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ENGINEERING AND INFORMATICS
RESEARCH DAY

Editors:
Dr Michael Madden
Dr Peter Corcoran
Dr Marcus Keane
Dr Sean McGrath

7 April 2011
NUI Galway
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Ergonomic Evaluation of the Xbox 360 Wireless Video-Game Controller
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Abstract
The objective of the project was to evaluate the Microsoft’s Xbox 360 wireless video-game controller from the ergonomics point of view. A gender balanced group involved 10 adult participants playing two different video-games. Questionnaire was used to collect user’s data. Anthropometric data of hand sizes was also collected and included in the analysis. Besides the hypotheses tested, the physical characteristics of the video-game controller were also evaluated.

1. Introduction
All game consoles provide only 1 size of the controllers, although different manufacturers offer different types of controllers for different games, for e.g. Nintendo Wii offers nun-chucks, guitar, steering wheel, Microsoft offers steering wheel, guitar, turntable, etc., assuming that they fit everyone’s hands. The games available on the market vary from 3+ years to 18+ years of age, and are in Europe classified by The Pan-European Game Information (PEGI) age rating system.

The problems with the game controllers can occur with the holding, gripping, use of excessive force for pressing the buttons, high repetition of finger movements related to certain types of games while using the game controller, and the overall time of playing video games. Games are no longer designed to be played for a couple of hours. On the contrary, they are designed to be played for hours and even days. The excessive playing can lead to the development of musculoskeletal disorders, such as the “trigger finger”, or “numb thumb” problems and other problems such as an addiction to certain video games.

2. Methods
Several factors were taken into consideration for the ergonomic evaluation: size, weight, surface, edges, grip (force), layout of the controller, the amount of work done by each and both hands, the amount of work done by each finger, the repetitiveness of finger movements, body posture, etc. The experimental group consisted of 5 male and 5 female video-game players, playing Forza Motosport III, a car racing game, and Call of Duty – Modern Warfare 2, a first-person shooter game, for the duration of at least 20 minutes, and up to 90 minutes per video-game. The participants filled out a specifically designed questionnaire at different stages. Anthropometric data of hand sizes was also collected and included in the analysis. Seven different hypotheses were tested in relation to the video-game controller using the PASW program. Besides the hypotheses tested, the physical characteristics of the video-game controller were also evaluated.

3. Results
The results confirmed that the controller was not suitable for the average hand size, that the musculoskeletal discomfort did appear while playing video-games, that both hands did not do the same amount of work, that some fingers did more work than others, that a lot of force was not exerted on pushing the buttons, that the grip of the controller was not the same during the game, that the finger repetition was different in both games.

Some of the participants reported that the weight of the controller was “just right”, that the surface felt “smooth” and the edges felt “rounded”. However, only half of the participants liked the vibration feedback while playing the video-games.

The controls were quite easy to learn for the male participants, and quite difficult to learn for the female participants. The experience of learning to play the video-game using the controller was quite easy for all participants. It was easier to play the video-games for the male than for the female participants. It was also easier for the male participants to advance during the video-game than for the female participants. Both, male and female participants enjoyed playing the video-game quite a lot.

4. Conclusion
The results confirmed the controller was not suitable for the average hand size, and that further ergonomics research on the design of the controller should be taken into consideration.
Generation and Analysis of Graph Structures with an Application to Generate Levels (Turn Based Patroller-Intruder Games)

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Abstract
This project focuses on automatically testing game content and consequently designing a tool which automatically generates game content. This research is relevant to current game design techniques as it reduces game testing times and allows for quick generation of content.

1. Introduction
Current game design fundamentals include conceptualising a game, planning how this shall be accomplished, executing this plan, testing the results and then refining the game [1]. This can be a long process along with extensive testing needed to be performed before a game can be completed. One way for the testing time to be reduced would be to develop automated testing of the game that could occur during all levels of the design stage.

Another way to decrease the length of game design would be to automate level design. This is especially useful for genres like patrol games, FPS (First Person Shooter), RTS (Real Time Strategy), where levels are often quite similar with just small changes in terrain allowing for different gaming experiences. If the properties of a level were analysed, then levels could be generated automatically allowing for much more game content, increasing longevity and enjoyability for users.

In this research, the domain of patrol games is used develop ways of testing levels automatically and generating levels automatically based on the results. A patrol game involves an intruder agent and one or more patroller agents [2]. The intruder is inserted into a predefined area in a level and then must make its way towards another predefined area in the level known as the goal. The patrollers are constantly patrolling the level on predetermined paths trying to find the intruder. An intruder success is when it reaches the goal area while a failure occurs when a patroller and an intruder cross paths.

2. Simulator Model
The graphs being tested by the simulator correspond to levels of a 2D turn based, node based, patroller-intruder game. A level is represented as an adjacency matrix and all possible pathways through the graph are calculated by brute force. The simulator then randomly generates paths for both the intruder and patroller. The simulator plays the two agents against each other and records either a success or failure depending on the outcome. If the result is a failure, the positions of the agents at failure are also recorded. The agents are competed against each other for a large sample of randomly generated paths. The ratio of successes to failures will show the level of difficulty of the graph.

3. Current Work
By recording the frequency of failure localised to each node with respect to the total number of failures occurring throughout the simulation we hope to identify certain graph characteristics. The levels of difficulty each of these characteristics bring to a graph need to documented and assigned and influence value.

The main characteristics identified so far that influence graphs are connectivity, choke points, chains, dead ends and small cycles. Choke points for instance severely restrict pathways through an area of the maze making safe navigation for the intruder more difficult.

4. Future Work
Using the values described above, we hope to be able to generate new graphs within a certain level of difficulty. This will be accomplished by evaluating different sections of graph and using genetic algorithms to form a totally new graph from constituent parts.

Furthermore we hope to run these newly generated graphs through another simulator (3D real time game) created by a colleague [3]. By comparing the results of the two simulators we will see if the same characteristics and values identified in the 2D turn based environment, hold true for the 3D real time environment.

5. References
Abstract
This project focuses on researching the feasibility of an FPGA based embedded system to implement a H.264(MPEG4-AVC) compliant video codec. Various options for implementing such a system are investigated using an FPGA evaluation board and an open source video codec.

1. Introduction
Compression of digital information is commonplace in modern systems, without which the size of data files would become prohibitively large. This is especially true in the context of images, video and sound.

This project aims to examine a low cost method of providing high quality video compression at a rate which will allow live streaming via existing network structure while not having any perceptible decrease in quality. FPGA based designs are unique in that they provide a system that can be rapidly transferred from design to working prototype. The development platform used for this project is the Xilinx ML403 Evaluation board, which houses a Xilinx Virtex 4 FPGA together with some associated logic and hardware such as memory modules, USB interfaces, UART devices etc. Figure 1 shows a block diagram of such a system.

Figure 1. Typical Embedded System[1]

The open source video codec used is x264. For the purposes of this project however, the user variable inputs to the codec will be replaced with hard coded system specific parameters.

2. Proposed Approach
The proposed approach for this project is in 3 distinct phases:
2.1. Phase 1:
Design the system hardware, using the Xilinx Embedded Development Kit(EDK) and the hardware cores supplied by Xilinx. Configure and test the FPGA with this hardware, together with an open source operating system, then load and run the video codec on the system to get a benchmark for performance.

2.2. Phase 2
FPGA based systems have the advantage of being able to implement certain software routines within the hardware fabric of the device. This can lead to substantial gains in the overall performance of the system. Figure 2 shows a flowchart detailing steps involved with the division of a large C language application into dedicated hardware and a smaller software application.

Figure 2. Hardware/Software division flowchart[2]

Phase 2 of the project investigates the optimal hardware/software division based on performance of the system.

2.3. Phase 3
Phase 3 revolves around implementing the live streaming aspect of the project. This will be dependent on achieving the performance (in phase 2) required for compression and transmission of a digital video signal.

3. References
Evolution and Analysis of Strategies for Mancala Games

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Abstract

Mancala games are a range of strategy games. This research attempts to better understand the variants of the game by investigating heuristics to play the game. We then combine a number of heuristics together to form a strategy. A genetic algorithm is used to evolve the most successful strategy for this game.

1. Mancala Games

Mancala is a family of two-player board games that are popular all over the world. There are over 300 documented variants of Mancala. The object of mancala games is usually to capture more seeds than one’s opponent.

The game begins with the players placing an equal number of seeds, as per the variation in use, in each of the bowls on the game board. A turn typically consists of removing all seeds from a bowl, placing one seed in each of the following bowls in sequence, and capturing seeds based on the rules of the game. The exact rules for capturing vary considerably among the variants.

For more than a century, board games and strategy games have been the topic of many scientific studies by psychologists and scientists. “Board games have long fascinated as mirrors of intelligence, skill, cunning and wisdom” [1]. Mancala games represent an interesting topic of study given the wide range of rule variations resulting in games of differing levels of difficulty.

2. Hypothesis

Many interesting research questions exist in the domain of mancala games. These include: are there winning strategies? For which variants do these strategies exist? Can these strategies be represented as heuristics? Are heuristics developed for one game transferrable to another? Which changes to the rules change the difficulty?

In this paper we focus our studies on one variant of the game, Bantumi. We hypothesise that a set of heuristics can be developed and empirically tested to measure their efficacy and secondly, that evolutionary computation can be used to learn a robust strategy.

3. Methodology

The methodology employed in this study includes: design and development of a simulator, design and development of heuristics, empirical testing of these heuristics and the use of a genetic algorithm to evolve a suitable strategy.

4. Current work/Results to date

A simulation for the mancala game Bantumi (and variants) has been designed and implemented. Seven heuristics have been designed (following analysis of the literature and game play) and implemented for Bantumi. These are:-

- H1 - Pick a bowl that allows the player to have another go
- H2 - Pick a bowl that allows the player to make a capture
- H3 - If the opponent has seeds in bowls that allow him another go, disrupt it
- H4 - If the opponent can capture some of the player’s seeds on the next go, move them
- H5 - Always pick the closest bowl to the score bowl
- H6 - Avoid picking a bowl that, after sowing, results in giving the opponent another go
- H7 - Avoid picking a bowl that, after sowing, results in allowing the opponent to capture some of the player’s seeds

All heuristics were tested against each other in a round robin tournament. The results of these experiments showed that H1 and H5 were the two strongest heuristics of the group, while H3, H6 and H7 were the weakest. The results of this experiment are shown below:

Combining heuristics H1, H2, H4 and H5 in a linear order to form a new heuristic was shown to win an average of 83% of games when played against all other heuristics. A genetic algorithm was designed and implemented in our simulator for Bantumi. After numerous generations, and millions of games played, a strategy has evolved when using 3 seeds per bowl that wins an average of 96% of games when played against all other heuristics.

5. References

A Computer-Vision Based Interface for the Control of Parameterised Music Effects

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Abstract

It is increasingly common for musicians to route the signal from their instrument through a MIDI interface to be processed digitally by commercially-available software rather than by traditional analog effects units and amplifiers. This allows for greater sonic possibilities and control.

This project investigates the potential of utilizing computer vision techniques in the task of controlling this processing, i.e. parameterised music effects. The proposed system would create a flexible and intuitive interface, enabling the control of any processing being applied to an instrument's signal in real-time by using head movements as an interface to generate MIDI control signals.

Introduction

At present, the parameters of music effects are controlled either through the knobs, sliders and faders found on MIDI interfaces or through floor-based units.

Current MIDI interfaces have the limitation that in order to change a parameter, one must do so by hand. This has the implication that one hand is essentially removed from the instrument being played.

Floor-based units also have knobs enabling the control of parameters. More tailored units enable the control of a single parameter through a foot-pedal that moves along one-axis (i.e. rocked back and forth from heel to toe).

A computer-vision approach based on head movements would enable the control of a number of effects over three axis of motion – pitch, roll, and yaw – while enabling both hands to be engaged in playing the instrument at the same time.

Problems

Head tracking poses two distinct problems: 1) the detection of the head in an initial frame and 2) tracking the head, or features within the face, in all subsequent frames. The human face has, by its nature, a high degree of variability in its appearance. This makes face detection a difficult problem in computer vision in comparison to other problems, where the appearance of the object to be detected and the location of the camera may be known in advance.

Although a number of head-tracking systems already exist, few are examined under or designed for all the conditions that such a system would be required to operate in. Namely:

- Low latency, ensuring the high level of responsiveness that would be required by a musician.
- Low-level ambient lighting
- High levels of dynamic lighting
- Complex backgrounds where motion independent of the focus head is present
- Handle partial/full occlusions of the face gracefully & scaling of face as performer moves in relation to camera
- Intuitive to use

Approach

As part of this project, a feature-based tracking algorithm is developed. A successful system should be one that is identity-independent i.e. can automatically detect features without any prior user-focused feature training; and, one which is capable of doing so efficiently and robustly.

Feature-based tracking, involves matching local interest-points between subsequent frames to update the tracking parameters. Because local feature matching does not depend on training data, it is less sensitive to illumination and object appearance. This is in contrast to appearance-based approaches, such as 2D Active Appearance Models (AAM)[1] which, although more stable, can have difficulty generalising to unseen/untrained images.

The system is developed in C++ with the OpenCV library, a library developed by Intel, optimised for Intel architecture and focused on real-time image processing.

References

Multimedia Synchronisation

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Abstract

The delivery of multimedia over IP Networks has seen exponential growth in recent years. IP Networks provide a flexible delivery system to deliver all type of information and media data to final users but were not originally designed with such data in mind.

If IPTV private services providers want to compete with free cost Internet they need to offer added value to their product; synchronising multiple media streams and displaying them to the user-end is one example. Multimedia synchronisation over IP Networks acquires particular relevance in sports events and is main focus of our research.

1. Introduction

The delivery of multimedia service employs two types of IP Network, public, free and non-managed on one hand, i.e. public Internet, and private, admission controlled and managed networks, such as those used for IPTV, on the other.

One of the main uses of multimedia is the transmission of sport events where time and timing is crucial. The challenge we address in our research is to synchronise logically and temporally related media streams from different sources and delivered over IP Network to display combined media. Examples include a mosaic of multiple video streams, a video and radio audio or a video visualised with a twitter account. [1]

2. Time/Timing

All humans follow a collection of established parameters to be able to synchronise among themselves. People don’t fully appreciate how their lives follow universal time norms.

An important condition for synchronisation is each element to synchronise shall have a clock. Two people can never be synchronised if one of them does not have a clock thus does not know the time.

Three parameters shall be considered in clocks, time resolution, time frequency and timestamps.

First of all, time resolution, the smallest time unit with which a clock is updated; humans typically use seconds. Secondly time frequency, the rate of time change, again seconds for human perception. Finally timestamps is the set time humans establish to meet.

Multimedia systems follow the same structure. To synchronise multiple multimedia all of them shall have a clock and run at the same frequency and set up timestamps to arrange to be synchronised at a precise moment in time.

3. Multimedia Types

3.1. Video

The two audio-visual standards used by professional TV delivery systems are MPEG2 and MPEG4. MPEG2-2 is actually widely employed whereas MPEG4-2 use is expanding due to its great improvement in data compression. MPEG2 and MPEG4 use as a container MPEG2-1, Transport Streams, which specifies who to packetise and deliver video standards.

3.2. Audio

The standard commonly use for audio, internet radio, is MPEG2-3 using as a container MP3 defined within the same part.

Audio Advanced Codec (AAC) is defined in MPEG2-7 and its container is MPEG4-14 MP4 file format, it has not yet substituted the previous standard.

3.3. Web pages

Web pages include information about different areas. Web pages such as Twitter include the idea to follow whatever a person has to say.

8. References

Visualisation and Relationship Building using 1901 and 1911 Census Data
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Abstract
In this project census data is visualized using familiar platforms such as Google Maps or a typical genealogical family tree site (eg. myheritage.com or geni.com). The release of 1901 and 1911 census data from the National Archives, brings with it many genealogical opportunities, to visualize the movement and change in population over a 10 year period a century ago.

