicated over different platforms, without the possibility to merge or port any part of it [1], thus forcing users to also manage this data separately. In reality each user has just one identity, characterized by several attributes, namely the name, surname, date of birth, sex and country of birth. Therefore, our aim is to enable the user to create, extend and merge online profiles into one digital identity through the di.me\(^1\) userware – a single access point to the user’s personal information sphere [2].

2. Motivation
The integration of heterogeneous online user profiles is not a straightforward task, for two main reasons. First, no common standards exist for modeling profile data in online accounts [3], making the retrieval and integration of federated heterogeneous personal data instantly a hard task. Secondly, the nature of some of the personal data on digital community ecosystems [4], such as known contacts and presence information, is dynamic. To address these difficulties, we propose the use of a standard format that is able to handle both the more static as well as dynamic profile data. This comes in the form of an integrated ontology framework consisting of a set of re-used, extended as well as new vocabularies.

3. Approach
Our approach is to map and integrate various online user profiles onto this one standard representation format. The first stage of this approach discovers semi/unstructured information by crawling attributes that are available through online account APIs, resulting in a separate representation for each respective online profile. These representations maintain links to the source account as well as to the external identifiers of the specific online profile attributes. Additionally, all crawled attributes, in our case the profile information, are aggregated into what we refer to as the user's 'super profile'. The second stage of our approach targets the mapping of attributes for each of the represented online profiles with equivalent attributes for the super profile. The use of ontologies and Resource Description Framework as the main data representation means that the mapping we pursue considers both syntactic as well as semantic similarities in between online profile data. Based on the results of individual attribute matching, we then attempt to determine semantic equivalence between persons (this includes both the user and their contacts) that are known in heterogeneous online accounts. The discovery of semantically equivalent person representations results in their semantic integration at the personal information model level of the user’s data.

4. References

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\(^1\) http://www.dime-project.eu/
Harnessing Linked Data in Cloud-Based Service Infrastructures

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I. THE CHALLENGE

Cloud computing from a conceptual and technological point of view offers one of the most powerful and at the same time largest services in ICT domain by using Internet infrastructure. This service consists on allocation of services facilitating service deployment and simplifying computing tasks reducing price for operations known as pay-as-you-go services [1]. Cloud computing success relies on the objective to outsourcing with security, reliability and scalability operations and services [1]. As one of the most listed challenges in cloud computing systems, the autonomous control about the elasticity of cloud infrastructures and its management is one of the most complex problems to solve in today cloud-based systems [2]. Thus enabling elasticity of virtual infrastructures as a response to other load balancing protocols or remote monitored data processing is fundamental. Likewise managing cloud services lifecycle by enabling scalable applications and using distributed information systems and linked data processing in a fashion way is crucial.

The evaluation in performance of cloud service management solutions focuses on their capability for controlling virtual infrastructures and their capacity to run computer applications and processes independently; and also how dynamic systems monitoring is performed either by using distributed user data metrics and/or application data demands. In DERI we are currently conducting research focused on new cloud management perspective - linked cloud data perspective- based on semantically aggregated monitored data and user profiles, cloud services are to use shared infrastructures resources and efficient deployment of services and applications. We introduce linked data as mechanism to aggregate semantically monitored performance data and end user profile information by meaning of linked data relations to enable faster distributed data analysis. Thus linked data is used in cloud service management infrastructures for enabling scalability and efficient management [1].

II. HARNESING LINKED DATA IN CLOUD

Differently from the conventional designs based on proprietary servers solutions, cloud computing allows a flexible world of options in configuration and elastic in expansion disclosure of servers. Cloud computing help them to expand services and also to improve the overall performance of the current system by building up an overlay support system to increase service availability, task prioritization and service load distribution, and all of them based on users’ particular interests. In DERI, we are studying the main research challenges in cloud computing systems for enabling elasticity in the cloud [1][3]. In this particular research activity we make reference linked data mechanisms, distributed data monitoring tools and policy-based management systems as enablers for providing cloud services lifecycle control.

The fact cloud computing take advantage of the computing parallelism is always an attractive feature to optimize the usage of the computing resources. This optimization is translated into economic benefit and recently catalogued as green ICT where computing processing optimization contributes to energy efficiency usage. For this and other economic reasons physical infrastructure has migrated to the cloud [1]. An experimental testbed implementation using distributed monitoring data enabling elasticity has been designed. The challenge is without doubt the cloud system must be able to support public clouds up to their breaking point. The speed to start up and run modes has to be reduced and executed as fast as possible respectively. In the figure 1 the cloud management architecture is depicted. From a data model perspective, scalability and prediction by computing data correlation between performance data models of individual components and service management operations control model can be performed. To simplify the complexity we have focuses the model on performance values such as available memory, CPU usage, system bus speed, and memory cache thresholds. Instead of exact performance model we use an estimated model calculated based on linked monitored data.

![Figure 1. Cloud-Based Service Management Architecture.](image)

III. CONCLUSIONS AND FUTURE WORK

One of the most important research challenges in cloud computing systems is the dynamic control of elasticity of the cloud infrastructure. Based on performance metrics (i.e. log files from computing applications) or data processing request (i.e. annotated data as streaming data analysis). By using linked data mechanisms we can control full cloud service lifecycle. The concepts and trends discussed in this article can be applied to public or private cloud instindently.


Self-organizing Cloud Environment for the Internet-of-Things
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I. CLOUD COMPUTING AND IOT CONVERGENCE

Despite recent advances in the Internet-of-Things (IoT) area for developing control systems into the cloud, the proliferation of inter-connected entities and the collection of diverse information act as big challenges in order to provide full control over IoT devices. Solutions to the problem of formulating and managing internet-connected objects in cloud environments i.e. environments comprising “entities” and resources (such as sensors, actuators and smart devices) in cloud infrastructures are still at early stage of development. DERI coordinates research efforts and participates dynamically in a collaborative EU project to formulate principles for self-organizing utility-driven IoT into cloud environments and design a framework, within the emerging Internet-of-Things (IoT) infrastructures and applications into the cloud [1]. In this paper the main functional characteristics of a framework are introduced, which emphasizes on-demand establishment of IoT services based on the automated formulation of societies of internet-connected objects. The framework leverages well-known technologies (i.e. Linked Sensor Data) and standards (notably the W3C Semantic Sensor Networks ontology and the IETF COAP protocol).

II. OPEN SOURCE CLOUD BASED IOT FRAMEWORK

The OpenIoT project focus on providing an open source middleware framework enabling the dynamic formulation of self-managed cloud environments for IoT applications [2]. The OpenIoT middleware framework will therefore serve as a blueprint for non-trivial IoT applications, which will be delivered in an autonomic fashion and according to a utility model based on clouds infrastructures. The OpenIoT (Open Source blueprint for large scale self-organizing cloud environments for IoT applications) middleware infrastructure will support flexible configuration and deployment of algorithms for collection, and filtering information streams stemming from the internet-connected objects, while at the same time generating and processing important business / applications events [1][2].

OpenIoT framework is a joint effort of prominent open source contributors towards enabling a new range of open large scale intelligent IoT (Internet-of-things) applications according to a utility cloud computing delivery model [1]. OpenIoT framework is perceived as a natural extension to cloud computing implementations, which will allow access to additional and increasingly important IoT based resources and capabilities. In particular, OpenIoT will research and provide the means for formulating and managing environments comprising IoT resources, which can deliver on-demand utility IoT services such as sensing as a service [3].