1. Introduction
This work aims to deliver this census data by a more interactive and visual means, such as genealogy trees, and a visualisation of the census using Google Maps. In particular the movement of population, religious groups, occupations etc. can be clearly displayed. In order for this, permission was granted from National Achieves to gather census data from both census years.

2. Data Collection
As there is/was no public API available from the census.nationalarchives.ie website, from which to collect and parse the census data, web scraping techniques were applied to retrieve data on ~936,000 homes containing ~4.7 Million occupants in 1901, and ~908,000 homes containing ~4.4 Million occupants in 1911. This web scraping code was developed using a combination of PHP and jQuery.

3. Data Visualisation – Google Maps
Once collected, the data was normalised for geocoding and occupant matching. According to Google Maps Documentation, “Geocoding is the process of converting addresses (like "1600 Amphitheatre Parkway, Mountain View, CA") into geographic coordinates (like latitude 37.423021 and longitude -122.083739), which you can use to place markers or position the map” [1]. In turn, these addresses are used to populate a customizable map of this census data, based on a user search query.

To avoid client side process overloading, a clustering technique was used to reduce place markers from hundreds of thousands, to several expandable place markers.

4. Data Visualisation – Family Trees
Occupant relationships between 1901 and 1911 census data are developed by comparing individual occupants to a subset of the alternate years’ data. A subset of the full data set is returned and occupants data are passed through a weighting algorithm to find the best matching occupant. The algorithm can be adjusted to trade off between the number of false matches and false non-matches (misses). This process is repeated for all related occupants within the household until all members of the family have been matched. The resultant data is used to develop a genealogy standard [Genealogical Data COMMunication (GEDCOM) file used to plot family trees. [2]

5. Issues
Data integrity is a key issue faced with when analyzing this census data, as over 17,000 uniquely spelt religions were recorded in the 1901 census. To compensate, 97% of 17,000 uniquely spelt religions were normalized to 26 religions. The remaining 3% were indecipherable and could not be normalized. Similarly, there are many variations in names spelling either due to families’ variations in spellings, or how census-takers interpreted and recorded them. Best results were achieved by using a Soundex algorithm to produce consistent representations of similar names.

When matching occupants over the 2 census years, SQL queries are based heavily on Forename, Surname and Age. All other data is subject to change between censuses. In cases when marriage has taken place between censuses (approximately 28,000 per year), surnames of females are subject to change. This results in weaker matches on recently married women, and longer processing time.

Performance issues have arisen as data has increased from small sample data, to a full dataset of 4.7 Million database rows. Restructuring SQL queries and the mySQL database itself, resolved many of these issues.

8. References
Applications of Reinforcement Learning in Gaming Domains
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Abstract
This paper introduces the concept of Reinforcement Learning (RL) and then describes the elements of a reinforcement learning system. Some related work is briefly mentioned and then some potentially relevant domains are discussed. The paper is concluded by stating the goal of this research.

1. Introduction
Reinforcement learning is a branch of Artificial Intelligence in which a learner, often called an agent, interacts with an environment in order to achieve an explicit goal. The agent receives feedback for its actions in the form of numerical rewards. The agent learns from its interactions with the environment and aims to maximize the reward values that it receives over time. The agent must make a tradeoff between exploring the effects of taking novel actions and exploiting the knowledge that has been acquired from earlier exploration.

2. Reinforcement Learning System
In addition to the agent and its environment, Sutton and Barto [1] have identified four primary sub-elements that form a reinforcement learning system. These are: a policy; a reward function; a value function; and a model of the environment. A policy is a definition of the proposed agent’s behaviour in a given situation. This is essentially a mapping from states to actions. The reward function assigns a single numeric reward value to each state in the environment to represent the desirability of being in the state. These values can be used as the basis of altering the agent’s policy. The value function estimates the amount of reward that an agent can expect to acquire from the current state over possible future states. The values are estimated with a view to increase the amount of rewards achieved over time. A model consists of the agents internal representation of the environment and is used to predict future states and rewards before they are actually experienced, which is useful for planning ahead.

3. Related Work
Gaming environments have been widely used as test beds for reinforcement learning algorithms. One of the most successful applications was Gerald Tesauro’s TD-Gammon [2] which was developed in the early 1990s. This used an Artificial Neural Network which was trained using a temporal difference learning algorithm called TD-Lambda[3]. It achieved a level of play close to the top human players in the world.

4. Potentially Relevant Domains

4.1. RoboCup Soccer Tournament
The objective of this annually held tournament is to promote research into robotics and Artificial Intelligence. Teams of researchers from around the world compete every year in both the robotic and software simulation competitions. The overall goal is to produce a team of fully autonomous humanoid robots that can play against, and beat, the current world cup holders of 2050[4].

4.2. First Person Shooter (FPS) Bots
As graphics in modern computer games move closer to photorealism, the emphasis is switching to improving in-game artificial intelligence. Rule-based and traditional scripting systems are being replaced by intelligent reinforcement learning agents. There has been some recent promising work in this area but there is plenty of scope for improvement.

4.3. Educational and Training Software
This would involve creating an intelligent agent that could build up a user profile based on what it learns from the user’s interactions. This could possibly be applied to “brain training”, “typing tutor” or similar type games. The practicability of such an approach would have to be tested as there is very little reported work of reinforcement learning being applied to such problems in the literature.

5. Conclusion
The overall goal of this research will be to examine the current state of the art in the application of Reinforcement Learning to gaming domains. Future work will involve identifying a specific gaming domain following an extensive literature review. Novel experimentation will then be carried out in this area.

6. References
Analysis and Evolution of Strategies within Turn Based Strategy War Games

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Abstract
The aim of this research is to provide an analysis of various playing strategies and styles within a turn based strategy war game. Moreover, we wish to use evolutionary computation techniques to find an optimal strategy or strategies in order to explore under which conditions these games are solvable.

1. Introduction
Within the computer games industry is the Massively Multiplayer Online Role Playing Game (M.M.O.R.P.G.) genre which itself is extremely diverse, where some of these M.M.O.R.P.G.s have as many as 12 million subscribers [1].

There are several variations of turn-based, browser MMORPGs where players control an army and attempt to grow their army’s size and power in competition with other players. A few examples of this type of game include Gatewars.com, Sgancienwars.com and KingsofChaos.com. While the game mechanics behind each of these may be different, the general game play is similar.

A common goal of all players is to gather resources to increase their unit productions so that their armies grow faster and hence will be able to gain further resources or recover from attacks.

Each player must decide what portions of their population should be assigned to defence, offence, intelligence, counter-intelligence and income as building an impenetrable defence would require a large amount of units leaving you a negligible income to protect. Building a massive offence with little defence would leave you vulnerable to having your offence easily destroyed by an angered enemy. Investing in counter-intelligence can hide statistics about your account such as troop deployment, economy size, etc. from enemies who have not invested enough in intelligence.

These balances between economy, defence, strike, covert and anti covert can be used to characterise multiple strategies of play.

A few examples of these strategies include: turtle, sniper, tank and balanced. Turtles would typically be passive players who maintain relatively large defences. The opposite of a turtle would be a sniper which maintain relatively high offences, low defences and are very aggressive. Tanks would maintain relatively high offences and defences while being moderately aggressive. While a balanced player would maintain a moderate defences, offences and aggression.

2. Research Hypothesis
Models and simulations can be created to analyse the various strategies available within a turn-based strategy game. A detailed understanding of each strategy’s advantages and disadvantages can be recorded, in various environments and situations within the game. Secondly, evolutionary computation techniques can be employed to find an optimal strategy or strategies in order to explore under which conditions these games are solvable.

3. Current Work
A simulator based on the games available online has been constructed. This allows us to run the game at an accelerated pace under a completely controlled set of parameters.

With the code in place to support all the actions a human player would be capable of making in one of these games, a finite state machine was designed to simulate the actions a player would make each turn within one of these games. The state machine transitions are controlled by an array of parameters which influence how aggressive the artificial player will behave, how much of their population they will assign to defence, offence, economics, etc. By varying this controlling array the artificial player can simulate players with different strategies.

4. Future Work
Firstly by comparing how various defined strategies of play perform under a range of circumstances a report of the strengths and weakness of each strategy will be compiled, e.g. comparing how an aggressive player performs amongst a population of passive players.

Later evolutionary computation techniques will be used to attempt to learn an optimum set of values for the controlling array of the artificial player under similar conditions to the earlier test cases, e.g. to find the strategy that performs best amongst a population of passive players.

5. References
Assessing the effects of interactivity features on learning effectiveness in an asynchronous video-based online learning environment

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Abstract
In the past few years many universities, including MIT, Harvard and Stanford have begun to provide video lecture content for free online, and non-academic equivalents such as Khan Academy have seen a sharp rise in popularity. Their growth can be attributed to the increased availability of broadband, the growing popularity of video-sharing sites and the availability of free video hosting from these sites. However, these video-sharing sites are not designed with education in mind. The goal of this research is to improve the state of video technologies used in an educational context.

1. Online Learning Environments
The constructivist learning theory asserts that students learn when they actively construct knowledge through interaction with peers, instructors and course content, with a focus on active participation. The constructivist approach is well-suited to online learning environments. These environments allow students to work at their own pace and in their own time, and interact with others through synchronous communication (e.g. real-time chat) and asynchronous features (e.g. discussion boards, e-mail). Hypertext content is easily navigated, well-structured and quickly searchable (a feature lacking in traditional media).

2. Video Learning and Content Interactivity
Research into video-based learning environments has shown marked improvements over text-based environments, but its efficacy is contingent on the interactivity features present in the system. University institutions that provide online lectures have generally not gone beyond the formats of linear video, due to the constraints imposed by technology and video providers. Current online video solutions generally suffer from poor structural transparency, low navigability, high cost of editing and no control of pace.

3. Proposed Design
The following features will be explored in the design:

3.1. Navigation
Typically, text media can be navigated through a nested table of contents. Video navigation could be improved by adding a table of contents and colour-coding sections in the video navigation bar.

3.2. Searching
Associating subtitles, keywords and descriptions with sections of video allows students to quickly locate relevant material.

3.3. Controlling pace
The ongoing development of the HTML5 standard allows native video to be displayed within the browser, allowing the ability to change the rate of video playback without altering the pitch, allowing users to control learning pace in the same way that they can control the pace at which they read a textbook.

3.4. Editing
Video material is difficult to edit due to the cost of production. The use of text annotations to add corrections may provide some relief in this regard.

4.1. Integrating online community features
Video e-learning has rarely been integrated with online learning environments which permit interaction and engagement with peers and instructors. This project will explore the combination of video and text environments on learning effectiveness.

5. Measuring Learning
Student completion rates can be 10-20% lower in online courses when compared to face-to-face courses. It is therefore important to measure student satisfaction when assessing a particular environment, as students’ enjoyment of using a particular system could affect their willingness to continue using it. It has been shown that test grades do not accurately measure learning outcomes. The constructivist approach focuses on real-world problem solving, and thus an assigned task might be a better reflection of learning outcomes. This research will explore the most appropriate method to quantifiably assess learning gains using task performance as a proxy.

5. Conclusion
While many institutions have invested resources in exploring the potential of on-demand video education resources, the development of suitable technologies has not reflected this interest. Current systems lack navigability, are difficult to search and edit and don’t allow users to control the pace of learning. This research seeks to advance the state of the art of on-demand educational video technology.
Non Verbal Communication within Collaborative Virtual Environments

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Abstract
This research aims to examine the usefulness of achieving unobtrusive avatar control in Collaborative Virtual Environments (CVE’s) as a means of tracking and communicating non verbal cues. Through the capture of user data in real time their avatar can in turn be animated to replicate user movement in real time. This passive control of the avatar will provide for a more realistic representation of a user in the virtual world, which in turn will provide a channel through which non verbal clues can be communicated and interpreted by participating users of the CVE.

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 or simply virtual business meetings.

In everyday face to face interactions, participants are able to utilize a full range on non-verbal communicational resources. These resources include the ability to move their head to look at each other, point or use hand gestures to address objects, change their gaze direction, posture, facial expression or their position [1].

Social psychologists have argued that more than 65% of the communicational information exchanged during such a face to face encounter is carried on the non verbal band [2]. Therefore, it is given that there is a need to provide support for such channels of communication when designing a platform for remote person to person communication.

2. Previous Work
Much work has been done in the areas of presence, immersion and awareness in CVE’s, all pertinent topics with regard to rating the quality of interactions in a virtual setting. To date many approaches taken to capture user data to recognize a hand gestures have involved mountable sensors which are used for mapping a hand movement of to that of an avatar [3]. In terms of capturing a participants emotional state much research has been based on capturing the fundamental human emotions as described in the works of emotional psychologists like Robert Plutchik [4] and Paul Ekman [5], who propose separate but similar lists of 6-8 fundamental human emotions. Most prototypic development of emotion capture solutions as applied to CVE’s to date, have solely been trained to capture this static & finite list of primary emotions, lacking the dynamic capacity of capturing other unread emotions.

3. Proposed Work
The proposed work will investigate the usefulness of a user passively controlling their avatar’s facial expression by mapping their own expressions onto their avatar in real time, to convey further unread emotional states. Work to date has limited itself to focus on a few trained fundamental emotions, whereas in reality there are many more subtle emotions that only facial expressions capture. By adopting the more dynamic approach of monitoring all expressions instead of searching for a trained few, the non verbal channel of communication could be fully utilized thus improving user communication and sense of presence. A sample experiment may involve giving subject A tasks or readings to trigger these untrained emotions, and have subject B monitor the expressions of A’s avatar keeping a log of interpreted emotions. Consultation between both subjects would then determine the accuracy of B’s perceptions. The technique of tracking user’s facial data from a live video stream [Fig 1] and using this data to control an avatar’s expression in real time could offer a dynamic solution for tracking emotional states beyond Plutchnik and Ekman’s fundamental taxonomies.

4. References
Abstract

An FPGA-implemented stereo camera based system is proposed whose aim is to generate real-time accurate depth maps at VGA resolution.

1. Introduction and progress of current research

The aim of our current research is to generate real-time accurate depth maps. There are two main types of depth map generation algorithms. In case of the first one, the resulting depth maps are not accurate enough and they have a lot of noise, but they can be implemented in hardware for real-time applications [1]. The second types of algorithms are computationally expensive, but they can generate very accurate depth maps [2].

Based on our study so far, almost all the researchers have created scenes for testing that are the most suitable for their algorithms and that cannot be found in the “real-life” environment. Some of these pictures can be found in figure 1.

![Figure 1. Tsukuba stereo pair](image1)

Our idea was to create setups for testing that are very likely to be found when the user will be trying to create depth maps using the handheld stereo camera. An example of this can be seen in figure 2.

![Figure 2. Stereo image of a face for the “real-life” scenario](image2)

The tests that we carried out were done with the less computationally expensive algorithms. For each setup we have taken pictures from four different distances and four different illumination conditions. In figure 3 a, b, c the difference between different algorithms and setup conditions can be seen.

![Figure 3.a. Difference between SAD and NCC algorithms](image3a)

![Figure 3.b. SAD algorithm, different illumination](image3b)

![Figure 3.c SAD algorithms, similar illumination and different distance](image3c)

2. Future work

Regarding our future work, the plans are to find an algorithm that works well and gives similar results under different conditions (illumination, distance). The second step will be to make it work well when using human faces. The reason for this is that in the Consumer Electronics industry, most of the camera features are developed for faces. In the end, the algorithm will be implemented in a SoC and it will be optimized to work in real-time (30 fps) at VGA (640x480) resolution.

3. Acknowledgement

The project is financed by the Irish Research Council for Science, Engineering and Technology (IRCSET) and Tessera (Ireland) Ltd.