OpenIoT framework is pertinent to a wide range of interrelated scientific and technological areas spanning: (a) Middleware for sensors and sensor networks, (b) Ontologies, semantic models and annotations for representing internet-connected objects, along with semantic open-linked data techniques (c) Cloud/Utility computing, including utility based security and privacy.

Figure 1. OpenIoT Service Management Architecture.

OpenIoT is developing a framework for the convergence of cloud computing and the internet-of-things (IoT) focused on pervasive environments (e.g., sensors and WSN (Wireless Sensor Networks) [2]. Indeed, sensor networks are location dependent, resource constrained and expensive to develop and deploy. On the contrary, cloud computing infrastructures are location independent, elastic and provide access to a multitude of computing resources [3]. OpenIoT will bridge the gaps associated with these differences, since it will allow IoT middleware to leverage the rapid elasticity of data storage clouds in order to store the abundance of sensor data streams that are produced in the scope of large scale deployments. Moreover, computing resources of a cloud could be also used to facilitate stream processing and management (especially in the case of computationally intensive signal processing algorithms. Overall OpenIoT will connect sensors with cloud computing infrastructure, while at the same time providing service oriented access to sensor data and resources.

III. CONCLUSIONS AND FUTURE WORK

The convergence of cloud computing with the internet-of-things (IoT) is associated with a host of opportunities, as well as with several technical challenges stemming from the different characteristics of the two technologies (cloud, IoT). Based on the OpenIoT platform, service providers will be able to request the on-demand formulation of IoT services. Among the main characteristics of the introduced system is that its implementation could be based on existing open source platforms, which could be enhanced on the basis of popular and emerging standards for IoT.

Scalable Query Answering in Large Semantic Sensor Networks

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I. BASIS OF RESEARCH

Distributed measurements of physical quantities, such as temperature, pressure or pollutants, facilitated through different types of sensors connected to wireless networks of autonomous devices, are a core area of current research. Within these networks, data can be retrieved using device/sensor-specific query languages and protocols, whereas continuous integrative data evaluation is generally unsupported.

II. HYPOTHESIS UNDER INVESTIGATION AND MAIN AIMS

My hypothesis is as follows: in large-scale data stream systems, such as sensor networks, the semantics of various data models and specific characteristics (e.g., temporal relevance, availability, asynchronicity, noisiness, uncertainty of data) can be continuously integrated and processed by a rule-based logic programming layer. By that, queries and optimisation measures can be applied directly on the rule language level without the obscurity and overhead of translations between different standards. To this end I will not simply re-use existing rule languages but also introduce language extensions to capture the aforementioned characteristics of sensor data. Furthermore, I will adapt the related reasoning engines to cope with huge amounts of incoming stream data.

III. CURRENT WORK AND NEXT STEPS

Since last year I am investigating technologies for reasoning on streams based on Answer Set Semantics (ASP) [3], a purely declarative, non-monotonic rule language tailored for knowledge representation and reasoning. I developed a concept [1] and evaluation for stream reasoning in terms of an extension of the ASP-based event processor oclingo [2], as a result of the collaboration between DERI and the Knowledge Based Systems Group at the University of Potsdam. To cope with the sheer amount of information in streams this approach imitates a sliding window which allows us to seamlessly integrated new incoming data as well as disregard expired data. For the future I plan to add further optimisation techniques to this framework. Additionally, we will set up a full-fledged stream reasoning system (see Fig. 1) for real-life scenarios that combines oclingo and CQELS [4], a SPARQL-based RDF stream processor that was developed by the Sensor Middleware Unit (USM) at DERI. There, we will take advantage of CQELS high-throughput capabilities to aggregate and pre-select data as a preprocessing stage for our stream reasoner, and introduce load shedding techniques, formalisation and implementation for both finite and potentially infinite domains.

Fig. 1. Stream Reasoning System based on CQELS and oclingo.

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REFERENCES

Protecting your RDF data: An Annotation Domain for Access Control

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Abstract

The Resource Description Framework (RDF) is a data representation format which provides a common framework for data integration from different sources. However in many scenarios, data protection is a major concern. In its core, RDF does not support any form of Access Control and current proposals for extending RDF with Access Control do not fit well with the RDF representation model. Considering an enterprise scenario, we present a model and a framework that caters for Access Control over the stored RDF data in an intuitive and transparent manner.

1. Introduction

In this paper we rely on an integration solution that extracts information from the underlying data silos into RDF, and we define a mechanism to enforce access control over the resulting RDF graph, implemented via logic programming. Our approach provides a flexible model to represent access control policies and also caters for permission propagation via logic inference rules.

2. Access Control Annotation Domain

A set of credential elements C, are used to represent usernames, roles, and groups in our Access Control Domain (ACD) model. Intuitively e ∈ C, e and ¬e are positive and negative access control elements respectively.

An access control statement S consists of a set of access control elements. S is consistent iff for any element e ∈ C, only one of e and ¬e may appear in S. This restriction avoids conflicts, where a statement is attempting to both grant and deny access to a triple. A set of access control statements is called an Access Control List (ACL).

Example 1: Consider the entities jb and js (employee usernames), st is the softwareTester role and it the informationTechnology group. The annotated triple:

\[ \tau: [[it], [st, \neg js]] \]

states that the entities identified with it or st (except if the js credential is present) have read access to the triple τ.

An ACL A can be considered as a non-recursive Datalog with negation (nr-datalog\(^-\)) program, where each of the access control statements s ∈ A corresponds to the body of a rule in the Datalog program. The head of each Datalog rule is a reserved literal access of C and the evaluation of the Datalog program determines the access permission to a triple considering a specific set of credentials.

Example 2: The nr-datalog\(^-\) program corresponding to the ACL \([it], [st, \neg js]\) (Example 1) is:

\[ \text{access} \leftarrow \text{it}. \]
\[ \text{access} \leftarrow \text{st}, \neg \text{js}. \]

The set of credentials of the user session, provided by the external authentication system eg. \([js, it]\), are considered the facts in the nr-datalog\(^-\) program.

3. Access Control Framework

In order to provide a complete framework to handle authorisation in RDF, the domain modelling presented in the previous section needs to be part of a system that is capable of enforcing the access control policies. Figure 1 provides a high level overview of the components required for such a system. In our enterprise data integration use-case, the Integration Service extracts the underlying data from the LOB applications and access control mechanisms using XSPARQL [1]. The data is stored as RDF and the permissions are stored as the annotations. The Access Control Layer restricts access to RDF data based the Access Control Annotation Domain model. We rely on an Annotated RDF reasoner and query engine for evaluating queries and domain-specific rules. The Authentication Service returns the user credentials composed of one or more usernames, roles and groups and may also be extracted from each of the LOB applications. The Query Rewriter takes a query specified using the SPARQL query language for RDF and, using the list of credentials provided by the Authentication Service, expands it into an AnQL [2] query, which ensures that users only have access to the information they are allowed.

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Approximate Semantic Matching of Heterogeneous Events
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Abstract
The emergence of applications in large-scale and dynamic environments such as the Internet of Things is pushing the limits of event processing in distributed systems. Event-based systems have loose decoupling within space, time and synchronization, providing a scalable infrastructure for information exchange and distributed workflows. However, event-based systems are tightly coupled, via event subscriptions and patterns, to the semantics of the underlying event schema and values. In order to address this new semantic coupling requirement, we propose natural language-based subscriptions together with the use of approximate semantic matching of events. We examine the requirements of event semantic decoupling, event ranking, and subscription language usability. The semantic event matcher utilizes a hybrid approach to matching with thesauri-based and distributional semantics-based similarity and relatedness measures. A real-world use case from the energy management domain is also investigated.

1. Introduction
Event-based technology has become more attractive for research with the rise of new applications ranging from smart homes to the Internet of Things [1]. The high degree of semantic heterogeneity of events in large and open deployments such as these and the resulting semantic coupling make it difficult to develop and maintain event-based systems. Scaling out these systems to include participants from diverse domains poses the challenge of the semantic interpretation of events. Current systems assume mutual agreement on event semantics which adds explicit dependencies between interacting parties. Thus, there is a need to enable event semantics as a new dimension of decoupling.

2. Approach
This work proposes a hybrid matching approach based on WordNet-based [2] and Wikipedia ESA-based [3] semantic relatedness measures for matching heterogeneous event schema and values. The proposed approach, Figure 1, forms a basis for dynamic fusion of events with background knowledge [4].

3. Evaluation
The approach is evaluated over a structured representation of Wikipedia and Freebase events and initial evaluations show that the approach matches events with high precision and recall. Figure 2.

Figure 1. The proposed hybrid matcher approach

Figure 2. The hybrid matcher outperforms other approaches

4. References
Managing Entities through Collaborative Data Management: A Mixed Machine-Human Computation Approach
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Abstract
This work presents a new approach for managing human contribution within entity data management over heterogeneous information sources. The proposed approach builds upon the concept of human computation to support automated integration and cleaning algorithms with user feedback. Furthermore, a framework for routing feedback tasks according to potential quality improvement is proposed, where quality is based on data uncertainty and data quality rules.

1. Introduction
Data quality issues and uncertainty are inherent in heterogeneous information environments such as large enterprises. Specifically, issues like duplication, conflicts and missing values become visible while integrating data about entities of interest from multiple sources. Current approaches for data integration and quality management within an enterprise require considerable upfront effort by data experts in terms of cost and time. However, there is a potential to involve non-experts in data management and has been demonstrated on web-scale by Freebase1. Recognizing the potential of collaborative data management as well as the need for high quality data within enterprises, this work focuses on investigation of collaborative entity management within dataspaces [1].

2. Proposed Approach
The proposed approach is a combination of rule-based entity management, human computation [2], and provenance-as-annotations. It is argued that this approach is a new contribution in data management and community information management space that can address limitations of existing approaches. The proposed approach relies on specification of data quality rules, for integration and cleaning, under a combined formalism. In this regard, data dependencies [3] have been used for specification of rules for entity resolution. Furthermore rules are utilized to define a ranking strategy based on the value of perfect information (VPI). Feedback for entity resolution is modeled as a human computation task which is ordered according to potential benefit.

3. Results
Figure 1 shows the results of experiments conducted to evaluate effectiveness of the task ranking strategies for entity resolution. Effectiveness is defined in terms of the number of rules satisfied after feedback. Clearly, VPI performs better and after user feedback for 30% of the tasks the improvement in dataspace utility reaches the maximum for VPI. In comparison, 70% feedback is required for simple ranking based on confidence of entity resolution.

Figure 1: Comparison of task ranking strategies for user feedback on entity matching. The evaluation dataset is based on drugs dataset from Instance Matching Benchmark 20102.

4. Conclusion
Preliminary results of feedback ranking experiments suggest that the proposed approach is promising but requires further investigation. Future work includes addressing challenges of entity management with evolving rules, human computation for data quality and effective provenance management to facilitate trust.

5. References

1 http://www.freebase.com
Cross-Community Influence Analysis and Maximisation

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I. INTRODUCTION

Relationships in social networks are often analysed on a node-to-node scale, e.g. ego-centric analysis [1], or in terms of the relationships between an actor and its community, e.g. community-finding [2]. However, less work has been done on analysing aggregated relations between communities, i.e. cross-community analysis, which offers complementary insights into social network dynamics at a different level of granularity. We are interested in the measurement and prediction of influence one community has on another. We define this influence in the context of overlapping discussion communities — as the ability one community has to stimulate another one towards higher activity, measured by the number of replies.

Initially, we investigated various node centrality measures on a community graph [3], but the scores highly correlated with number of posts, and we were unable to find communities which arguably should be highly influential, e.g. a community of moderators or system administrators. We therefore developed a framework for cross-community influence analysis which extends the notion of actor centrality to the cross-community level: it defines the influence of community A on B as the average number of replies members of A received in B, weighted by the degree of membership in A. We evaluated the framework by conducting a series of experiments on 10 years of data from the largest Irish discussion system, Boards.ie.

First, we investigated mutual influence between communities and their dynamics. We then used the framework to predict which communities to target in order to maximise information diffusion [4] in the underlying social network.

To the best of our knowledge, cross-community influence and its maximisation has not yet been addressed, motivated by the fact that in discussion fora the information is typically shared to the community as a whole rather than to individual users. The main contributions are that we 1) developed and assessed an extensible framework for cross-community influence analysis; and 2) defined a community-aware diffusion model for the study of information cascades in the context of discussion communities.

II. RESULTS

Our initial findings show that the framework identified communities which intuitively had high influence on other communities, such as system administrators or moderators. This was further supported by our experiments with the diffusion model. From each out of q targeted communities, we sampled 1–15 seed nodes (s), and measured the fraction of all users activated at the end of the diffusion process (a). This process was repeated for three different targeting strategies: our framework (IF), group in-degree (GI) [5], and random baseline (R). Figure 1 depicts the case of targeting only one community. The results showed that our method performs better than the other investigated strategies up to the factor of 2, when only one community has been targeted and only one user sampled from the community, i.e. for q = 1, s = 1. We observed similar results for the whole investigated range q ∈ [1, 5].

III. CONCLUSION

We have developed a novel framework for cross-community influence analysis, which proved to be useful for the measurement and prediction of how one community influences other communities. Our experiments with information diffusion further confirmed the suitability of the framework to detect highly influential communities. In future we aim to extend the framework with topic analysis.

IV. ACKNOWLEDGEMENT

Research presented in this abstract is supported by Science Foundation Ireland under Grant No. 08/SRC/11407 (Clique: Graph & Network Analysis Cluster) and Grant No. SFI/08/CE/11380 (Lion-2), and by the EU under Grant No. 257859 (ROBUST).

REFERENCES

MODELLING CAPABILITIES AND INTERLINKING THEM
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Abstract
In our work, we plan to provide a user-centric service discovery environment. To this end, the first step consists of defining a conceptual model describing service capabilities (what a service does). In this abstract we present our research problem, introduce our solution and present our future work.

1. Introduction
The concept of capability is a cornerstone element in service description. Nevertheless, despite its fundamental role little effort has been seen to model service capabilities.

Current approaches either fail to consider capabilities as feature-based entities and confuse them with annotated invocation interfaces or fail in modeling capabilities at several abstraction levels and establishing links between them. In particular, they are not able to model and deal with concrete capabilities (i.e., capabilities that reflect real customers’ needs).

In our work, we propose a conceptual model as an RDF-schema for describing service capabilities. Our model defines capabilities as an action verb and a set of attributes and their values. It is also able to define capabilities at different levels of abstractions/concreteness and establish links between them.

Most importantly, our model enables describing concrete capabilities which directly correspond to consumer needs.