4. References

Abstract

University Rankings are a tool used to compare universities based on a number of criteria deemed to be common to all universities. A university’s rank has been shown to influence admission numbers for that university [1] and so universities actively compete to better their positions in rankings. Visualisation refers to presenting raw data in visual form. Visualisation of data makes information clearer and more accessible. This research proposes to investigate the different ranking systems and their current flaws as well as different visualisation techniques suitable for representing university rankings. A treemap visualization will be implemented showing a university’s ranking over time.

1. Introduction

World university rankings began in 2003 with the publication of the Academic Ranking of World Universities (ARWU) by the Shanghai Jiao Tong University. Initially the purpose of this publication was to measure the differences between Chinese and World class universities. The rankings attracted attention worldwide and have been cited in The Economist magazine. Today it is one of the most influential rankings, along with the QS World University Rankings and Times Higher Education World University Rankings. University rankings also exist at a national level. For example “The Sunday Times” ranks universities in Ireland.

2. Methodologies

THE and QS World University Rankings were not always separate and used to be called THE-QS World University Rankings. The two split in 2010 with THE adopting a new methodology. Both use an academic reputation survey which gathers the opinions of academics on universities. This criterion has a high weighting in both and is subject to much criticism. ARWU give the highest weightings to the criteria ‘quality of staff’ and ‘research output’.

3. Visualisation Techniques

A treemap is a visualisation tool. It is a visualisation of a hierarchical structure. Data items are represented as rectangles and their size is proportionate to a particular attribute defined by the user. For example the amount of a particular item a store has in stock. The more of the item in stock, the larger the rectangle is drawn. A time series can show how a measurable feature, for example products sold or rainfall; changes over time [2]. It is a series of data points, measured at regular intervals.

Examples of a treemap and a time series are shown below:

Figure 1: Treemap depicting soft drinks consumed

![Treemap depicting soft drinks consumed](image1.png)

Figure 2: A time series

![Time series](image2.png)

4. Implementation

The visualisation will be implemented using Processing, a Java-based language specifically designed for coding interactive graphics and animations.

5. References


An analysis of the capability of primary school textbooks to promote scientific inquiry in Irish primary schools

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Abstract
This study analyzed several primary school textbook sets to see whether the textbooks could be used to promote inquiry based methodologies in the classroom. The analysis was created from the results of the 2008 survey of Irish primary science which found that teachers are still relying on textbooks as a primary source of teaching. As the primary science curriculum in 2003 was changed to be more experiential, didactic teaching from textbooks does not follow from the new aims and objectives of the curriculum. This research applied 3 current textbook groups into the 5Es model of teaching. The 5E model is a proven framework for inquiry teaching. It was decided that if the books followed a process of inquiry, defined by meeting the requirements of 3 of the 5Es per lesson in a certain order, the textbook could be used within an inquiry lesson. The results showed a large variance across textbooks in their approach to different topics however, if a teacher is properly educated in the structure of an inquiry lesson, then the textbooks could become a valuable resource in these lessons.

1. Background
This project was designed to further research that was carried out by the National Council for Curriculum and Assessment (NCCA) in 2008 [1]. This longitudinal study examined science teaching and learning in Irish primary schools. The research looked at how the introduction of a new experiential curriculum in 2003 had changed teaching methodologies and student learning in science. Also investigated in the study was whether teachers were using the experiential curriculum as a guide to adapt their practices from more traditional, deductive approaches into more constructivist, inquiry based approaches. A deductive approach is considered as a teacher centered approach [2] to teaching where the teachers give the information to the students using methodologies such as “chalk and talk”. An inductive or constructivist approach centers around the idea of student directed learning and includes methodologies such as investigations.

2. The 5Es Model of Education
The 5Es model is a structure of teaching a lesson which meets all of the requirements of an inquiry based approach [4] [5]. The 5Es are: Engage, Explore, Explain, Elaborate and Evaluate. The engage phase relates to the idea of prior knowledge that the students may have on a topic. The explore phase allows a student to look deeper into topics and letting the students’ create their own ideas and information from the subject matter. The explain phase allows for the addition of any relevant information that the students may have not been able to take from the explore phase. The elaborate phase often extends beyond the constraints of the curriculum and allows the students to fully research a topic to create a full body of information. Finally in the evaluate phase the students are required to present the knowledge and understanding that they have gained from a topic.

3. Results
The findings highlight several interesting items when looking at the capabilities of textbooks being used to promote inquiry. The varied approaches of the textbooks mean that, depending what textbook a teacher uses, the teacher must adapt to the approach of that textbook. The three textbook series could be used in various ways to promote IBSE, at various levels, however the teacher must be properly versed in the strengths and weaknesses of the textbook to utilize IBSE properly.

4. References
## ENERGY SYSTEMS ENGINEERING

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Building Information Modelling during the Operational Phase of the Building Lifecycle

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Abstract

The growth of Building Information Modelling (BIM) in the past few years has been exceptional. The majority of firms in the AEC industry are either using BIM in some form or are developing skills in this area. Up to now, the focus has largely been on the design and construction phases of the Building Lifecycle (BLC)[1]. Building owners and operators are keen to optimize their building operation and to reduce costs where appropriate. The capture and utilization of operational data is a primary concern. Standards and guides are now emerging into the area of operational data and the transformation of this data into meaningful information on building performance [2] [3].

This research is concerned with investigating the role of BIM within the operational phase of the BLC and the integration of the BIM with operational data to provide greater levels of performance information for the building operator.

1. Introduction

Modern buildings tend to be highly complex and unique structures and building projects tend to bring disparate groups of experts, including architects, contractors, sub-contractors, project managers and operators together, on what is often a once off basis, in order to construct a building in often inhospitable conditions.

Communication methods between the various domains and throughout the Building Life Cycle (BLC) tend to be paper based and interoperability is a recognised problem [4].

The pattern of building operation is often far removed from that envisaged at design time. The commissioning process often produces MEP systems different to what was designed.

2. Research Problem and Proposed Solution

This research seeks to establish direct links between design intent and actual performance. The role of the Building Information Model is crucial in this regard as it serves as a repository for all information relating to the building [5]. By seeking to integrate the BIM with operational data, the author hopes to demonstrate efficiencies in building operation.

The type of information stored within an as-built BIM should provide a significant informational aid for facility managers in the realm of building operation, building maintenance and asset management. The definition and presentation of building operational data is also an important part of this research and seeks to build on efforts already made in this regard.

The proposed solution to the research problem will include:

- An investigation into the role of operational data in building optimization;
- The use of Building Information Modelling in the operational phase of the Building Lifecycle;
- The integration of BIM with existing facility management practices to promote interoperability and efficiencies.

3. Conclusions

This research is focused primarily on the operational phase of the Building Lifecycle. It specifies practices that will promote efficiencies in building operation and seeks to further define the role of BIM in the operational phase further away from an asset management and scheduling resource towards a tool for the interrogation of operational data.

4. References

Environmental analysis 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. This reduction is to be achieved in the 2005 – 2012 time period. 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.

2. Offshore energy extraction

Sustainable energy can be harnessed from sources that are located offshore in the seas and oceans. Offshore wind farms, wave energy extraction devices and tidal extraction device are some of the methods that are used to harness energy from offshore sources.

2.1. 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 then 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 (Commission 2007)

4. Numerical modelling

The flow of fluid is governed by three principals, the conservation of mass, Newton’s second law and conservation of energy. (Falconer 1998) Theses principals are expressed mathematically by integral and differential equations. There are no analytical solutions to these. Numerical models, such as DIVAST, FLUENT and MIKE, replace the integral and differential part of the equations with discrete algebraic forms. These equations can then be solved to get values of the characteristics of the flow field at certain point in time and space. These methods can give a good insight into the flow of fluid in certain areas, which are hard to measure experimentally. Numerical models are also used for water quality assessment, with the assessment of solute and sediment transport.

The research project has developed new analysis techniques with the use of tidal ellipses and the actuator disk theory. The project will expand its analysis techniques with the introduction of two-way nested modeling techniques. (Bockelmann, Fenrich et al. 2004)

5. 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.

7. References


Abstract

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

1. Introduction

The dwelling energy assessment procedure (DEAP) is encapsulated in Irish law as the method used to assess the energy performance of a residential building. The owner of every building that is sold or leased is required to provide a building energy rating (BER) certificate. The BER is calculated by DEAP based on the design, location and material specifications of the building. Important parameters such as workmanship and maintenance condition, which significantly impact performance, are not considered.

Recent advances in wireless sensor networks (WSN’s) have enabled the development of non-invasive, distributed sensor systems. Such systems can gather data from a large number of nodes and communicate the information back to a central hub for analysis. The aim of this project is to explore the use of such a system to measure the actual thermal performance of a building: the Dwelling Energy Measurement Procedure (DEMP.)

An important output of the project is the determination of a figure of merit for the building that equates to its actual thermal performance; in a manner similar to the BER. In addition, it is intended that the system will allow users to see how the thermal performance varies from room to room: something which DEAP does not facilitate.

Having reviewed the hardware and software requirements for the system and considered a range of options; the Zigbee standard was selected for this study.

2. Zigbee Standard

Zigbee (IEEE 802.15.4) is an emerging wireless technology standard, developed by the Zigbee Alliance. The standard is designed to facilitate the provision of low-cost, low power, personal area networks. The standard can support up to 65,000 nodes, operating at up to 250 kbps. In this study star and mesh network topologies are being explored and the capabilities and suitability of each is being assessed.

3. Test Procedure

A range of residential buildings have been selected as test cases for the investigation. Each building has been assessed using DEAP and a detailed inspection of its fabric was performed.

We are currently working in one of the test case buildings; implementing a wide range of experiments under tightly controlled conditions. The results are being analysed to develop methods to isolate the different parameters that impact its thermal performance and to determine useful metrics for the figure of merit.

Once complete each of the case study buildings will be measured and the resulting figures of merit compared to the BER ratings calculated via DEAP.

4. References

Assessment of Ireland’s Tidal Current Energy Resource

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Abstract
In 2008, fossil fuels accounted for 96% of Ireland’s primary energy demand of which 95% were imported [1]. Careful exploitation of Ireland’s indigenous renewable energy resources is required to help curtail this over-reliance on imported fossil fuels and to reduce greenhouse gas emissions. Tidal currents represent a substantial indigenous energy resource that is both sustainable and predictable. The accessible tidal current energy resource has previously been estimated at 2.63 TWh/y [2].

1. Introduction
The most recent assessment of Ireland’s tidal current energy resource (SEI, 2004) requires updating. This assessment used the ‘farm method’ which has since been shown to over-estimate the tidal current resource as it ignores the effects of energy extraction. In addition, turbine technology has progressed significantly in the intervening years. This research aims to produce a more accurate assessment of Ireland’s tidal current energy resource by incorporating the effects of energy extraction by modern turbines in a multi-scale nested model of Irish coastal waters.

2. Aims and Objectives
The primary objective of the research is to develop a nested model of Irish coastal waters using a 2-D depth integrated numerical model (DIVAST). Optimisation of nested boundary conditions will then be explored to develop a more efficient and accurate transition from the low resolution parent domain to the highly-resolved nested domains. Once the nested model is developed the resource will be assessed and suitable locations will be identified. Resource maps and an online GIS database will subsequently be generated upon completion of the resource assessment. Finally, the research will attempt to develop a methodology to determine extraction capacities using a rating system that incorporates the hydro-environmental impacts of energy extraction and different turbine categories.

3. Most Recent Assessment
The 2004 assessment (SEI, 2004) applied the farm method to the results of a 2-D depth integrated model developed by RPS Kirk McClure Morton. A grid spacing of 405m was employed (Figure 1) and further detailed modeling was carried out at selected suitable sites with grid spacing’s of 135m and 45m respectively. The results were validated using tidal height & current meter data.

4. Methodology
The most recent resource assessment adopted the farm method. A major problem associated with the farm approach is that extraction affects the available resource but this method ignores extraction effects, therefore, the farm method is not valid.

This research will combine the farm method with the flux method to provide a more realistic and accurate assessment of the resource. Kinetic energy fluxes within the tidal stream will be effectively reduced due to energy conversion, support structure drag effects and by the slower moving water in the turbines wake merging with the faster stream tube. The flux method incorporates such effects of energy extraction on the tidal currents.

5. Conclusion
The use of high resolution nested grids and the incorporation of the effects of power extraction using modern turbine performance characteristics will result in a more accurate quantification of Ireland’s tidal current energy resource.

6. References
Numerical Modelling of Tidal Turbines
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Abstract
Tidal current energy resources have the potential to provide a sizable proportion of Ireland’s energy; however, the technologies required to utilize tidal stream resources and deliver energy on a usable scale are very much at a developmental stage. More importantly, while promoted as ‘clean’ energy technologies, the siting of marine renewable energy devices in estuarine and coastal waters will alter current flows and water levels, and therefore has the potential for adverse environmental and economic impacts. The main objective of this research is to develop a generic numerical model capable of simulating energy extraction from coastal waters via tidal turbines. The model will then be used to assess the hydro-environmental impact of turbine deployments. A nested three-dimensional hydrodynamic model will allow spatial resolution at device-scales thus enabling accurate assessment of turbine yields and impacts.

1. Introduction
Tidal current energy resources can provide a sizable proportion of Ireland’s energy. By utilizing this indigenous, sustainable resource we can reduce our over-reliance on fossil fuels. The siting of tidal stream energy devices in coastal waters has the potential for adverse hydro-environmental impacts. The primary objective of this research is to develop a generic numerical model capable of simulating the effects of energy extraction (via tidal turbines) on coastal waters.

2. Research Aims
The aims of this research are as follows:
1. Develop a 3D numerical model to simulate the effects of tidal turbine power extraction
2. Investigate effects of power extraction on hydrodynamics (i.e. currents and water levels)
3. Investigate and optimize configurations of turbine farms for maximum yield and minimum impacts
4. Determine optimum conditions for turbine deployment sites

3. Research Methodology
The DIVAST (Depth Integrated Velocity And Solute Transport) model will be used for this research. The following methodology will be employed:
1. Develop 2D nested model
2. Incorporate tidal turbines into model
3. Develop 3D nested model
4. Incorporate turbines into 3D model
5. Use 2D and 3D models to investigate far-field effects of power extraction

4. Nesting Technique
Nesting techniques allow the use of high resolution within particular regions of interest, while lower resolution is used elsewhere in the domain. This research aims to build on a novel nesting technique previously developed at NUI Galway. Figure 1 illustrates the nesting process. The area of interest, where higher resolution is desired, is highlighted in a deeper blue. A high resolution grid is specified in this area of interest. This “child” grid uses the results of the lower resolution “parent” grid as boundary conditions.

Figure 1: Diagram showing the turbine model contained within the nested grid of the model domain.

5. Turbine Modelling
Horizontal axis tidal turbines can be modelled as an actuated or porous disc. This method is useful as the complex geometry of the turbine need not be fully specified. The actuated disc applies a thrust force to the moving fluid; this force can be incorporated in the governing equations of flow to simulate the extraction of energy from the flow by a turbine. The thrust from the disc to the flow can be derived as:

\[ T = \frac{1}{2} \rho C_T A u^2 \]

where:
T = thrust from the turbine to the fluid
u = velocity
\( \rho \) = fluid density
A = area of the turbine defined as an actuated disc
\( C_T \) = coefficient of bypass and turbine wake flow

6. Conclusion
The development of accurate numerical models for the assessment of tidal current energy resource, power extraction and the hydro-environmental impacts of power extraction is important for the development of the tidal turbine industry.
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 deviations from the expected building behaviour and to optimise the building performance.

8. References
Abstract
This paper investigates laminar heat transfer characteristic of two-phase microencapsulated phase change material (MPCM) suspension flows within mini-channels under a constant wall heat flux boundary. Capsules containing paraffin are examined and found to be well suited for electronics cooling applications using liquid cold plate technologies. In particular, it is shown that the large thermal capacity of MPCM slurries around the phase change temperature can lead towards greater isothermality of isoflux systems, a characteristic of significant interest to telecommunication, laser and biomedical applications.