2. Motivation
In real world settings it is very hard, even impossible, to model statically capability offers due to the following reasons:
• Highly configurable attributes: some of the attributes can have several values and enumerating all of them will result in a huge data set.
• Interdependency between attributes: this means that the value of one attribute influences the possible values the other attributes and vice versa, which will result in a combinatorial explosion.
• Attribute dynamicity: the value of an attribute may depend on a dynamic variable.
• Sensitivity of attributes: for business reasons, it appears that some attributes of a service cannot be revealed.

In our work, we propose a solution to the above mentioned problems. We particularly show that capability categories play the role of declarative specifications to dynamically generate capability offers according to a certain customer request.

3. Our solution
In our work, we propose a conceptual model, as an RDF-Schema, for describing capabilities [1].

Our meta-model defines capabilities as an action verb and a set of attribute-featured entities via a set of properties and their values. It is also able to describe capabilities at different levels of abstractions and establish links between them in order to create a capability hierarchy.

Most importantly, our model enables describing concrete capabilities which are directly consumable by and delivered to consumers contrary to current meta-models which describe the abstractions of these descriptions.

Current models describe services capabilities in a static way, however, services capabilities can be dynamically and automatically generated if needed (during the discovery phase for instance). This enables taking into account attributes dynamicity, sensitivity and dependency on consumers’ input.

Our model is based on RDF and uses Linked Data to define capabilities attributes as well as their values.

4. Future work
As part of our future work, we are planning to enrich our conceptual model and provide (i) the needed algorithms for maintaining the capability hierarchy and (ii) a user friendly interface for navigating it. Fig.1 depicts the overview of our intended platform.

5. References
SOFTWARE

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Social Networking: Who shall be in which group?

A Study of Capacity-Constrained Graph Coloring Problems

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Abstract

In this research we introduce a social network research application for team-based multi-player online games. We consider capacity-constrained graph coloring problem as a model of this application, and propose two different ways of solving this problem. We also implement an algorithm which could be used in practice and provide suggestions on further research.

1. Introduction

We propose a strategy to form groups for team-based game/tasks. Generally, on social networking platforms when forming groups for competition, people usually choose to play with people they already know. However, evidence also shows that there exists another area that is specific for groups of people who don’t know each other well to compete.

As Facebook opens its APIs to all developers, our idea is to develop a platform for Facebook Apps which would be able to analyze connections between all game/task participants and assign them to different groups.

There are three issues that we are aware of: firstly, the size of each group will be a parameter provided by input; secondly, solution time will always be a concern, as the platform should be able to provide results in an acceptable length of time; thirdly, within a certain time limit there should always be provided suitable solutions (output), which might be either strictly optimal and incomplete solutions or suboptimal, but complete and fair.

2. Problems and Proposed Solutions

We describe a more general problem from previous context in following: given $n$ people, we need to assign people into groups with size less or equal than $s$, note that people in same group shall have no connection with each other, and number of groups shall be minimized.

To our knowledge this problem originates from both the traditional graph coloring problem and list coloring, with a different general purpose restriction which we called capacity. Here we call this capacity-constrained graph coloring problem.

Assume that $G = (V, E)$ is an undirected graph with a set $V$ of vertices and a set $E$ of edges; a traditional graph coloring assigns colors to the vertices such that no two adjacent vertices share the same color and total of colors used are minimized. If we restrict each vertex with a list of allowable colors, it is called the list coloring problem. For capacity-constrained graph coloring it remains the same except that each color can only be used no more than $c$ times where $c$ is named the capacity (in this research, $4 \leq c \leq 5$).

Based on this, we propose an approach which is based on DSATUR [1] and PASS [2] by introducing this new capacity. Meanwhile, motivated by improvements of general purpose ILP/LP solvers, we plan to integrate Integer Linear Programming (ILP) model [3] with the Capacity-Constrained Graph Coloring, thus providing an ILP/LP-based solution.

3. Conclusion and Future Work

Our two proposed solutions are accomplished by improvements on solutions for traditional graph coloring problems. For the DSATUR/PASS based solutions, in the capacity-constrained graph coloring context, we can get optimal but incomplete solutions (assume this is from real practice) under a certain time limit. And we assume the ILP/LP based solution will be the same. Based on this, time will be the only concern in practice which shall be improved when dealing with large-scale graphs.

Specifically in this research case for the ILP/LP based solution, we cannot strictly comply with the rule that two adjacent vertices cannot share same color (otherwise, there might be always no suitable both complete and fair solutions which is required in specific real practice), in this case to measure balance between each group we introduce another parameter $f$ which shall be minimized (Quadratic Programming (QP) based) and is given as:

$$f = \sum_{i=1}^{N}(x_i - \mu)^2, \text{where } \mu = \frac{1}{N}\sum_{i=1}^{N}x_i$$

where $x_i$ is the assess value of each group. Again, in this solution, time will be a certain concern which needs to be improved.

4. Acknowledgements

The research is funded by Irish Research Council for Science, Engineering and Technology (IRCSET), and China Scholarship Council (CSC).

5. References

Challenges of Evolving Sequential to Parallel Code: An Exploratory Review

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Abstract
Large legacy systems that have been in use for several decades need to evolve in order to take advantage of new technological advances. One such development is the emergence of multi-core processors and parallel platforms. However, the evolution of code written for single-core platforms into code that can take advantage of multi-core technology is challenging. The aim of this research is to explore the challenges that parallel programmers face in the evolution of existing software to exploit multicore and parallel architectures. A review of the current literature was conducted and ten frequently reported challenges were identified. It is important to raise awareness of potential challenges that practitioners may face when evolving sequential code to exploit multicore platforms in order to be better prepared for future evolution.

1. Introduction
The availability of parallel hardware through the affordable and continuously evolving de facto standard multicore-based architectures, generates a new requirement in the field of parallelization. That is, support for the evolution of the code from serial to parallel form [1, 2]. However, the task of parallelization is often referred to as one of the key constituents with respect to the next software engineering crisis [3]. This research reviews current literature exploring the challenges posed when migrating from sequential to parallel deployment infrastructures.

2. Challenges in Parallel Computing: A Review of the Literature
The literature review returned a set of ten challenges that developers face when evolving systems from sequential to parallel. A high level overview of the results are presented in Table 1. Common themes were derived between these challenges and are illustrated in

Table 1 Challenges facing parallel programmers

<table>
<thead>
<tr>
<th>Category</th>
<th>Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developer</td>
<td>Parallel Comprehension</td>
</tr>
<tr>
<td></td>
<td>Lack of Training</td>
</tr>
<tr>
<td></td>
<td>Lack of Domain Knowledge</td>
</tr>
<tr>
<td>Development Methods &amp; Tools</td>
<td>Testing</td>
</tr>
<tr>
<td></td>
<td>Lack of Tools</td>
</tr>
<tr>
<td></td>
<td>Complex Debugging</td>
</tr>
<tr>
<td>Application Specific</td>
<td>Data Dependencies</td>
</tr>
<tr>
<td>Constraints</td>
<td>Interdependence of Abstraction Levels</td>
</tr>
<tr>
<td></td>
<td>Hardware Variance</td>
</tr>
<tr>
<td></td>
<td>Time Limitations</td>
</tr>
</tbody>
</table>

Figure 1. The developer performs and uses development methods and tools, to parallelize a legacy application while various constraints form a boundary in which this evolution takes place.

3. Conclusions
The findings in this study show that there are serious, unresolved challenges in evolving from the sequential to parallel paradigm. These challenges are unlikely to be overcome quickly or easily, and if increased computing power continues to depend on the best use of available cores, then it is probable that we are going to have to prepare for continuous evolution to avail of the performance opportunities presented by ever-increasing core counts.

Acknowledgements
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8. References
Localisation Service Description Facilitating Automatic Selection of Services.

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Abstract
This work presents a framework for the automated selection of services in a localisation workflow using a descriptor that captures functional and quality attributes of the vendor offering.

1. Introduction
Automated and near-optimum service selection must be now supported in order to meet the growing demands on the localisation industry [5]. This research contribution aims to provide more syntactically explicit and unified localisation service description that supports this requirement.

Localisation is a process that supports a product to be recognised globally by transforming contents to the target market requirement. Localisation is moving towards automation by introducing computer-aided tools to its workflow. Automation is becoming increasingly more common in localisation, for example, MT services are now available for “various background and cultures, linguistic demands” [2]. Which MT service offering should be included in the workflow? This decision currently resides with a project manager who has to manually trawl through documentation to determine the appropriateness of the service whenever a new one enters the market place or an existing offering changes. In order to automate selection, service descriptors are required that can be used by a software broker to select a service from amongst several competing offerings.

Another challenge is to develop a method for the unified description of services. Without such a standard, components such as MT may and do lack descriptions with respect to quality, cost, availability, etc. Service selection currently relies on project manager’s prior experience to ensure a near optimal selection which is undesirable for the promotion of a market place for third party localisation components [4]. For automation, services should be benchmarked.

2. Service Descriptor
Functional and non-functional requirements capture what the software must do to meet the user needs. The proposed descriptor is based on the taxonomy of requirements [1], incorporating functional attributes, non-functional attributes such as performance and quality; and constraints. The taxonomy of localisation service attributes is developed as a result of a pilot study using Noun Identification Technique [3] on brokering service web sites between translators and translation service providers as well as three Online MT service providers. Eighty eight attributes are categorised under four headings: Service, Profile, Reputation, and Project. The findings form the basis for a service descriptor that models MT components in localisation workflows. The descriptor is used by a broker to select the service that best satisfies the requirements for translation as specified by an abstract node in the high level workflow. Broker attributes are set by the project manager such as equal or user specified weights being assigned to each non-functional attribute when calculating the cost of a service offering. This prototype will serve as a basis for development of a method for third party developers to complete a descriptor for a component that they develop.

This research is supported by the Science Foundation Ireland (Grant 07/CE/I1142) as part of the Centre for Next Generation Localisation (www.cngl.ie) at University of Limerick.

References
SOLÚBHTA – A Flexible Business Transaction Model

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Abstract
The increasing trend of organizations moving toward service based applications (SBAs) for performing business operations promotes enormous complexity in designing transactions. The traditional models do not have adequate ability to underpin designing business transactions of SBAs. This research offers a business transaction models that facilitates correlating business entities in transaction model and also provide techniques to build a flexible business transaction model.

1. Introduction
A business transaction is the successful operation of business activities such as, order processing, payment processing, and goods/service delivery. In service oriented collaborative businesses, these operations are carried out through interactions across the network of business partners. Business partners should perform the operations by conforming to the agreement between/among them. Thus, organizations today need a business transaction model that facilitates the users (e.g., business analysts, application engineer) to correlate business entities such as Quality of Services (QoS). The model should be adequately robust to deal with the challenging business factors which entail uncertain and dynamic business events so that it can prevent failure. Additionally, the model should be built on flexible properties or techniques that assist to resist the abortion of transactions.

2. Shortcomings of Traditional Models
After critically analysing existing business transaction models, we have found that they are unable to correlate the business entities. In addition, the models lack the ability to prevent abortion of transactions due to strict principles (e.g. atomicity). The models do not tolerate any minor fault or failure of a non-vital (optional) activity. They also lack the techniques to deal with dynamic and uncertain business events.

3. Business Transaction Model
Our goal is to overcome the shortcomings of current transaction models. To achieve the goal, we have developed a business transaction model [1] named Solúbhta that will be used to design flexible business transactions for SBAs that underpin service oriented collaborative businesses. The model includes real-world business entities. The key purpose is to correlate business entities explicitly with transactional activities so that a transaction can be defined and governed not only functional (or operational) but also from business perspective. Furthermore, to achieve higher degree of flexibility, alongside the traditional compensation actions Solúbhta relies on policy based recovery, associating base activity by contingent activity and retrying actions. The policy based recovery is strategic actions that will be performed upon failure or prior to the failure of transactions. Additionally, since it is evident that the flexible behavior cannot be implemented relying on classical atomicity semantics, we have extended the semantics of classical atomicity named eventual failure atomicity. Although Solúbhta aims at providing highest degree of flexibility, yet it carries the notion of atomicity because of guaranteeing integrity both at business and data levels. Note that, the underlying principle of atomicity in Solúbhta is different. More specifically, atomicity here follows all vital or nothing principle whereas classical atomicity obeys all or nothing principle. Flexible behavior of transaction that we have defined in Solúbhta is formalized using first order temporal logic (FOTL).

4. Evaluation
This research is in evaluation phase. The evaluation is being done against a business case developed in S-Cube project [2] http://www.s-cube-network.eu. Although the names in S-Cube case study is fictitious but the case represent the real-world business scenario. Furthermore, we will evaluate the model through expert opinions at later point of time.

5. Conclusion and Future Works
In this research, we have developed business transaction model for designing business transactions. The key idea behind this research is to facilitate designing transactions from business point of view. Stakeholders such as business analysts are the beneficiaries of the model. The application designers will also reap benefit particularly, designing flexible transaction operations. The model needs a tool to support business transaction designing, is our future work. We also plan to extend the functional aspect of the model to support business transactions service based applications (SBAs) in cloud environment.

8. References
Expert explanations of software

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Abstract

Gaining an understanding of unfamiliar software systems is hard. Existing studies of program comprehension have focused on the information sought by software developers, but often the developers themselves do not know what to look for. Here an alternative is proposed: studying the information “pushed” from software experts to new developers during onboarding may provide insight into more effective ways to learn about unfamiliar code.

1. Introduction

Many software developers struggle to understand unfamiliar code, leading to increased maintenance costs. Research on program comprehension has primarily studied individual developers’ performance. However, software developers also mentor each other [1] to transfer understanding. The content of mentoring sessions can be analysed to reveal the experts’ way of explaining their systems.

2. Methodology

Little is known about the content or structure of developers’ explanations of their code, so a grounded theory approach is appropriate. A similar approach [2] was used to investigate the overall experiences of developers joining an established software project.

3. Data collection

Data is collected when experts are explaining their program code to other developers (i.e. “onboarding” sessions). This is a naturally rich transfer of information about the system. A set of audiovisual recordings, surveys, interviews and source code (where permitted) allow analysis of onboarding sessions. The collection has been guided by initial analyses revealing the need for further materials.

Following a pilot study, videos were collected from eleven onboarding sessions at eight locations (three academic projects and five commercial projects). The companies range from two-person startups to global corporations.

3.1. Analysis and future work

In a grounded theory study, the researcher aims to generate theory that is grounded in the data. Following transcription of the videos and interviews, the materials can be coded. Coding is a grounded theory technique that reveals themes and patterns in the data and allows a theory to be built up. This analysis is ongoing.

4. Acknowledgements

This work was supported, in part, by Science Foundation Ireland grant 04/CE2/I303,1 to Lero - the Irish Software Engineering Research Centre (www.lero.ie). The author thanks Jim Buckley and Norah Power for their suggestions and advice.