Introduction
Phase Change Materials (PCMs) have been widely used in thermal energy storage applications. They offer the ability to absorb and store large quantities of thermal energy through the endothermic melt process. The high latent heat of fusion and considerable energy densities associated with such materials have made them very desirable and these thermal properties have led to many direct applications in a range of fields. Investigations have found important uses in solar energy storage to reduce peak demands on systems, El-Sebaii et al. [1] and subsequent incorporation in numerous building materials, such as wallboard and under floor heating, Farid et al. [2] However, significant potential lies in the field of MPCM slurry flows, allowing store energy to be easily transported.

Thermo Physical Properties
The primary aspect of the MPCM slurry is the latent heat of fusion associated with the phase change process. This can be quantified using a DSC and for simplified modeling, the latent heat is absorbed as a specific heat capacity enhancement. This results in a step change in the apparent heat capacity over the melt temperature range as demonstrated in Figure 1.

Analytical Model
Heat transfer for single phase flows in circular geometries is described using the Graetz solution. This is characterized by the Nusselt number which in based on the inverse of the temperature difference between the wall and bulk mean of the fluid. Theoretical wall temperatures can be determined based on the modified bulk temp from the enthalpy model shown in Figure 1.

Results
Experimental wall temperatures determined from the Infrared Thermography are plotted versus the predictions using the Graetz solution. An example using 30.2% mass particle concentration is represented in Figure 2. Further tests were carried out investigating various scenarios, i.e. constant heat flux or constant flow rate. Different particle concentrations were also investigated, from 5.03 – 30.2%.

Discussion
From the experimental conditions examined, there is very agreement in the temperatures until the wall value reaches the onset melt temperature. Downstream of this experimental values deviate from predictions, resulting in an augmentation followed by a degradation in heat transfer. This is before the temperatures collapse once more, when the particles have changed from solid to liquid phase. Compared with single phase flows, MPCM slurries can provide temperature reductions up to 33%.

References
Building Energy Modelling

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Abstract
The Energy Efficiency of the buildings in which we live and work is becoming increasingly scrutinized. A major problem is the amount and subsequent cost of unnecessary energy that buildings consume through heating, cooling, lighting etc. The tools available to evaluate building energy performance are currently inadequate. The objective of this research is to develop a building energy model along with data from a weather station on campus, to predict energy demand. Being able to predict the energy demand of a building will support the analysis of actual energy used and thus assist in identifying wastage and ultimately reducing energy consumption. The Nursing Library extension on campus at NUIG is to serve as the demonstrator building underpinning the energy model. An energy model is currently been developed using the Simulink software package. The main considerations for the model are the thermal characteristics of the building envelope, the building heating and cooling system and the outdoor environment. Simulation results will be compared to actual sensor readings of thermal and power loads in the building.

1. Introduction
With the cost of energy rising there is an increased demand to develop and operate energy efficient buildings. Construction and energy managers are increasingly turning to technology to provide the answers. However, the tools available to evaluate building performance are currently inadequate. One of the major problems is the amount and subsequent cost of unnecessary energy that buildings consume.

2. Research Objectives
The objective of this research is to develop a building energy model that will be used together with data collected from an on-site weather station, to predict energy demand. The weather station has recently been installed on the NUIG campus and is being used to provide data for a number of energy related projects on campus. Being able to predict the energy demand of a building will help in the analysis of actual energy used and thus assist in identifying wastage and ultimately reducing the energy consumed. The Nursing Library Extension on campus will provide the basis for the building energy model. This building is fitted with a number of sensors that take readings for temperature and CO₂ levels. The actual thermal and power loads for the building are also measured. Simulation results will be compared to these actual readings.

3. Model Development
An energy model is currently been developed using Simulink, a tool in the MATLAB software package [1] for modelling, simulating and analyzing multidomain dynamic systems. There is a large number of building energy modelling software packages available such as EnergyPlus, DOE-2, and BLAST. Simulink was preferred to these packages due to its adaptability and modularity. The main considerations for the model are the thermal characteristics of the building envelope, the building heating and cooling system and the outdoor environment. A building physics toolkit developed by universities in Denmark and Sweden is being used to further develop the model [2].

4. References
Abstract

Rising energy costs have focused the attention of data centre management. Processing power and storage capacity are no longer the only concern. The operating cost of hardware and the associated heating and ventilation systems (HVAC) are becoming more important, particularly in today’s economic climate. Both existing and higher capacity data centres (being rolled out to meet the rising demands of cloud-based computing) are increasingly required to include these performance metrics in their monitoring systems.

1. Research Aim

The aim of this research is to specify, design & develop an integrated hardware / software system which will monitor and report data centre energy efficiency using the ISS (Information Solutions & Services) data centre in NUI Galway as a test bed.

Employing a wireless sensor network for cabinet temperatures and SNMP (Simple Network Management Protocol) polling for all other values, the resultant application will provide real-time information to assist ISS personnel manage the energy efficiency of their data centre.

2. System Architecture

The system will consist of two main data capture schemes illustrated in the figure below.

Temperature and humidity data are captured via a network of Tyndall 25mm platform wireless sensors. The sensors sample every 30 seconds and transmit the raw data values to a base station in the Data Centre, using the IEEE 802.15.4 protocol. This data is then processed and logged in an SQL database with any network issues flagged to a system administrator via email.

Additional data centre parameters are captured using the SNMP protocol. SNMP allows for a wide range of values to be captured on equipment attached to the ISS network. Of interest in this application are; CPU Load (Process queue average), CPU Draw (Watts), CPU Fan Speed (RPM), HVAC Draw (Watts). These values are collected using a C#.NET SNMP poller, running on the base station and transmitting the collected data to a SQL database.

3. Visualisation & Reporting

External access to the raw dataset is provided by a website hosted in the IT Department. (www.enformatics.eu)

Authorised users can access a clickable floor plan of the data centre. If readings are available for a given cabinet, then this cabinet will be clickable and the user is redirected to the reporting page.

The user selects one or more sensors from the cabinet’s available list, chooses the time range for the report and clicks ‘Report’. A chart is generated where visual comparisons can be made between sensors.

4. Implementation

It is proposed to capture data sets across 3 cabinets within the data centre for a period of two weeks. Cabinets will be chosen so that different combinations of server types and general loading conditions will be monitored. Each cabinet will be fitted with six Tyndall sensors to monitor temperatures throughout the rack.

The resultant data sets, after analysis, will allow for identification of hot-spots within racks and the data centre as a whole as well as correlation analysis. Through balancing server loads and improving data centre design in terms of air flow it is hoped that overall efficiency can be improved and, more importantly, quantified.

5. Future Work

The basis upon which good decisions are made is good information. Once reliable data is being received and analysed, we propose to incorporate an artificial intelligence agent into an analysis and modelling engine. This will aid data centre staff making both short-term optimisation decisions and formulating energy-saving strategies for the medium to long-term.

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Calibration of a Building Energy Model to Energy Monitoring System Data Using an Analytical Optimisation Approach

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Abstract

The built environment accounts for approximately 40% of global energy consumption and is responsible for 30-40% of greenhouse gas (GHG) emissions. Energy modelling tools such as EnergyPlus provide a means of understanding and optimising energy performance in buildings. This study focuses on the ‘calibration’ of such models to actual measured data using an analytical optimisation approach. Numerical multi-variable optimisation techniques will then be used to analyse the calibrated model and optimise building control strategies for enhanced energy efficiency and occupant comfort.

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. Due to the complexity of the built environment and prevalence of large numbers of independent interacting variables, it is difficult to achieve an accurate representation of real-world building operation. By ‘calibrating’ the model to measured data, we can achieve more accurate and reliable results. 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.

2. Literature Review

Since the calibration problem is itself over-parameterised and under-determined, it is impossible to find an exact, unique solution. A mathematical formulation process has been suggested to find a solution whereby a value and weighting is assigned to certain known or measurable parameters. [1] By using an objective function approach, the aim is to find a solution which minimises mean square errors between measured and simulated energy use data while conforming to these weighted values. More recently a methodology has been developed whereby best-guess estimates are assigned to a heuristically defined set of influential parameters. [2] These are then subject to a Monte-Carlo (MC) simulation involving thousands of simulation trials to find a set of promising vector solutions. Simulations are carried out using the template-based DOE-2 software and calibrated to data attained from building audits as well as monthly utility bill information. This study provides an excellent basis for further work on analytical optimisation of the building simulation calibration process. However, this approach has so far been limited to basic template-based simulation tools and only focuses on buildings where limited design and energy-use data is available.

3. Proposed Methodology

This project will attempt to validate a similar analytical optimisation approach to calibrate a more detailed EnergyPlus model of a naturally ventilated building. A thorough literature review has not found any previous calibration studies for naturally ventilated buildings. Thus, this will serve as a basis for future studies as well as highlighting potential problems related to this type of building. Long-term monitored data from the Building Management System, measured data from an on-site weather station, and numerous site surveys during the calibration period will be incorporated into the calibration methodology. A Building Energy Simulation (BES) model of an existing 700m² library will be developed. Data pertaining to the building construction, systems and operating schedules will be acquired. The model will be developed based on this evidence and will be tracked using version control software. Subsequently this BES model will be calibrated using the proposed analytical methodology. This will involve reducing the dimensionality of the parameter space by performing a sensitivity analysis to determine influential parameters and reasonable parameter values. A two-stage MC simulation process will then be used to find a realistic set of solutions that satisfy the objective function. Finally, by isolating controllable parameters identified in the initial optimisation approach, it is proposed that the calibrated model will be used to assist in the identification of optimal operational and control strategies.

4. Acknowledgments

Research funded by NUIG College Fellowship

5. References


An embodied energy and carbon assessment tool using a hybrid energy input-output methodology

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Abstract

In the aftermath of the Kyoto protocol [1] the ‘carbon market’ has incentivised industries to become more sustainable and change their outlook. The energy intensity of every sector of the Irish economy is being scrutinised, but very little attention has been paid to embodied energy (EE) and embodied carbon (EC) in our products and systems. It is critical that EE/EC can be assessed, as previous studies have emphasised just how important it is. In reference to the built environment: the EE of a multi storey building can account for up to 67% of the operational energy (OE) for a 25 year LC [2]; for a low energy house the EE can account for up to 50% of the OE over a 60 year LC [3], EE may be expressed as megajoules (MJ) per unit weight (kg) or unit area (m²). The EC is measured in carbon dioxide equivalent (CO₂e). This research focuses on the development of a framework, by the authors, enabling the quantification of EE/EC in an Irish context using a hybrid Input-Output (I-O) methodology. An initial study applies the framework to cement, which is a material high in EE/EC and consequently a material included in the European Union-Emissions trading scheme (EU-ETS).

2. Assessment of cement manufacture

Cement is the largest contributing factor to the EE/EC of concrete equating to 5% of total Irish CO₂ emissions in 2005 [5]. In order to investigate the validity of the hybrid I-O energy analysis methodology for calculating the EE and EC of a product or system, as part of an LCA and also as part of the EU-ETS, cement was chosen as a product for assessment. The IPCC guidelines and the ISO EN 14044 standards [6] were accorded to for EU-ETS and LCA calculations, respectively. The I-O energy and carbon intensities of 4.41 MJ/€ and 0.33 kgCO₂e/€, respectively. The hybrid I-O energy and carbon emissions intensities, for cement produced in Ireland in 2005, were found to be 3.32 MJ/kg and 0.86 kgCO₂/kg.

3. Conclusion

This research demonstrates how the I-O energy analysis methodology can account comprehensively for energy and emissions throughout the economy at both a sectoral level and in respect to the products and systems therein. The results can be utilised in LCAs of buildings to calculate the OE versus the EE and EC or on renewable energy technologies, to calculate the payback period in terms of energy and carbon. Conversely, as energy and CO₂e emissions associated with the Irish electricity generation sector reduces, EE and EC will become larger over a complete LC. Hence, there is a need for robust and complete analysis, which takes both direct and indirect energy and carbon into account.

References:

[1] UNFCCC, Kyoto protocol to the United Nations framework convention on climate change. 1998, UNFCCC:
Calibrating building energy models to detailed measured data
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Abstract
Building energy simulation tools are commonly used within the construction industry to improve energy efficiency. However, there is often a large discrepancy between the simulation results and the actual building. It is vital to improve the accuracy of these models if they are to be used with any confidence in the results. Thus, calibration of these models is essential. Once calibrated, the models can be used to examine retrofit options and optimisation strategies in existing buildings. However, there is no widely accepted methodology for calibrating these models. This project developed a new method for calibrating simulation models that focuses on a scientific, reproducible and evidence-based approach. This methodology was successfully demonstrated through a detailed application to a 30,000m² industrial building.

1. Introduction
Building energy simulation tools are commonly used within the construction industry to improve the energy efficiency. However, there is often a large discrepancy between the simulation results and the actual building. It is vital to improve the accuracy of these models if they are to be used with any confidence in the results. Thus, calibration of these models is essential. Lessons learned during the calibration process can be fed back to users and software developers in order to improve simulation quality. Furthermore, the calibrated models themselves can be used to examine retrofit options and optimisation strategies in existing buildings. However, there is no widely accepted methodology for calibrating these models.

2. Objective
This project developed a new method for calibrating simulation models that focuses on a scientific, reproducible and evidence-based approach. This methodology was demonstrated through a detailed application to a large industrial building.

3. Method
The methodology is described in a recent paper [1]. All of the model geometries and constructions used throughout this research are Industry Foundation Class (IFC) Building Information Models (BIM) converted to EnergyPlus input syntax via a new tool: IDFGenerator. Heating Ventilation and Air Conditioning (HVAC) equipment and internal loads were modelled using a tool developed specifically for this project: EnergyPlus HVAC Generator.

4. Results
Figure 1 shows the results of the calibration for the demonstrator building. Mean Bias Error (MBE) and Cumulative Variation of Root Mean Squared Error (CVRMSE) give an indication of how closely the model matches the actual building. Values closer to zero indicate better correlation. The coloured surface plots indicate absolute percentage error between the building and the model at various times and conditions over an entire year.

Fig. 1: Final model error results

5. References
SmartOp - Smart Buildings Operation
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Abstract
SmartOp focuses on optimal building and HVAC systems control underpinned by reduced order models. The focus of the project is on sport facilities which denote a highly variable usage profiles.

1. Introduction
Current building operation strategies do not account for the dynamic behaviour of building usage. An integrated ICT base methodology is required to support optimal building and systems operation and control. SmartOp will define an ICT based methodology that is capable of supporting optimal decision making in relation to building and system operation. With a vast array of information not previously available in terms of building energy performance, SmartOp will develop the proposed methodology underpinned by novel mathematical models that will use this data to make optimal energy management decisions with particular consideration to the triple dimensions of energy flows (generation, grid exchange and consumption).

1. Project outline
A large body of research regarding building operation is focused on the acquisition of higher resolution data leveraged through the enhancement of sub metering and smart metering technologies. SmartOp is focused on the development of mathematical energy optimisation models that are capable of capturing and predicting the dynamic behaviour of building operation. These mathematical models will be developed and enhanced using high resolution data sets that can be obtained from both whole building energy simulation models and smart metering technologies. These models can provide quick response in terms of performance prediction that is the key requirement for dynamic building and system optimal operation. Artificial Intelligence (AI) concepts and techniques that include fuzzy logic and neural networks, provide significant potential in the development of the mathematical models proposed in this research.

A case study building will be used to demonstrate the main research challenges associated with dynamic building usage with load optimisation, power pricing and occupancy scheduling, etc... The case study building chosen for this purpose will be a sport facility. Sport facilities possess unique features such as:

- variable energy demand profiles (timing and peaks) and usage patterns (long periods of low use and then short periods of high use sporting event);
- complex environmental conditions (comfort and ventilation requirements), facility functional characteristics (e.g. swimming pools, indoor courts, saunas, and the like) and open spaces (multiple buildings, complexes, parking areas, lighting, etc.).

The innovative SmartOp methodology is structured in three layers (Figure 1), the decision making layer, that represents the main contribution of this work, and other two supporting layers: the sensing layer and the controlling layer that will be examined within the project. The sensing layer objective is to focus on the required smart metering network to support the proposed methodology. The controlling layer objective is to focus on the systems control side (actuation) in order to implement the decision driven by the sensed parameters and the energy optimisation models that are the core of this research work (decision making layer). As shown in Figure 1, the decision making layer will take inputs form the facility manager in form of optimisation scenarios. The facility manager specifies the optimisation scenarios that he wishes to achieve such as minimise zonal energy consumption while maintaining environmental temperature set points, or maximise the energy sold to the grid. These optimisation scenarios then act as inputs to the decision making layer whereby the mathematical models within this layer perform the optimisation routines.

![Figure 1 – SmartOp methodology overview](image)

2. Acknowledgements
This project is funded by IRCSET and D'Appolonia within the Enterprise Partnership Scheme.
Formal calibration methodology for CFD model development to support the operation of energy efficient buildings

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Abstract
Computational Fluid Dynamics (CFD) is a robust tool for modelling interactions within and between fluids and solids. At every stage of the Building Life Cycle (BLC), CFD can help understand and predict phenomena that are difficult to test experimentally leading to cleaner, healthier, and better controlled internal environments. Previous research has focused on developing and validating CFD models for different internal and external environments. However, limited work has been done in developing formal procedures for calibrating CFD models. Once calibrated, these models can be used to determine optimal physical sensor positions, which can aid in improving environmental and energy performance.

1. Introduction
CFD gives an opportunity to model interactions within and between fluids and solids. This may lead to improved prediction and understanding of phenomena that are difficult to test experimentally. When used appropriately, CFD may provide cleaner, healthier and better controlled internal environments.

Previous research has described the use of CFD models for various internal and external environments [1]; [2]. However, limited work has been done to develop formal procedures for calibrating CFD models and to use them to determine optimal physical sensor positions so that both the environmental and energy efficiency constraints are achieved.

2. Research goals
This project aims (i) to develop a formal calibration methodology for indoor environments that require specific conditions (e.g. office spaces, clean rooms, etc.) and (ii) to determine the best position of sensors controlling these environments.

3. Methodology
Using existing geometrical documentation and real data gained from the on-site measurements, a reliable 3D virtual model of indoor environment is being developed. The CFD model is calibrated with real data gained from a well-positioned wireless sensor network and weather station. The reliable CFD model is used to determine the best sensor position for controlling internal environments. Figure 3.1 shows the process of creating a reliable CFD model of internal environment.

4. Demonstrator
The demonstration building used in this research is a 3 storey, (800 m²) “Nursing Library” expansion to the James Hardiman Library at the National University of Ireland in Galway. The building is naturally ventilated with the support of mechanical ventilation.

For the simulation of an internal environment, a CFD model of one of the study rooms in the demonstration building is developed. Data obtained from the on-site weather station provide boundary conditions for the CFD model. A well-positioned wireless sensor network collects real-time data at multiple locations within the indoor environment. The data are compared with CFD model results and a calibration procedure is being developed. The calibrated CFD model will be used to optimise the positions of the physical sensors for the control of the internal environment. This will result in significant energy and economic savings by providing a more accurately controlled internal environment.

5. References
Ocean Wave Energy Exploitation in Deep Seas

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Abstract

Ocean wave energy is one of the world’s most powerful forms of energy and, as of yet, is a relatively untapped natural resource. The main goal of this research is to challenge some of the opinions of current developers [1, 2] by exploring the advantages and efficiencies of relatively small Wave Energy Converters (WEC’s), which operate in the heave motion. This is to be achieved by optimising their structural shape and developing reliable methods for carrying out Structural Health Monitoring of the devices.

1. Introduction

Since the publication of Stephen Salter’s groundbreaking paper on his Wave Energy Duck [1], thousands of patents have been issued for Wave Energy Converters (WEC), incorporating a variety of methods. However, as of yet, no ‘winning’ device design has been established. This leaves plenty of scope for Ireland to become a world leader in the development and design of the necessary technologies. Furthermore, Ireland is located next to a vast ocean, maximising the available wave energy.

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%.

2. Project Objectives

- Develop an analytical approach for calculating the wave forces on a vertical cylinder in deep water.
- Use computational fluid dynamics (CFD) to explore the wave forces on complex geometries for axisymmetric vertically oscillating wave energy converters (WEC’s).
- Develop a method of matching the frequency of a WEC to the to the peak frequency of the wave spectrum of a given location by optimising its geometry.
- Perform physical experiments in order to verify the results of the study.
- Explore methods for the structural health monitoring of offshore devices.

3. Analytical solution for calculating the wave force on a floating cylinder

The derivation uses the wave-water problem [3] and eigenfunction expansions to obtain the velocity potentials. A boundary value problem was set up to derive the interior and exterior 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 for a low frequency incident wave [4].

4. Computational Fluid Dynamics

A variety of complex geometries will be examined using the fluid-structure interaction aspect of CFD, as the frequency of the incoming linear deep water wave changes. In order to insure the properties of the incident wave are accurate, a study for creating an accurate and optimum model was carried out. The next stage was to explore the 2-dimensional interaction between the incident wave and a floating rectangular prism.

5. Conclusion

An analytical solution for determining the excitation forces on a floating vertical cylinder has been developed. A method for generating realistic waves in CFD has been developed and the CFD fluid-structure interaction is being explored.

For every sea or ocean region around the world the energy and properties of the waves is unique. Therefore, it is necessary to design a WEC depending on its expected location. The outcome of this project will enable a designer to optimise the geometry of the device by matching its natural frequency to the peak frequency of the wave spectrum of the location. This will aid to increase the frequency range of a vertically oscillating axisymmetric WEC when mechanically tuning the device to match the frequency of the incident wave, in order to force it to resonate. Furthermore, designers will have user-friendly methods to carry out reliable SHM of devices.

6. Acknowledgments

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References

Multi-Level Enterprise Energy Management

Linked Data for Semantic Complex Event Processing

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Abstract

Energy consumption management has become a very crucial topic for enterprises due to energy cost and environmental impacts. Energy monitoring usually takes place on a very low level in enterprises such as sensors. However, different people in an enterprise would be interested in different conceptual levels and granularities of activities and thus energy monitoring in its current state-of-the-art lacks the ability to bridge the vertical information gap between hierarchical levels (e.g. maintenance, operational, upper management) in an enterprise. Our research is aimed at exploiting semantic web technologies and complex event processing technology to strengthen energy monitoring task and associate energy aspects with activities and business processes in different operational and management levels of an enterprise. This will allow organizations to understand accurately the relationships between its activities and energy consumption and thus being able to find possible opportunities for energy saving or business process development.

1. Introduction

Monitoring technology has evolved in a slower manner than business information systems [1]. This difference has created a gap between different layers of an enterprise. For example, energy sensors data is very low level and can be understood by maintenance personnel but doesn’t make sense to upper management which might be interested in a business objective such as reducing energy consumption by 10% throughout the next two years.

2. Complex Event Processing for Energy

Event-driven systems have attracted much interest recently because of its nature of low-coupling and asynchronous communication. This nature makes events a good choice for real time monitoring in highly dynamic systems.

CEP addresses the aforementioned information gap with vertical causality between events and abstraction hierarchies to reflect multi-layered enterprises [1].

3. Linked Data for CEP

Linked Data technology [2] provides an approach for systems integration and interoperability. The self-contained semantics in Linked Data improves its suitability for sharing and gives it a potential to be reused with significantly lower cost.

We suggest the use of Semantic Web technology to model energy and events concepts and environments. We also propose the use of linked data as a rich context for CEP systems in order to make CEP engines more effective in a high-scale, real time energy monitoring scenario.

4. Current Results

Sustainable DERI [3] and DERI Energy (figure 1) are in-progress projects to investigate the potential of our approach in a typical SME with a medium size data center and other office energy consumption equipments.

Figure 1, Architecture of DERI Energy Platform

5. References

Future Smart Grid Synchronization Challenges
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Abstract
The success of the evolving smart grid project will depend hugely on ICT (Information and Communication Technologies) to revolutionise the traditional power grid and will place various demands on current synchronisation techniques. Utilisation of wireless communication systems within the smart grid infrastructure seems inevitable, thus, if the smart grid project is to reach its full potential then some of the shortfalls of current synchronisation techniques over wireless must be remedied.

1. Introduction
The current electricity grid is a real-time system whereby generation must always match demand. In any real-time system, time is a critical factor and when the system is distributed, synchronisation of its various elements is essential. Current grid infrastructures employ synchronisation techniques to permit such functions as fault detection, protection testing, load balancing, scheduling and analysis. While the reliance on synchronisation techniques is quite significant, the future smart grid will be much more demanding in terms of synchronization requirements.

The smart grid project aims to revolutionise the current grid infrastructure in order to reduce inefficient energy consumption, to facilitate the move towards renewable energy, and to better utilise the grid’s capacity so as to accommodate growing electricity demand. Smart grid will by definition significantly increase the complexity of the current grid’s static design by transforming it into a much more dynamic network where the distinction between producer and consumer will often be blurred. The composite elements of this complex system will place significant demands on current synchronisation technologies in order to meet its full potential.

2. Research
A key driver for the smart grid project will be through integration of ICT into the electricity grid, from generators through transmission right down to consumers. As such, a smart grid system will utilise synchronisation techniques currently employed by ICT systems. Within the wired domain of current ICT infrastructures, synchronisation protocols such as the Network Time Protocol (NTP) and IEEE 1588 (PTP) allow a host to discipline its clock to within a millisecond and a microsecond of UTC time respectively. These protocols are limited in that in their basic state they assume symmetric message delays to and from a host. Although this assumption may often hold for wired networks, it is rarely true of the wireless domain. The asymmetric communication latencies observed over wireless networks, particularly those with many hosts and high traffic loads, significantly affect the performance of these protocols. This can be attributed to the medium access rules imposed by common wireless protocols, which dictate that hosts access the shared medium in a fair manner, thus, resulting in contention and, hence, varying medium access delays.

3. Solution
One method of overcoming this issue is to provide these protocols with information related to medium access delays. This necessitates a method of determining the wireless medium access delays associated with a message and delivering this information in a suitable manner such that these protocols can use it to mitigate synchronisation errors.

Another possible solution that will be explored is the possibility of improving synchronisation protocols by analysing past data. Analysis of past data could help to identify network trends and make predictions about the future state of the network.

Regardless of the approach taken, the ultimate contribution will be a module that can be linked to some synchronisation protocol and used to mitigate the effects of wireless contention.

Acknowledgements
Our research is being undertaken at NUI Galway within the Performance Engineering Lab (PEL) research group and is funded by IRCSET. We also wish to acknowledge the assistance and contributions from ESB Networks.

8. References
Embodied Energy Analysis and Visualisation Tool
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Abstract
Embodied Energy (EE) is the energy consumed over the duration of a product’s lifecycle. Having the quantity of EE clearly visible to designers during the design process should make them conscious of the impact their decisions are having on the EE of a product. This is increasingly important due to rising costs of energy and awareness of environmental impact. This research investigates the different methods of analysis and is developing a unique EE software tool to assist engineers to accurately calculate the EE of a product. The tool will focus on the manufacture of concrete specifically in Ireland.

1. Introduction
EE comprises direct and indirect energy. Direct energy is the energy used for the main process, whereas indirect energy is used to create the inputs of goods and services to the main process. There are three main methods used in EE analysis: process, input-output and hybrid. Hybrid analysis is a combination of process and I-O analysis.

2. Analysis
The accuracy and completeness of EE analysis is very much dependent on the method used. Process methods were the first methods used to assess EE. I-O analysis was modified into an energy analysis tool by [1]. Bullard et al [2] developed a process-based hybrid analysis, whereas Treloar [3] developed an Input-Output based hybrid analysis.

3. Concrete
As the production of energy from fossil fuels is environmentally unfriendly, materials that have a lower EE are more sustainable than those with a higher EE. Concrete has a relatively low EE. However, according to the Cement Sustainability Initiative [4]:
- Concrete is the second most consumed product in the world after water.
- Over two tonnes per person on the planet being used per annum.

Associated high usage in construction results in higher total emissions than any other material. For concrete, replacing Ordinary Portland Cement (OPC) with Ground Blast Furnace Slag (GGBS), a by-product of steel manufacture reduces EE [5]. The embodied Carbon (EC), measured in carbon dioxide equivalent (CO₂e), of concrete is also reduced by replacing a portion of OPC with GGBS [6].

4. Analysis and visualisation tool
A web based analysis and visualisation tool is being implemented to evaluate the EE and EC of concrete. This tool will incorporate all the different methods of EE analysis. The main functions of the tool include:
- The option to change cement (CEM I, CEM II/A or CEM II/B)
- To calculate energy values associated with cement, aggregate, water, reinforcement and delivery
- To calculate percentage wastage

These calculated figures will be compared and displayed graphically in terms of embodied energy and equivalent carbon dioxide (CO₂e). The scalable architecture is depicted in Figure 1.

5. References
Web-Based Building Energy Usage Visualisation
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Abstract
The objective of this research is to develop a method of visualising a building’s energy usage by combining several existing technologies including the latest web technologies. This method of visualisation should be easily understandable, accessible and interactive. The use of existing technologies means that it can be used in standard environments and bridges the gap between these technologies, bringing previously specialised technologies to a wider audience. These factors combine to create a tool, which will potentially lead to increased energy efficiency and awareness.

1. Introduction
Energy efficiency is becoming more and more important due to environmental and economic reasons. Current Building Management Systems (BMS) can often be difficult to understand and use. This often leads to inefficient energy usage. Therefore, an easier, more intuitive and more accessible way to visualise and control this energy usage is needed.

An intuitive method of visualising this information would be by using a 3D model of a building, showing the energy usage in different zones. Building Information Models (BIM) are a new technology used in the Civil Engineering industry to design buildings in 3D. Part of this research is in developing ways to create easily accessible and understandable 3D energy visualisations based on these.

To do this, models will be displayed via web-browsers using the state of the art in 3D web-based graphics, WebGL. This can be displayed in web-browsers without using plug-ins. Data from a BMS can then be displayed on the model, to show energy usage for each building zone.

2. Building Information Modelling
A Building Information Model (BIM) is a 3D model of a building incorporating information about the properties and attributes of individual parts of a building. BIMs are a relatively new technology, though usage is growing. It is the next logical step on from 2D CAD (Computer Aided Design). It greatly increases the cooperation of those involved in the design process and the model can then be utilised and modified throughout a building’s life cycle.

3. Building Management Systems (BMS)
Many modern buildings use these to control and monitor buildings’ mechanical and electrical equipment, such as heating, ventilation and air-condition (HVAC), power, lighting, security etc. Their proper use however often requires special training and therefore their potential to be used to increase energy efficiency often is under-utilised.

4. 3D Web Visualisation
The latest developments in web browser technologies and standards, especially the introduction of HTML5 and WebGL have opened the doors to the potential uses of web browsers. Displaying 3D graphics in a browser currently requires special plug-ins. Next generation browsers, which incorporate WebGL support, will no longer need these.

5. Prototype
A 3D web-based model of the new Nursing Library Building in NUIG is currently being developed.

This building was chosen to be used for the prototype because it already has a BMS up and running and a BIM. The separate zones that will need to be interacted with will be saved as separate BIM ifc (Industry Foundation Class) files and converted to COLLADA (COLLaBorative Design Activity) dae files. These can then be reassembled to seem as one 3D model on a webpage using WebGL; each zone can then be interacted with independently.

Data from the BMS can then be fed directly into the website database and displayed on the 3D model, which can be used to monitor energy usage.

6. Potential of the System
The current potential of BMS to increase energy efficiency often is under-utilised. Creating an easy to understand and accessible visualisation of the energy usage greatly increases the likelihood of improving energy efficiency.