References


Mining of Data from Census of 1901/1911
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Abstract
Following on from the digitization of the census data of 1901 and 1911 on the National Archives website, there has been renewed interest among Irish people in exploring their heritage and the history of where they live. The digitization of this data offers new opportunities to mine the data that was not available in previous censuses.

This project aims to exploit these opportunities by evaluating existing research in this area and propose new techniques to match people between the two censuses, build partial family trees and investigate trends to give an insight into how lives changed between 1901 and 1911.

1. Introduction
Census data can be a very helpful resource for people tracing their genealogy. However, there are a number of challenges when searching and matching people across censuses. No national unique identifier is recorded so people must be matched based on other characteristics such as name, age and address. The details and spelling of these characteristics may not have been recorded accurately or multiple people may have similar attributes.

This project will create a program which uses a probabilistic algorithm to overcome some of the above challenges to matching people across census. Once a person has been matched – any relatives found in either can be joined to create a partial family tree.

In previous research in this research group [1], Matthew Byrne downloaded data from both 1901 and 1911 censuses from the National Archives site and has made that data available also for this project.

2. Record Linkage Algorithm
Record linkage is a term used to describe the process of matching the same record across two different data entities that do not share a unique identifier. Introduced by Fellegi and Sunter in 1969 [2], there has been a lot of application and further research in this area across different domains including medical databases and census information.

Using an approach defined in “Data quality and record linkage techniques” [3]; given two records, record A from 1901 and record B from 1911, the algorithm computes the probability that A and B refer to the same person.

For each field in the record, the algorithm computes the M-Probability (probability that a field agrees given that the pair of records is a true match) and the U-Probability (probability that a field agrees given that the pair of records is NOT a true match). From these values, the likelihood of the records matching is calculated:

For a field which agrees, the weight is calculated by:

$$\log\left(\frac{m}{u}\right)$$

For a field which disagrees, the weight is calculated by:

$$\log\left(\frac{1-m}{1-u}\right)$$

The total record weight is calculated by summing each individual field weight for that record. Any weights that are above a pre-defined threshold are considered a match.

3. Evaluating the Algorithm
The precision and accuracy of the algorithm will be calculated using a Confusion Matrix.

<table>
<thead>
<tr>
<th>Proportion of positive cases that were correctly identified (TP) True Positive</th>
<th>Proportion of negative cases that were classified correctly True Negative (TN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FP) False Positive Proportion of negative cases that were incorrectly classified as positive</td>
<td></td>
</tr>
<tr>
<td>False Negative (FN) Proportion of positive cases that were incorrectly classified as negative</td>
<td></td>
</tr>
</tbody>
</table>

4. Future Work
When the algorithm is completed, this project will use it to build relationships across censuses and store this in a GEDCOM [4] format that is compatible with most family tree software.

Finally, this project will mine the data to investigate if general trends such as urbanization and changes in family structure can be identified over the 10 years.

5. References
Exploring Genetic Algorithms in regards to card games

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Abstract
The premise of this project is to explore the use of Genetic Algorithm in regards to multiplayer complex card games. The aim of this research is to discover if through the development of strategies and the use of the Genetic Algorithm if we can create a game playing system that will evolve a set of game strategies that will simulate the process of learning to play a game and in the end hopefully lead to an optimal set of game play rules for the game.

1. Introduction
For this project we built a playable version of the Hearts card game and are developing a genetic algorithm that will rate and rank strategies that we devise for the playing of the game and through the genetic algorithm operators of selection, mutation and crossover will develop an optimal strategy that will allow us to play Hearts successfully.

1.1. Game
The game that we have chosen to emulate is the card games Hearts as it is a complex multiplayer game. The game itself is played with four players and will continue until one player reaches a score of 100 points or more, the player with the lowest score after the game ends is the winner.

The complexity of the game play comes from a number of factors the first of which is each round continues until all 13 cards in each players hand are played, coupled with this some cards are scoring cards (all card of the heart suit and the queen of spades) and others carry no score go strategies must be made depending on what cards are played. Another complexity is that for every 3 out of 4 turns each player passes three cards to another player thus the game is not fully visible(i.e. for 75% of the turns each player knows 3 cards in another players hand) this adds to the complexity of the game play.

The scoring of the game happens at the end of each round once all cards have been played. Each card of the suit of Hearts carries 1 point while the queen of spades carries a score of 13 points. The reason that this adds complexity is that after each card is played one doesn’t know if they have scored a point or not as there is a strategies called “shooting the moon” in this strategy if one player collects all the scoring cards then 26 points are added to the scores of all other players and nothing is added to that players score.

1.2 Genetic Algorithms
A genetic algorithm is an algorithm that evolves through evaluating strategies that it is given based upon their performance in achieving a goal.

The process through which a genetic algorithm works is by taking the strategies and assigning them in random order into different arrays. In our case these arrays will contain 13 elements to be filled as each game in Hearts have 13 moves. The genetic algorithm then tests these strategy arrays and ranks them. We then tell it how many generations to produce; this tells the algorithm how many times it should run for. Now the algorithm takes to top ten strategy arrays and mixes them together through process such as crossover and mutation this produces new arrays of strategies the algorithm then ranks these strategies and compares them to their parents if they are ranks better than their parents they replace them if not they are discarded. This process continues until we reach the number of generation that was to be produced and this should have produced the optimum array strategy for the game.

2. Methodology
For this project we have created the card game Hearts and are currently devising heuristics (rules) to play the games. These heuristics are based upon the rules of Hearts and strategies on how to play them. An example of the heuristics that we are currently writing is: If the queen of spades is played play a lower card of the same suit or if the queen of spades is not the first card played and is not the same suit as the first card then if possible play a lower card of the suit of the first card played.

One we have created all our heuristics we will use them to populate two different rule set that we will in turn pass to our genetic algorithm that will in turn evaluate the rule sets, evolve them through evaluating them as the game is played to calculate

3. Future Work
It is hoped that outside this project we could build game trees that would have different rules based upon any situation that may arise at any point in the game. These games trees could be evaluated and populated through the use of a genetic algorithm so that an optimal move may be used at each turn in the game.
Predicting wind energy in Ireland using live weather conditions

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Abstract

Renewable energy resources such as solar, ocean and wind energy are more and more important due to climate change and increasing fossil fuel prices. The objective of this research is to develop a simple model to predict how much wind energy will be produced by the combined wind farms in Ireland using live and predicted weather conditions. Live data such as wind speed, wind front direction and speed will be gathered from the weather station on the National University of Ireland, Galway (NUIG) campus and several regional collection points.

1. Introduction

Wind energy is a very significant resource for Ireland. Ireland currently has 169 wind farms in 27 counties with a total capacity of 2010MW [1]. Accurate forecasting of wind energy production is necessary for the security of the National Grid, managed by Eirgrid, and for reducing the need for costly standby plants. This research will complement existing wind forecasting research by focusing on a high level analysis that uses simple inputs and a black box approach to estimate current output and predict future (short window of a few hours) wind energy production in Ireland.

2. Methodology

Live wind conditions will be collected from several collection points — critical metrics are wind speed as well as weather front direction and speed. These will form the boundary conditions. For example, if the weather front moves from west to east, the average wind speeds in the west of Ireland and wind front speed will be used as boundary conditions.