The use of web-based technologies in particular means that energy usage data becomes far more accessible. No longer will specialised software be required to view it and it can be viewed remotely from any device with an up to date web browser.

It also paves the way towards better integration of existing technologies. For example, the possibility of incorporating energy simulations into this architecture and visualisation of simulated changes is also being investigated.

In any event, the change in the key metric of kWh/m²/year will be, in the long term, the criterion to evaluate whether this technology can significantly help increase a building’s energy efficiency.
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Image Recognition and Classification of tuberculosis Bacilli.

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Abstract
In this project we present a new method for identifying tuberculosis in microscopic images of sputum. The problem with automatic identification is that in an image there are many other objects that are not the bacillus. In order to be able to correctly identify the objects we use a method called shape profile that creates a profile based on the distance from the centre of an object to its border. The bacilli shapes have a similar profile to each other but are different enough to other objects to distinguish between them. We then use dynamic time warping to perform nearest-neighbour classification on the objects.

1. Introduction
Tuberculosis detection is done by obtaining a sputum sample from a patient and examining it under a microscope for bacilli.

The problem with manual bacilli detection is that it is a very tedious task which requires skilled personal resources and can lead to low sensitivity. Depending on their angle and the position of the bacillus there can be much dispute about what a bacillus is as the shape of the bacillus can vary greatly from cane shapes Figure 1(a) and concave Figure 1(b). Sometimes even doctors will dispute what a bacillus is.

Image detection has taken many forms before the most obvious tell tale of any bacillus is its bright florescent color which has been used before to identify them [1]. The profile method we are using has been used to identify tumors in cancer tissue [2] and predict the models of cars by measuring and comparing the profiles of objects found in images [4].

Figure 1(a). Cane-shape Figure 1(b). Concave (c). Image after edge detection of (a).

2. Method
In order to create our profile we convert the image to a grey scale image and apply the Sobel edge detection algorithm on it Figure 1(c). We pick out all objects with a closed boundary with a certain area threshold; this allows us to discard objects that would be too large or too small to be a bacillus. Taking our acquired objects boundary we first find our centre point and convert the pixel coordinates from Cartesian to polar.

Every boundary pixel has two values r, which is the distance between it and the centre, and θ which is the angle. To normalize our profiles we start from the pixel which has the greatest r and we set its θ to 0 and set our last θ to 2π.

2.1 Shape Profile Representation of Bacilli
In order to get high classification results our shape profiles must be distinguishable from non bacilli objects. The problem with this is that bacilli can have many different shapes. This can lead to incorrect classifications of both bacilli and non-bacilli objects. Once we have our θ and r values for each pixel we can represent them on a graph. One problem that may occur in bacillus of concave shape is that θ does not increase in a monotonic manner and leads to inconsistent representation of our objects.

To get around this problem we edit the θ values slightly and output them in pixel order. This allows us to interpolate our profile and create a vector of a fixed length even though we may have different size objects.

Figure 3. Profile of figure 1(c)

3. Classification
In order to classify our profiles we will be using dynamic time warping [3] and K-NN. This works by obtaining the distance of the test profile to the training profiles using DTW and then outputting the class of the closest match. That is the sample with the minimum distance.

4. References
A Multi-Platform Medication Support System for Clinical Use

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Abstract

Drug dosage calculation is a complex process which involves multiple steps when calculating a single dose. This multi-step process is error-prone, as it requires experience and the full attention of physicians or nurses involved. The potential for error is high and the consequences potentially serious. Software technologies offer much added value in ensuring that patients receive the correct dose of a drug based on their individual needs. Taking this into consideration this project aims to develop software technologies for critical drug dosing problems.

1. Introduction

Drug dosing errors are one of the most common errors found in a hospital environment. One frequent example is the errors associated with gentamicin, a potent antibiotic capable of causing kidney failure if used incorrectly. An audit conducted in UHG in November 2010 revealed that despite several strategies to improve gentamicin prescribing only 7/16 (44%) starting doses were deemed appropriate [1]. Whilst low-technology strategies have been developed such as paper-based dosing algorithms and labour-intensive physician education, it was felt that automation of calculation may result in more patients receiving the correct dose first-time in future.

2. Aim/Objective

To develop a calculator
- that automates the calculation of drug dosages.
- using technology which is accessible at the bedside or in the clinical room.

3. Related work

- A manual system for drug calculation was recently deployed at UHG. It provides paper algorithms for assisting physicians. However it has not been fully successful in changing physicians prescribing behavior.
- There are numerous online calculators available, which lack basic standards (like poor version control); some of them are even incorrect.
- Gentamicin calculators produced in Bristol NHS.

4. Current work

- Research into clinical support systems for calculating drug dosages.
- Research into software frameworks to build a plug-in type architecture for pharmacy administrators, that can be used create their own drug dosing system according to the requirements.
- Design of a prototype system running on JAVA enabled mobile phones and desktop PCs which are accessible at the bedside or in clinical rooms for doctors.
- Extension of Gentamicin calculator to other drugs related to kidney function.
- Extension of architecture to ensure safe clinical use with respect to version control and protocol validation.
- Building communication channels which assist clinicians to rapidly identify and find patients who require follow-up.

5. Future work

- Bringing the prototype into clinical use through a supervised pilot and wider rollout.
- Extension of technology to assist in other dosing problems such as those found in newborn babies, or patients receiving chemotherapy.
- Expansion of the system to collect usage data on high priority drugs across organizational boundaries. For example, expensive or controversial therapies like intravenous immunoglobulin.

6. Conclusion

The potential for software technologies to solve real patient problems has been demonstrated. Mobile, connected solutions that provide decision support to physicians in a safe environment are needed. Additionally such connected technologies should communicate valuable information to assist colleagues who may be following such patients. Key to the development of these technologies is a transparent and safe process for bringing prototypes into clinical use.

7. References

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Android Based Multi-Feature Elderly Assisted Living Application

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Abstract
The design and methods of a Telecare application intended for use on a common smartphone is discussed. The proposed application will incorporate many different Telecare assistive technologies and combine them into one software solution that is accessible using an Android smartphone. Some of the proposed features are fall detection, physical activity monitoring, GPS tracking and movement detection. If the application perceives that a user needs help, it will check with them if they need aid before contacting care. Also carers will be able to view the physical activity and locate an application user remotely for indirect monitoring.

1. Introduction
Telecare is the term given to the continuous, automatic and remote monitoring of real-time emergencies and lifestyle changes over time in order to manage the risks associated with independent living \cite{1}. It is an umbrella term for remote care to a wide array of potential problems such as falls, strokes, heart attacks where a user may be incapacitated, to tracking dementia suffering wanderers, to monitoring carbon dioxide levels and medicine intake. It becomes increasingly difficult for an elderly person to lead an individual life out of care as they age. Falls account for approximately 80\% of all injuries to the aged, they are also the cause of 90\% of all fractures. Falls are the fifth most common cause of death with elderly people \cite{2}. Even if this is not the case, confidence in one’s self and quality of living is diminished after suffering a fall. Another concern is caring for sufferers of Dementia. This is a highly common condition affecting elderly health in recent years. Applying Telecare to aid this condition would allow an individual to have a much better chance to lead their own life outside of care and potentially save a large amount of money that goes into the care of sufferers.

The physical activity of a person is another important aspect to consider in an elderly persons health. Active elderly people reduce their chances of strokes, obesity, high blood pressure, diabetes and disability even with just a moderate amount of physical activity \cite{3}.

2. Application Features
Many Telecare devices are currently available to buy. These devices usually perform one, maybe two functions and are built specifically for these purposes. The aim of this project is to try to implement many different features in one affordable, readily available, non-intrusive device.

The ‘fall detection’ feature uses the vector magnitude of the accelerometer to detect if the phone is falling. If a threshold is passed (falling), the orientation of the phone is stored. This threshold needs to be passed 10 times in succession (~0.5 sec). When the phone comes to a stop (landing), the orientation is compared to before the fall. If they differ by a certain amount, a fall is detected and an alarm plays to check is user ok. If there is no response, emergency contacts are contacted.

If a carer texts the word ‘enable’ to the patients phone, this will activate ‘GPS Tracking’ which writes the users location to a database and this is viewable on a webpage. Similarly, texting ‘disable’ will stop the GPS tracking to save battery life.

‘Physical Activity Monitoring’ is another feature whereby the accelerometer measures how much the user is moving by counting the amount of time that it is below a threshold – user is sedentary, and the time above the threshold - user is actively moving about. These values are stored every hour and will be viewable by the carers to remotely monitor a patients activity levels.

For ‘Movement Detection’ another fine threshold is set for the accelerometer which, if the phone does not move at all, will not be passed. If this does not happen for an extended period of time, an alarm sounds to check is the user ok again as they may be incapacitated.

3. Results
At the moment, development is still in the implementation stages. Once this phase is completed, further refining of algorithms to improve accuracy will be undertaken. All features will then be tested and results reviewed to see how reliable they are and how effective it would be to use a smartphone as a prospective multi-feature Telecare device.

4. Acknowledgements
Des Chambers – Project Supervisor
Joe O’Connell – IT Administrator

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Abstract

Using a Decision Support System (DSS) to monitor the lung function of Cystic Fibrosis (CF) sufferers allows a Health Care Professional (HCP) to determine if a decline in lung function has occurred in real time, without the cognitive overload of a large dataset which this type of testing will generate. A Bluetooth enabled Android phone is proposed as a method of transferring data throughout the system and displaying results of previous tests to the users. The phone will allow users to retrieve test results from the spirometer, to input other symptoms such as cough severity, to perform any necessary pre-processing, to upload the results to an online database and to display graphs of previous results. The system will provide automated warning messages to the patient and the HCP if a decline in lung function is detected. The phone will also allow communication between HCPs and patients to arrange appointments and to ensure compliance with testing regimes and procedures via text messages, calls and emails.

1. Introduction

1.1 Testing Methods

Lung function testing of CF sufferers currently generally takes place four times per year in a clinic setting [1]. Home based testing hopes to decrease the time taken to intervene when a decline in lung function is detected which indicates a lung infection by routinely monitoring lung function and uploading the results to an online database. This testing method leads to a large amount of data for the HCP to analyse to determine if a decline in lung function has occurred. A DSS can be used to filter patients with steady or improving lung function parameters from those showing a decline in function [2]. The DSS rules are based on the previous performance of the patient in tests [3].

1.2 Compliance with testing regime

Compliance with a testing schedule is an issue with home based testing [4]. As the DSS rules are based on previous test results it is necessary have a comprehensive dataset to base the rules on. Ideally the patient would send results each day but often three times per week is sufficient. To ensure compliance with a testing regime a number of both active and passive methods have been shown to be effective. Automated motivational messages can also be used to encourage the user to access the system and to upload results. If a patient consistently fails to send test results a HCP can call the patient to encourage them to send results regularly. Passive methods can be used to increase the user’s interest in testing such as displaying graphs of previous results, health tips, blogs, jokes, messages on birthdays and adherence statistics [4].

2. Android

2.1 Capabilities

The Android operating system has many features which can be used to successfully implement a Decision Support System for CF sufferers. Since Android 2.0, the operating system has supported Bluetooth connectivity which allows the transfer of data from a spirometer to a device. Android also supports internet connectivity which allows test results to be transferred to an online database. Android phones have their own database system which can be used to store test results if a network connection cannot be made. The touch screen interface allows symptoms to be easily inputted by those with limited computing experience. Through a third party API the system supports functions which can create graphs which will allow HCPs and patients to view previous test results. Calls and texts can be started and sent from within an application to allow contact between a HCP and a patient in case of an emergency or non-adherence with a testing regime. Android’s internal alarm system and calendar apps can be used to schedule tests and appointments.

2.2 Limitations

The Android operating system has limited support for Bluetooth functionality. The current SDK only allows a user to read an input stream from an external device. To fully enable the user to easily retrieve test data from the external device it will be necessary for the SDK to support file system browsing on an external device and the ability to copy files from an external device.

3. Conclusions

The Android operating system is an effective platform to allow end to end communication between a CF sufferer, their spirometer and a HCP who is monitoring their condition. The system could also be adapted to monitor the condition of patients with other long term illnesses such as asthma, heart disease and diabetes where a suitable testing device is available and decision rules have been defined.

4. References


Determining Subjects’ Activities from Motion Sensor Data using Ensembles

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Abstract
Presented here is an approach to predict what type of motion or activity a person is performing using the Dynamic Time Warping (DTW) method based on data from accelerometers worn by or interacted with a person. DTW is a method of comparing similarities between two sequences of time series data. When a particular sequence is tested, it is classified as the sequence type to which it is most similar. Using ensembles involves taking the results of multiple sensors or streams of direction from each sensor i.e. X, Y, Z, and using the majority decision to be the overall classification. This technique is being applied to three separate datasets: 1. The MIT Place Labs, 2. uWave Application, 3. Cricket Umpire Signals. This is done to illustrate that the method can be used across a number of different activity types.

1. Introduction
One of the major motivations for research into activity detection is to develop methods for real time monitoring of elderly or post operative patients. “The number of older persons has tripled over the last 50 years; it will more than triple again over the next 50 years” [1]. Other motivations include the development of more commercial ventures such as computer games development. E.g. Nintendo Wii.

For each of the three datasets the subject(s) are performing multiple activities. The Place Labs contains information of subjects performing Activities of Daily Living (ADL) with accelerometers on the wrist, hip and thigh which include dressing, washing, preparing food, using phone, computer use and bathroom use. The uWave and Cricket datasets both have only one accelerometer and involve hand gestures with a Nintendo Wii remote/smart phone and signals of a cricket umpire (accelerometer on wrist), respectively.

2. Method
For each activity performed by a subject, the accelerometer returns the rate of acceleration with a timestamp. The Place Labs data is then preprocessed using down sampling, interpolation and moving averages where necessary, while the uWave and Cricket data was received processed [3]. Following this, the samples are separated into training and test data, they are then tested with the DTW algorithm. Every test case is compared with every training case and is classified to be the type to which it is most similar using the k-NN algorithm.

3. Ensembles
An ensemble classifier uses a committee of base classifiers that vote on classification to make a final decision. For each instance an odd number of different categories of data from the one instance are tested i.e. multiple sensors or multiple streams of data (X, Y, Z). In which case a number of predicted classifications are made, the majority decision is taken to be the overall classification.

Previous work on the uWave and Cricket datasets with DTW achieved results of approx. 72% [3] and 80% [3] respectively. However they have not been tested using ensembles, it is hoped to improve results with ensembles using similar DTW methods.

Ensembles have been tested on the Place Labs dataset which achieved results of 84.3% [5]. In an attempt to improve these results we plan to optimize the template selection, sampling frequency and warping windows.

4. References
A Practical Probabilistic Approach to Predicting Glycaemia Levels in Intensive Care Unit Patients

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Abstract

We propose a practical approach to predicting intensive care unit (ICU) patient plasma glucose levels so as to combat the occurrence of hyperglycaemia or hypoglycaemia. A dynamic Bayesian network (DBN) is designed for this purpose due to their ability to model probabilistic events over time. DBNs allow for the use of observed evidence to affect the probabilities of each possible outcome. Physicians have indicated that qualitative information is preferred to quantitative, leading to the design of a discrete model. The discrete DBN is compiled from the different variables that affect plasma glucose levels, as well as additional variables suggested by physicians.

1. Introduction

Glycaemia is the term used to describe the presence of glucose in the blood. Hyperglycaemia is a condition where there is an excess amount of plasma glucose. It can lead to nausea, vomiting and death in extreme cases. In ICU conditions, stress-induced hyperglycaemia in non-diabetics is a common occurrence [1].

Hypoglycaemia is the opposite condition, where there is a shortage of plasma glucose. Brain metabolism is dependent on a continuous supply of glucose in order for the brain to function correctly. Low plasma glucose levels can cause seizures, coma, permanent brain damage and death [2].