Wind energy production will be calculated using the above measured data, as well as the capacities of wind farms (shown in Figure 1) in the path of the weather front and finally, the performance characteristic of a standard wind turbine. Regarding the latter, the power curve of the Vestas V-90-3MW model [2] will be used for the calculations.

As the advancing weather front will reach later wind farms, the wind energy production of these wind farms will be estimated using the measured boundary conditions. For example, boundary conditions for a front moving west to east at speed of 50km/hr will reach Athlone in $T+2$ hrs and Dublin in $T+4$ hrs.

At the boundary of the system, it will thus be necessary to predict future conditions and simple prediction tools will be used for this purpose.

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At the boundary of the system, it will thus be necessary to predict future conditions and simple prediction tools will be used for this purpose.

3. Analysis and model implementation

The model is being developed using Simulink, an add-on tool in MATLAB.

The predicted wind energy production using this simple approach will be compared to existing models and such analysis will inform future iterations of the model. Uncertainly analysis will also be performed to estimate how wind energy production will change when the following data changes:

- Impact of +/- $x$ m/s wind speed
- Impact of +/- $y$ degrees front direction
- Impact of +/- $z$ m/s front speed

4. Reference

IDE support for Unstructured Software Documentation

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Abstract
Documentation is widely recognised as having a significant impact on the outcome of software projects. Software development teams collaborate to produce and consume design, technical and end-user documents. While there are numerous IDE tools supporting Source Control Management which involve a similar collaborative effort, IDE support is not widely available for document repositories. This paper proposes an IDE integration which provides standardised access to document repositories in order to improve the utilisation of software documentation.

1. Introduction
Large organisations use Enterprise Content Management (ECM) software e.g. SharePoint, Documentum, to implement information management policies. A common use case is the management of software project documentation which requires policies on versioning, security, backup and auditory compliance.

These requirements are driven by adherence to standards defined by the IEEE, ISO or methodologies such as the Rational Unified Process (RUP). Waterfall-modelled methodologies place a heavier emphasis on documentation at each stage than the lightweight iterative approaches found in agile development. The creation of document artifacts is nonetheless a common feature across almost all projects.

The purpose is to communicate meaningful information about a project to team members, stakeholders and end users. The individuals with the most domain knowledge available are often the engineers involved. The more involved they are in this process the higher the quality of documentation that can be expected [1]. The level of importance attached to it by software teams, however, will vary with the methodology in use and team resources.

Despite the recognised need for quality project documentation, it continues to be an area of software engineering which receives low priority. There have been significant improvements in automated tools, such as JavaDoc, for use with structured information. Tools for unstructured information in the form of Word, PowerPoint, and other formats lag significantly despite their prevalent use.

2. CMIS
The Content Management Interoperability Services (CMIS) specification standardises access to ECM repositories through open standards such as Web Services or Representational State Transfer (REST) [2]. It specifies a common data model i.e. definitions of files, folders as well as services that can be used on those objects such as navigation and retrieval. Bindings are currently defined for Web Services and RESTful AtomPub protocols which can be implemented in any language capable of supporting them.

3. Research Objectives
This paper will investigate the use of a CMIS client “plugin” to the Eclipse IDE, which will provide direct access within the IDE to project documentation contained in a CMIS-compliant ECM repository. The use of an integrated client is expected to improve the creation and maintenance of project documentation.

A case study will be carried out with a software project developed using an agile methodology and having SharePoint ECM software as the source of project documentation. Validation of the IDE integration will include:

- SharePoint auditing to measure documentation usage with and without integration.
- Agile iteration tasks analysed to determine if higher availability encourages the inclusion of documentation in the agile planning process.
- Qualitative assessment will be carried out using questionnaires to evaluate usefulness.

4. Conclusion
This paper has presented an approach to improving the software engineering process by making unstructured project material accessible within the software engineering environment. Integration may provide a basis for further software process improvements in the areas of requirements traceability, task context development, information retrieval and extraction.

5. Acknowledgements
This research is being carried out in collaboration with the European Commission.

6. References

Index terms: Documentation, Knowledge Management, Integration
Encouraging an Interest in Mathematics and English among Infant Level Students using Educational Video Games

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Abstract
This research endeavours to explore the possibility of encouraging an interest in mathematics and English among infant level students (aged four to six). This will be done by creating educational video games with an emphasis on interesting the children and testing them out in classroom environments and conducting a survey of teachers regarding the topic.

1. Introduction
PISA is a program for international academic scoring which is conducted every three years since 2000 which compares countries standard in education. Recent years have seen Ireland descend from a reputable position in PISA rankings in reading and mathematical literacy to a very average position, going from 4\textsuperscript{th} in 2000 to 21\textsuperscript{st} in 2009 in reading literacy and going from 17\textsuperscript{th} in 2003 to 26\textsuperscript{th} in 2009 in mathematical literacy [1].

Studies have shown that academic interest and academic achievement are related, and so it follows that to improve Irish PISA scores, steps should be taken to increase academic interest among Irish students [2].

Is it possible to use educational video games to achieve the goal of improving academic interest? Should we use educational video games to achieve the goal of improving academic interest? What are the main features of successful educational video games to achieve the goal of improving academic interest? This study focuses on these questions by conducting case studies with infant level students and their teachers, using educational video games, and seeing if it is possible to use these as a tool to increase interest, and by conducting a survey of primary school teachers to see what their experiences are with educational video games and get their opinions on the three questions.

2. Increasing Student Academic Interest Using Educational Video Games
Studies have shown how playing with children and nurturing an interest in them using things they are interested in can create interest in other areas [3], e.g. a child interested in dinosaurs might have a parent who helps him collect facts about dinosaurs and organize these facts, so through the interest in dinosaurs the parent has fostered an interest in science, some educational philosophers see this as where educational video games can be very useful in the future [4].

Research has shown that the most affective educational video games feature narrative context, and the game play should be a part of this narrative context, multi sensory cues, clear instruction and feedback, and that the games should be fun, but never at the expense of the learning material [5].

The educational video games made by the researcher will use these features and use games based on the Irish curriculum in mathematics and English, there will be a total of three games, and each will feature a different motivational aspect, e.g. game A will feature co-operative play as its motivational aspect, game B will feature competitive play as its motivational aspect and game C will feature enjoyment as its motivational aspect.

3. Research Approach
The Research for this study will use case studies and a survey to create a mixed method approach, which has been shown to have superior integrity [6]. The case studies will be done in three classrooms, the children will play the games and answer a questionnaire with the teacher present, who will then take part in an unstructured interview following the completion of the children playing the games. Observations will also be made by the researcher.

The survey will consist of questions focusing on the three research questions mentioned in the Introduction.

4. Current Work
The educational video games are currently being developed and should be ready by Easter. All of the case studies have been set up with three classes and their teachers agreeing to take part at dates after Easter and the survey is being currently being distributed.

4. References
Analysis of Difficulty of Mancala Variants

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Abstract
The aim of this research is to gain some insight into a selection of games found in the Mancala family of board games. This will be done by designing a set of heuristics and testing how robust they are from one game to another. Data will be collected on the ply depth and branching factor, so to investigate what changes in the game will lead to a more difficult game.

1. Introduction
Mancala is the name given to a family of ancient board games that are played across Africa, parts of Asia and in the Caribbean Islands. There are over a hundred versions of the game. The game is played on a board with two rows and a number of pits in these rows. The game starts with an equal amount of seeds placed in each pit. The aim of the game is to have captured more seeds than your opponent when the game is over. Each player owns one side of the board rather than seeds. Moves are referred to as sowing, this is where the contents of a pit are taken and placed across the remainder of the board place one seed in very seed passed. The capture of seeds then happens after all the seeds are sown if certain conditions are met.