2. Problems with Blood Glucose Measurement in the Intensive Care Unit

In ICU conditions, high glucose levels are treated with the infusion of insulin and low glucose levels are combated by glucose infusion. Plasma glucose levels are measured manually and infrequently, from 1 hour to 12 hour intervals, depending on the patient’s stability. Instrumentation errors can distort the true level of plasma glucose during these measurements. For these reasons, a model must be designed that can successfully predict true patient plasma glucose levels [3].

Each patient is unique and as such, each patient may react differently to insulin or glucose infusions. This inter-patient variability means that the model required should be able to be tailored to each distinct patient [3].

3. Dynamic Bayesian Networks

A Bayesian network (BN) is a graphical representation of all of the variables within a particular scenario and how they interact with one another. Each variable is represented by a node and each node has its own set of values. Each interaction is represented by an arc. Associated with each node is a conditional probability table (CPT), which lists the conditional probabilities of the occurrence of each of the node’s values as a result of the values of its parent node(s) [3].

A dynamic Bayesian network (DBN) is a model that predicts events over time. It is composed of BNs in a series of time steps. The length of a time step can vary to any consistent value. The state of a variable at one time step can be affected by the state of a variable in the previous time step. An arc is also used to represent this interaction [3].

4. The Discrete Model

Our research group has been working on a continuous DBN for the prediction of glycaemia levels. Values in this model are purely numerical. Physicians have suggested that a descriptive model rather than a numerical model would be preferred. This necessitates the design of a discrete DBN with each node value representing a range of values. As such, example values for nodes could be High, Normal and Low. For example, taking the variable Plasma_Glucose, a result of High would suggest that the patient could be hyperglycaemic, Normal would suggest that plasma glucose levels are regular and Low would suggest that the patient could be hypoglycaemic.

5. Future Work

True patient data and literature knowledge will be used to define the limits of each node value and will also be used to define the conditional probabilities in each node’s CPT. A physician will be asked to provide expert knowledge and to suggest any improvements.

Results of the discrete DBN will be compared to the true patient data in order to analyse performance.

6. References

New Analysis Techniques for ICU Data: Allocating Uncertainty over Time
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Abstract
This goal of this project is to optimise the performance of a dynamic Bayesian network by varying how uncertainty is applied across each node. The approach taken is inspired by simulated annealing [4] which is an optimization technique. There are many different types of uncertainty involved in these model types, however the focus of this research will be data uncertainty and the model parameter uncertainty and the trade off between the two over time.

1. Introduction
A key problem being dealt with in the course of this research is how an ICU patient can vary greatly over time from a healthy person but also from other patients. In order to overcome this issue it is proposed that the uncertainty applied to dynamic Bayesian network is alter and varied over time for both model parameters and data.

The reasoning for this is that data is used to calibrate a model to a patient, however it is possible that the data used contains uncertainty. If the models are well calibrated and the measurements do not fit well it is possible to apply greater uncertainty to the data and say the measurements are at fault. During the calibration period it is a wish to balance both types of uncertainty.

This will be done by applying greater uncertainty to the model parameters at first as we trust the measured values as this is the only information available, then in the later stages greater uncertainty is applied to the data as we trust the model parameters are a good fit and we are accounting for any numerical errors due to incorrect measurements in the data.

To test this we will use the models proposed by Enright et al [1,2]. These models are a dynamic Bayesian network representation of Bergman’s ICU-MM which is explained by Van Herpe et al [3].

2. Methods
The approach being used here involves using the abstract example proposed by Enright et al [2]. A number of tests were carried out by altering the standard deviation and mean in order to see what results were obtained.

It was found that the model will converge even when starting values are not correct. When a very narrow standard deviation was applied to the model it would not behave correctly and would reset at certain time-steps as there was no evidence matching the samples generated by the model. However with larger standard deviations it was found that the variables could retune and from a current approximation and fit with a later value that matches the evidence. To do this an optimization technique will be applied to vary the uncertainty and produce the best possible outcome.

3. Conclusions
This project aims to deal with the optimising the output of a dynamic Bayesian network. The data being used is targeted specifically at the problem of blood glucose levels however, it would be ideal to apply this research to many other data sets using a dynamic Bayesian network. There are two core concepts that need to be studied and understood; probabilistic reasoning over time and optimisation techniques.

4. References
ICT4Depression: your phone as your counsellor

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Abstract
The paper reports initial results obtained in the FP7 funded ICT4Depression project, which aims to develop a mobile phone based system for the treatment of depression. UL’s role in this project is the development of an Android application which is used to present treatment modules to the patient, to gather biomedical sensor data and to record the patient’s activity and mobility patterns.

1. Introduction
Major depression is currently the fourth disorder worldwide in terms of disease burden, and is expected to be the disorder with the highest disease burden in high-income countries by 2030. Estimated costs of depression are annually 177 and 147 million euro per 1 million inhabitants for major and minor depression respectively. Current treatment methods for depressive disorders can reduce the burden of this disease by approximately one third. ICT4Depression is an FP7 funded project with partners from 5 EU member states that aims to reduce the disease burden significantly further. To this end the ICT4Depression consortium has set out to develop a system for the provision of online and mobile treatment of depression.

2. Project Description
Through a close collaboration between psychologists and technology partners, a mobile system has been specified for the provision of depression treatment to the user whilst minimally changing the user’s normal daily patterns. Internet based treatments for depression have been used for some time and it has been shown that this approach is as effective as face-to-face treatment of depression (Andersson et al., 2005). Hence these treatments are now being adapted for presentation on smart phones. Furthermore, use is made of the mobile phone as a sensor manager; several sensors, including the phone itself, collect data on the user’s progression and report this information to the ICT4Depression system. In 2012 the system will be used in trials with 50 patients in the Netherlands and 50 patients in Sweden, thus thoroughly testing the system with real patients.

3. UL role
UL’s role in the ICT4Depression is pivotal as UL is responsible for the application running on the mobile phone. A first version of this application has been developed and combines four aspects of the system:

1. A patient application to interface with the system. As part of the treatment, the user is asked to think about and report on positive and negative feelings, activities that make the user feel good or bad and other factors that influence mental health.
2. A mobility monitor. Using the smart phone’s built-in sensors (accelerometers, magneto-meters and GPS) the phone keeps track of the user’s activity and mobility patterns. This information is useful to determine whether the user adheres to activity goals set as part of the treatment, but also as a measure for treatment progression; increased activity levels often correspond with improved mental health.
3. A sensor manager to collect data via Bluetooth. A set of Bluetooth sensors is used to collect data on the user’s heart rate, breathing rate and skin conductance. These parameters can be correlated with emotions experienced and are thus expected to provide new insights in the user’s mental state.
4. A medication adherence application. An important aspect of the treatment of depression is the use of medication. This medication will only be effective if taken regularly and without fail. To monitor medication intake, a smart pill box is used that records when medication is taken. The resulting information is visualized for the user in the adherence application.

Whereas the Bluetooth sensors and medication adherence system are provided by SME’s, the integration of both systems is done by UL. To allow for an end-user driven approach to development of the user interface, a module generator has been developed. This generator allows the psychologists to easily design and implement new treatment modules that can be presented to the user on a mobile phone or on a pc. New algorithms for activity and mobility monitoring using the mobile phone are being developed. These make use of time- and frequency-domain information to elicit as much relevant information from the data as possible. Future work will focus on the use of voice recordings made with the mobile phone to assess the emotional state of the user.

References
Abstract
Ireland is at the beginning of the national e-health journey. The challenge that lies ahead for the Irish healthcare domain is to build a solid foundation for national e-health systems, including e-prescribing. This will involve choosing appropriate strategies for the construction and adoption of e-health and e-prescribing systems in the years ahead. In this context, it is useful to compare the experience of successful national systems in other countries, and also in other domains, in order to provide a reference point for informing public policy on e-health and e-prescribing in Ireland. The research proposes to investigate the key factors common in countries that have successfully adopted national e-prescribing systems, and also investigate and compare a successful public e-government system in the Irish Revenue domain. A framework will be used to identify these factors as organisational, regulatory, technical, and adoption.

Introduction
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]. A growing body of evidence over the past twenty years has indicated that the introduction of electronic prescribing (e-prescribing) can reduce medication errors and improve patient safety, and many countries are pursuing this goal. In the early years of the last decade, some policy makers viewed e-prescribing as the “low hanging fruit among information technologies that could improve the quality and efficiency of healthcare” [3].

The decade ended recently, but has the promise of e-prescribing been realised in many countries? Which countries have successfully adopted e-prescribing? What were the critical success factors that influenced the development and adoption of e-prescribing? What are the lessons for Ireland on the e-prescribing journey? Are there successful national systems in other Irish public domains that can inform the health domain and the e-health context in Ireland?

Methods
Qualitative methods will be mainly used, including fieldwork. The evaluation of national information systems in healthcare is complex and difficult [4], so quantitative methods will also be used, but only where the data is factual and comparable.

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 clarifies 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, and includes the electronic transmission of prescription (ETP) as an intrinsic element.

Preliminary Findings
Preliminary research found that a good deal of up-to-date detailed information was available for many countries on the use of e-prescribing as part of an electronic health record (EHR) by general practitioners (GPs) in the primary sector. However relatively little information was available on the ETP aspect of e-prescribing, which was found to be the most problematic area in all countries, as in figure 1.

<table>
<thead>
<tr>
<th>Country</th>
<th>% of GPs using EHRs</th>
<th>% of GPs using e-prescriptions</th>
<th>% GPs using e-prescriptions &amp; ETP</th>
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<tr>
<td>Netherlands</td>
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Figure 1 Adoption of EHRs, e-prescribing and ETP by GPs in selected countries (2009)

Further study
Further study is under way into the national Revenue-on-line (ROS) system. Also, research is ongoing to establish the current status of e-prescribing and ETP systems in the leading countries.

References
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Contextualized Application Reasoning Environment (CARE)

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Abstract

The article briefly describes a Contextualized Application Reasoning Environment (CARE) system. We discuss the need of such a reasoning system for Health Care applications. We highlight core research issues of a knowledge-based system in dealing with various types of knowledge (e.g., profile, policy, temporal, spatial) as well as knowledge that is context-dependent. Finally, we discuss the current status and future work in developing the CARE system.

1. INTRODUCTION

The notion of context has a very long history within several research communities, leading to vast studies about how to define a context, how to take into account information coming from the context, how to contextualize knowledge and local information, etc. On the other hand, information systems that are deployed across organisations are usually context-dependent, for instance, constraints (e.g., profile, policy, preference, temporal, spatial) expressed by particular organisations are usually applicable within the organisations and their appropriate interpretation is meaningful only when contextual knowledge (e.g., place, event, time) is taken into account. In this article, we discuss the issue of context and constraints from two perspectives (1) Web reasoning and (2) when reasoning is applied on concrete domain like Health Care and Life Sciences (HCLS).

2. CONTEXT AND CONSTRAINTS: WEB REASONING

Semantic Web and the reasoning mechanism behind ontological knowledge bases are centralised in the way data and schemas are accumulated and processed. Ontologies—the pillars of semantic Web framework—are good in describing general invariant concepts and mappings or relations among those concepts. However, when the semantic Web enabled applications use data and schema that are distributed, heterogeneous and multi-contextual, then interoperability between interacting applications are effected adversely[1].

3. CONTEXT AND CONSTRAINTS: HEALTH CARE APPLICATIONS

HCLS has been one of the primary field of application for knowledge representation and reasoning systems. In the past researchers have tried to formalise and integrate the knowledge bases in HCLS systems and many of the successful systems in earlier times were centralised and limited to sub domain or particular application of a HCLS domain [2]. Nowadays, HCLS has become more global and distributed in terms of its use by related stakeholders[3]. Therefore, interoperability enabler, i.e., Web reasoning systems, need to be extended in a manner that they can reason various consequences while aggregating and interpreting global knowledge in conjunction with local information or constraints.

4. CARE

We are developing the CARE system that can identify the context of knowledge bases with a mechanism for handling constraints that do not lead to undesired interactions. This approach is partly inspired by [4], where axioms are separated into two T-Boxes, one for ontological axioms, the other for integrity constraints. This way, we define a local T-Box as a pair $(D, P)$, where $D$ describes a domain ontology, and $P$ represents the internal policies. If several local ontologies and policies exist, the overall knowledge is a distributed system $((D_i, P_i))$.

In CARE domain ontology $(D_i)$ can import other domain ontologies (i.e., import closure $D_i \cup D_j$). Internal ontologies $(P_i)$ are context-dependent (i.e., constraints) and allowed only to refer domain ontologies $(D_i)$ of their context. While reasoning, especially for local entailments, import closure of domain ontologies $(D_i \cup D_j)$ and internal ontology $(P_i)$ of the requesting system will be used. CARE allows global and local (context-specific) entailments over distributed knowledge-bases.

5. CONCLUSION

We have described use of CARE for health care applications. The initial prototype of CARE is able to categorise between different types of knowledge (e.g., general, policy) and use contextual information for avoiding undesired inconsistencies. The future task is to include modular semantics for the CARE system.

6. ACKNOWLEDGEMENT

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REFERENCES

Using Mashups to Satisfy Personalised Requirements in Telehealth

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Abstract
In this paper, we describe the architecture of Sqwelch, and show how it can be applied in the delivery of healthcare to patients in the community and to support their caregiver networks. We identify the challenges associated with the delivery of telehealth solutions to the patient in the community. Sqwelch is a mashup maker available at www.sqwelch.com which enables the creation of web applications by non-technical users.

1. Introduction
Currently, more than 90 million Americans suffer from a chronic illness [1] and one in ten of the population is 60 years old or more. By 2050 this proportion will grow to one in five [2].

To address the healthcare problems facing our society today, personalization and affordability of health and wellness technologies is essential, as the numbers of chronically ill and aged increases relative to our underlying population. To relieve the burden on healthcare delivery the technologies will be pushed out of healthcare centers and into the home, where real-time prevention, diagnosis, and treatment can occur.

2. Telehealth Challenges
Delivering telehealth services places a number of challenges, both technical and commercial, on the key stakeholders:

Differing, Complex Environments. Delivering healthcare services to patients in the community introduces complexity and heterogeneity in the target environment. Processes must be put in place for escalation in emergency situations, and the community must be involved as members of caregiver networks associated with each patient.

Distributed Collaboration. Enabling the patient to self-manage a chronic illness requires the support of a distributed team of specialists, physicians, pharmacists, and casual caregivers forming the caregiver network. Of course, the members of the caregiver network will be geographically distributed but yet will need to collaborate.

Personalized Requirements. Each member of the caregiver network, including the patient, will have requirements unique to their own environment, capability, and level of responsibility.

Cost Sensitivity. The challenge here is to provide healthcare services in a way which can be afforded by providers and payers alike. Telemedicine solutions are invariably closed-loop and proprietary resulting in high costs of deployment and maintenance.

3. Architecture
As noted in [3] mashups are about simplicity, usability, and ease of access which can be provided through a component model at the presentation layer to maximize reuse. Middleware is required to loosely couple resources together in mashups, and mechanisms are required to enable integration across layers in the application stack.

Figure 1 illustrates some of the technology choices taken in the development of the Sqwelch platform.

Figure 1 - Sqwelch Architecture

Sqwelch acts as a component registry which stores metadata about the resources while they remain hosted at distributed locations on the internet. Discovery is enabled through search routines which rank the results, through the use of catalogue features users will be familiar with such as “Most Popular”, “Latest Upload”, “Search”, along with Compatible Search which uses descriptions of the APIs to find other resource with which it could interact.