The main variations of the game are with the number of pits found in one row and with how many seeds are initially in each pit. The conditions that need to be met when making a capture are different from game to game.

Previous research done in the area of developing heuristics for the game of Mancala [1] and for the game of Bantumi [2] showed that a set of heuristics could be developed and used without the use of a large look ahead.

2. Hypothesis
This research project aims to look at the performance of a set of heuristics in a selection of games found in the Mancala family. The main variations that will be examined is changes in the pit/seed numbers at the beginning of the game and what effect do different capture rules have on the game. The set of heuristics picked were based on well known strategies for the games e.g. the strategy of moving seeds that can be captured by the opponent.

Out of this research we hope to be able to answer questions like: can a set of heuristics be robust to work across a selection of games in the family? Can the heuristics developed in earlier research be used to work across other forms of Mancala or are they limited to just those forms of Mancala? What changes in the rules of the game will it have on the complexity of a game?

What changes in the game will lead to a decrease or increase in the performance of the heuristics? What effect the changes in the game will have on what the optimal mix of heuristics is when evolved using a genetic algorithm?

3. Methodology
A simulator of the game is needed so test a collection of heuristics out on. One of the aims when designing this was to make it straight forward to accommodate changes in pit/seed amounts and to changes in game rules.

4. Current Work
A simulator was designed using C++. Then a set of nine heuristics were designed and tested. Their performance was tested against a random strategy. From the initial test so far, the strongest heuristics found were hoarding, move any seeds that are in danger of being captured and move any seeds that will lead to a capture. Heuristics that didn’t perform well against a random strategy were dropped.

5. Future Work
A genetic algorithm will then be designed to find the optimal mix of heuristics. While this mix is being evolved by the genetic algorithm, data will be collected on the ply depths and branching factor so that the complexity of a game can be analysed.

6. References
A Web Based System for Determining the Accurate Drug Dosage Levels in Renal Impairment

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Abstract
Drug dosing errors are common in patients with renal impairment. This is primarily as a result of the number of parameters that need to be considered when calculating the dose. Weight, height, age, gender and serum creatinine for example are required to estimate renal function using the Cockroft-Gault equation. Drugs with a low therapeutic index such as Gentamicin are particularly problematic. This paper describes a system which not only estimates creatinine clearance and calculates drug doses but also empowers clinicians to populate a drug library without any coding requirements.

1. Introduction
Drug dosage calculation is a complex, multi-step process. It needs to be repeated for every patient and is therefore time-consuming, requires training, experience and vigilance to ensure accuracy. Determining the correct dose to give a patient in renal failure is critical. With gentamicin for example, too much the result may be worsening renal function, too little and the infection may overwhelm the patient.

Hospitals in particular have to deal with resource issues, lack of staff training and patient overcrowding. The result is a high probability of medication errors, some with serious consequences [1]. According to a report from the Institute of Medicine (IOM) at least 44,000 to 98,000 US citizens die each year due to medication errors [2]. Out of these medication errors drug dosing errors are one of the most common ones. Calculation errors are a common cause of these errors. Apart from patients with renal impairment there are other populations at risk such as, children, neonates or those patients requiring intensive or high-intensity care.

The reasons for wrong dosage calculation include:
- The complex, multiple step calculation process itself.
- Changing dosage requirements with changes in the patient’s condition.
- Competency of healthcare staff in performing the calculations.
- Minor oversights such as decimal point error.
- Unit conversion confusion, e.g. converting micrograms per kg per hour to mg per hour.

2. Aim/Objective
The aim of the project is to develop a system which supports the quality use of drugs in a hospital environment. The initial focus of this project is on drugs that must be adjusted in renal impairment. The system allows pharmacy administrators to design and validate drug dosage algorithms using a centralised database and to deploy drug dosage applications onto devices available to clinicians. Provided that data-protection issues are addressed the system will facilitate physician rounding by trapping patient-specific data. These devices include ordinary PCs and handheld devices, the latter to facilitate decision support irrespective of location.

3. Current Work
1. Developed a system for inserting and calculating the drug dosing regimens, named System for Quality Use of Drugs (SQUD)
2. The web application is deployed in an Ireland server. It can be accessed by the URL: www.squd.eu
3. System is currently tested and trialled.
4. Registration has been extended to all clinical pharmacists prior to roll-out to doctors
5. The framework can be accessed/used by
   a) Java enabled mobile phones.
   b) Smart phones with internet connection.
   c) Stationary hospital PCs.

4. Conclusion
The research has shown that there is an increasing need for robust medication management systems for clinical use. The present prototype provides this functionality over a wide range of user platforms, while providing a reliable mechanism to generate, verify and communicate drug doses for patient who are at risk of medication error (by virtue of their impaired renal function.

5. References
Social Network Analysis applied to Unified Communications

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Abstract
In recent years, there is an increasing interest in understanding and improving what we call ‘the human network’. The explosive growth in communication platforms is transforming the way we interact with each other. The study of human behavior in this new environment would allow us to better understand the requirements for the next generation of communication networks.

1. Introduction
This study involves the use of social network analysis techniques applied to data extracted from unified communications (UC) systems. The goal is to understand how the users interact using different means of communication in order to make recommendations to end users and administrators on how to make the best use of the resources available.

2. Overview of Unified Communications
UC offers the ability to significantly improve how individuals, groups and companies interact and perform. UC may comprise a stand-alone suite, or they may be a portfolio of integrated applications and platforms spanning multiple vendors. Typically it integrates the following communication areas:

- **Voice and Telephony** – including voice over IP for deskphones, mobiles, softphones and the evolution of PBXs.
- **Messaging** – email, voice mail and SMS.
- **Presence and IM** – these play an increasingly central role in the next generation of communications. Presence can enable the aggregation and publication of presence and geolocation information from and to multiple sources. This functionality is called ‘rich presence’. Presence meaning availability.
- **Clients** – several types including but not limited to desktop clients, browser clients and mobiles.
- **Communication applications** – administration tools, collaboration applications, contact center platforms among others.
- **Conferencing** – separate voice, videoconferencing and web conferencing.

3. Social Network Analysis on UC
The goal is to apply social network analysis (SNA) to data extracted from unified communications. The data can be static, i.e. it can be obtained from compliance logging. Alternatively, the data can be dynamic, i.e. it can be intercepted in real-time as a stream of data. The two methods require different techniques for SNA. The initial dataset comprise of instant messaging data [1]. In the future, the idea is to combine data coming from different means of communication forming an heterogeneous network [2].

4. Static X Stream-based analysis
Initially, the study will focus on static analysis. We expect to extract as much information as possible to understand how the users are forming communities around topics being discussed. The roles played by the users in these communities. The second part of the study should focus on stream-based analysis obtained by replaying the communication flow using the static data. The goal is to compare the social analysis metrics that can be obtained using static data versus stream-based analysis of the same data.

5. Recommendations
The main purpose of the analysis is to be able to make recommendations for end users or administrators. For instance, if there is a group of people actively talking about a particular topic, an administrator would be able to facilitate their communication by creating forums, wikis, persistent group chats or communities in the enterprise social media platforms where the people can easily interact. Alternatively, the system would be able to automatically detect and recommend these resources to end-users, if they’re already available. Additionally, we could recommend experts in a particular topic being discussed [3].

8. References