8. References
MECHANICAL AND BIOMEDICAL ENGINEERING

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4.25 Modelling the Management of Medical Equipment in Healthcare
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3D Computational Modeling of Blood Flow in the Circle of Willis

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Abstract
Carotid angioplasty and stenting (CAS) has been developed in recent years as a minimally invasive procedure for the treatment of carotid artery disease. However, peri-operative complications can arise due to one of the internal carotid arteries being blocked during the procedure. In this study we examine how variations in the arterial structure of the brain contribute to hemodynamic compromise during CAS. This analysis was achieved by developing a generic model of the circle of Willis (CoW) from 50 MRA scans and conducting a CFD study on the model. The results suggest the variations in the arterial system have a major effect on the CoW’s ability to maintain sufficient cerebral perfusion and there exists a group of patients that possess a specific CoW variation that may make them unsuitable to undergo the CAS procedure.

1. Introduction
Modern surgical treatment of arterial disease is moving towards minimally invasive procedures. However, one area that is resisting this trend is the treatment of carotid artery disease. This is due to the peri-operative complications associated with the carotid angioplasty and stenting procedure (CAS). During this procedure blood flow in one of the internal carotid arteries is interrupted. However, it has been shown that not all patients can accommodate this interruption, with 3 to 13% of patients experiencing ischemic neurological deficits[1].

A key element in maintaining sufficient cerebral perfusion is an arterial structure known as the circle of Willis (CoW), figure 1. The role of the CoW is to distribute oxygenated blood around the cerebral mass. Studies have shown that among the general population the CoW demonstrates significant morphological variation, with less than 50% having a complete CoW[2]. The remainder of the population have a combination of absent or hypoplastic vessels, which limit the ability of the CoW to operate effectively.

This study aims to determine the effect morphological variations in the CoW have in relation to hemodynamic compromise during the CAS procedure.

2. Methodology
Due to the high level of morphological variation associated with the CoW, the approach adopted in this study was to create a generic model of the CoW. To develop this generic model, the arteries of the CoW in 50 MRI datasets were reconstructed using Mimics 12.11 software. Examining the 50 reconstructed datasets resulted in 20 models being labelled as complete as per published classifications[2]. These 20 complete models were then averaged to create a generic CoW model. This generic model was then analysed using Ansys 12 computational fluid dynamics software. To develop physiologically correct boundary conditions a porous zone was placed at each outlet from the CoW. This porous zone represents the peripheral resistance developed by the down stream arteries not included in the model and also incorporated an autoregulation mechanism.

Figure 1: Location and geometry of the circle of Willis.

To examine the effect variations in the CoW have on the blood flow hemodynamics the diameters of certain arteries were reduced to simulate the variation found in literature. This resulted in the creation of 23 different CoW models.

3. Discussion
This analysis indicates that if the CAS procedure is performed on a patient with a CoW incorporating a certain variation of arteries, insufficient blood supply to a particular region of the cerebral mass may occur. The key elements of the CoW that have the largest influence on ability of the arterial system to maintain adequate cerebral perfusion are the three communication arteries. Results suggest that there may be a group of people with specific, identifiable CoW configurations, who may be unsuitable for the CAS procedure. The ability to identify high-risk patients for the CAS procedure may prove important in a clinical environment and may result in improved clinical outcomes.

4. References
Microstructural Modelling of Fatigue Crack Nucleation in Stents

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Abstract
A methodology for modelling realistic microstructures of metallic materials is presented. The approach is applied to cyclic loading of stainless steel stents with a view to capturing the role of grain size distribution in fatigue crack nucleation.

1. Introduction
The use of balloon expandable stents as part of the angioplasty procedure has revolutionised the treatment of heart disease. Although stent design is a relatively mature topic, numerous instances of stent fatigue fracture have been reported, e.g. [1]. This is particularly the case recently with the advent of drug eluting stents where tissue in-growth over stent struts is impeded, allowing deformed geometries and fractures to be more clearly revealed than before. Hence, there is a clear need to gain a deeper understanding of stent fatigue behaviour and to develop fatigue failure prediction methods to aid stent design refinements. Typical stent strut dimensions are comparable with microstructural geometry, such as grain size [2-3], as shown in Fig. 1. Crystal plasticity (CP) modelling is therefore necessary to capture the inhomogeneity effects introduced by microstructure on deformation and hence fatigue behaviour of stents. Such a model will allow prediction and identification of microstructural phenomena during fatigue, including grain size effects [4] and crack nucleation mechanisms [5]. Voronoi tessellation is the first key step in this process, to model random microstructure of polycrystals [6].

Initial work focuses on a well-known stent material: 316 L stainless steel. A finite element micromechanical model of a representative volume element of polycrystalline 316 L was developed and used to simulate uniaxial cyclic loading for both continuum plasticity and CP formulations.

2. Materials and Methods
A Voronoi tessellation and Delaunay triangulation methodology was implemented into a Python script to generate a microstructural model representing inhomogeneous polycrystalline geometry. Tessellations with grain size distribution statistically close to that of a real microstructure were accepted (example shown in Fig. 1). An Abaqus user-material subroutine [2], incorporating an isotropic CP formulation, was employed. The stabilised cyclic response of the micromechanical model for strain-controlled uniaxial cyclic loading was then compared to the experimental macroscopic response.

3. Results
Good correlation was achieved between grain size distributions of the real and generated microstructures. Microscopic stress concentrations were predicted throughout the micromechanical model. CP material model constants were identified which agreed with the macroscopic cyclic stress range.

4. Discussion
A microstructural modelling methodology has been developed for realistic grain size distributions, capable of capturing inhomogeneity effects. The CP material model was calibrated to match macroscopic stress ranges for different applied strain ranges. Differences in hysteresis loop shapes, however, suggest that the next step involve the incorporation of a non-linear kinematic hardening formulation, e.g. [8], in the CP model. Future developments also include the introduction of a fatigue indicator parameter, such as accumulated plastic slip [5], to predict crack initiation during high-cycle fatigue.

5. Acknowledgements
Research funded by an IRCSET scholarship under the EMBARK initiative.

6. References
Experimental and Computational Investigation into Osteocyte 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.

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. 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 neighboring 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 $10^3$, $10^4$ and $10^5$/cm² on type 1 collagen coated coverslips of ligand density 100 µg/cm². The collagen was neutralised according to the manufacturer’s protocol using either NaOH, causing the collagen to form a soft gel (E<1kPa), or acetic acid, forming a stiff coating (E≈1.5 GPa). In this way the behaviour of the cells on substrates of different stiffness but identical ligand density can be observed.

Cells were stained at 1, 4, 7 and 14 days of culture using phalloidin-TRITC (Sigma) to examine their cellular structure (morphology). A colourimetric assay (Abcam) was used to quantify ALP expression from the same time-points. ALP expression increases as MC3T3 cells differentiate into mature osteoblasts, but subsequently decreases as the cells differentiate into osteocytes.

Finite element models of an osteoblast on either substrate were created using Abaqus software. Coupled temperature displacement elements were used to allow for the simulation of cell contraction. The cell was attached to the substrates using tie constraints. Cell stiffness values were taken from the literature (cytoplasm 34 kPa², nucleus 400 Pa). The stress response of the model was then examined in order to ascertain the cells mechanical response to the resistance offered by each substrate.

3. Results

Results showed that the substrate stiffness did influence the morphology of the cells. The soft substrate showed a 2 fold increase over the stiff substrate in the percentage of dendritic cells (cells with more than 2 processes) present, at the lowest seeding density ($10^5$/cm²). ALP expression was upregulated at 4 and again at 9 days of culture. This was followed by a downregulation after 14 days of culture for both substrates with no statistical difference between them.

Fig 1 Spread morphology of MC3T3s on stiff collagen (A) and dendritic morphology of MC3T3s on soft collagen (B)

Finite element simulations of the cellular response to each substrate stiffness revealed an altered stress distribution within the cell body while on the stiffer substrate, particularly in the distal regions of the cell.

Fig 2 Von Mises stress distribution of MC3T3 modeled on substrate of stiffness (A) 1.5 GPa and (B) 800 Pa

4. Discussion

The finite element simulations in this study show that a passive difference in a cells ECM, such as stiffness, can affect the cell at a basic mechanical level. The experimental results show how the cell responds to the varied level of resistance offered by the respective substrates by changing its shape and gene expression.

The results suggest that osteocyte differentiation will take place on a soft collagen matrix provided that cell separation necessitates process formation. This is interesting, as in vivo certain osteoblasts become embedded in newly formed osteoid, which is a soft, non-mineralised collagen matrix. We propose that this mechanical environment may play a role in triggering osteocyte differentiation. Overall these studies have shown the importance of stiffness and cell seeding density on osteocytic differentiation of MC3T3 cells.

8. References
An examination into how stem cells form bone in vivo
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Abstract
Stem cells are capable of forming different types of tissues such as bone, cartilage and fat when they receive appropriate cues, such as biochemicals and mechanical loading. However, the precise cues that control the tissues that stem cells ultimately grow remain unclear. The aim of this study is to examine what are the natural signals stem cells receive from their environment which stimulate them to form bone.

1. Introduction.
Mesenchymal stem cells (MSCs) within the marrow of bone are subjected to a unique microenvironment known as the stem cell niche. Here MSCs can experience not only biochemical signalling from surrounding support cells (osteocytes, osteoblasts, fibroblasts, adipocytes etc.) but also a mechanical loading influenced by the trabecular bone structure and marrow composition (1). While both biochemical signalling from support cells and mechanical loading have been shown to direct stem cell differentiation in vitro, their influence within the niche remains largely unknown.

Our objectives are (a) to examine the role of support cells on the differentiation of MSCs and (b) to develop an in vitro model which allows us to apply physiological loads to MSCs as they reside in the niche.

We examined the influence of mechanical loading on MSCs residing in their natural home of the bone marrow through the use of a custom built bioreactor (Figure 1).

Figure 1: Custom built bioreactor used to biomechanically stimulate explanted ovine bone tissue samples containing the trabecular structure and marrow.

The function of support cells on MSCs within the stem cell niche was also examined using conditioned media, collected from separately cultured osteoblasts or osteocytes and co-culture studies.

These set-ups allow us to delineate the importance of biochemical signalling between bone’s regulatory cells, osteoblasts and osteocytes, and MSCs.

3. Results and Discussion.
The support cell study showed a greater expression of alkaline phosphatase (osteogenic marker) in MSCs which had been co-cultured with osteocytes rather than osteoblasts highlighting the role that osteocytes play in regulating MSC differentiation (Figure 2) (2) and the importance of examining MSCs in their natural environment.

Figure 2: ALP activity for MSCs co-cultured with either osteocytes or osteoblasts.

With our bioreactor we retain this niche environment and also expose bone samples to physiological loads. Our preliminary observations show that a dynamic mechanical loading environment enhances the survival of the bone marrow in vitro (Figure 3), whereas unloaded static samples degraded in the first two weeks.

Figure 3: Histological section of trabecular bone and marrow stained with H&E.

Future results from different loading regimes could provide valuable information on the role of mechanotransduction on bone development in vivo.

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Experimental Analysis of the Thermal Effects of Surgical Bone Cutting

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Abstract
Surgical procedures depend on cutting tools that can provide surgeons with access to the organs, without causing extensive harm to surrounding tissues and cells. The need for continual innovation with these products is required to minimise the healing time and thereby enhance post-surgical patient outcome. We aim to advance the understanding of thermal effects of surgical cutting on cell and tissue integrity to optimise post-operative bone repair. These studies will inform design of next generation tools and improve patient outcome.

1. Introduction
Brain, orthopaedic implantation and spine surgery, rely on innovative technology that provides the surgeons with access to organs while minimising harm to surrounding tissue and post-surgery healing times. Continual development of these devices is required to enhance patient outcome. However there is a lack of knowledge regarding the effects of thermal elevations in surrounding tissue and cells during surgical cutting, and how these might affect the healing process. This thermal effect might affect patient outcome by causing resorption of thermally damaged bone leading to implant loosening and delayed healing. Studies are required to characterize the temperature generation local to surgical cut surfaces, and also to develop an understanding of how these changes effect cell and tissue regeneration.

2. Objectives
- Investigate temperature elevation and distribution during surgical cutting
- Understand thermal responses occurring at cellular and tissue level to elevated temperatures.

We use a combination of in vitro cutting on devitalized and live bone tissue, and in vitro cell culture experiments to address these objectives.

3. Methods

Heat Distribution: An infrared camera and thermocouples were used to build profile of heat generated during cutting for 0.5, 1, 1.5, 2 mins with sharp and blunt surgical blade (Figure 1).

Figure 1: (a) Embedded thermocouple, (b) Thermograph

Explanted bone: Cortical bone was cut from freshly harvested ovine vertebrae. Samples were cultured for 2 weeks (αMEM, 10% FBS, 1% Penicillin-Streptomycin) and heat treated at 60°C for 1 hour.
Cell culture: MLO-Y4s were exposed to heat shock for various time/temperatures (47°C, 60°C for 0.5, 1, 1.5 minutes) and allowed to recover. Thermal necrosis/apoptosis characteristics and actin filament disruption was investigated using histological methods [1].

4. Results

- Continuous cutting for 1 minute results in elevated temperatures, Figure 2a, but do not exceed thermal threshold of 47°C for 1 min [2]. Only 3% of the bone tissue is exposed to >50°C for 15 seconds, Figure 2b.

Figure 2: (a) Temperature v. time (b) temperature v. area of continuous cutting for 0.5, 1, 1.5, 2 mins.

- Cells heat treated at 60°C for 1 min are less dense showing characteristics of cell death (condensation of the cytoskeleton and rounded cell morphology), Figure 3b, compared to control of 37°C, Figure 3a.

Figure 3: MLO-Y4s at (a) 37°C, (b) 60°C for 1 min

5. Discussion
Continuous cutting remained below the thermal necrosis threshold [2] for a cutting duration of 1 min. Many surgical cuts are quicker, the main tibial plateau as short as 20 secs. Our results show exposure to elevated temperatures results in cell death, which is consistent with Li et al.[1] who observed apoptosis/necrosis for exposure of 48°C for 10 mins and reversible responses for ≤45°C for 10 mins. Further work is required to differentiate between apoptosis and necrosis. These results have potential to inform the design of next generation surgical tools and improve patient outcome by optimising post-operative bone repair.

6. References
Cortical Bone Failure Mechanisms during Screw Pullout

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Abstract
Many orthopedic devices use screws as their primary mode of fixation. Screw pullout at the screw-cortical bone interface is a common mode of failure for such devices [1]. In this study, a computational model is developed to investigate the failure mechanisms of cortical bone which lead to screw pullout. Simulations are compared to experimental results in order to validate predicted failure mechanisms and failure loads during screw pullout.

1. Introduction
The objective of this study is to develop a complete understanding of the mechanisms of failure that occur between orthopaedic screws and the surrounding cortical bone.

2. Materials & Methods
Experimental monotonic tensile pullout tests were conducted using commercially available orthopaedic screws anchored in bovine cortical bone. Rectangular mid-diaphyseal sections were extracted from the metacarpus. A novel test rig was built to facilitate the monitoring of failure modes in real time.

A 2D axisymmetric model was created based on the geometry of 3.5mm cortical bone screws. The Drucker-Prager constitutive formulation was used to model post-yield material behaviour of bovine cortical bone [2]. Damage initiation and evolution based on effective plastic strain was incorporated into the material behavior. Crack propagation was simulated using an element removal technique for fully damaged elements. Predicted patterns of crack propagation during pullout were compared to experimental tests that recorded the failure mode of screw pullout in real time.

3. Results
The experimental failure load recorded was 2.5 ± 0.3kN. The experimentally observed failure mode for a section of bovine cortical bone with osteons vertically aligned is shown in Fig. 1(A-C). Cracks propagate upwards from the tips of the screw threads. The separated material remains between the screw threads and is subsequently removed as the test progresses. The final fracture surface following screw removal is shown in Fig. 1(C).

Our computed failure mechanism leading to screw pullout is illustrated in Fig. 1(D-E). Following initial screw movement localised plastic deformation is computed at the screw tips, leading to plastic zones that initially extend vertically upwards and then propagate at 45° (Fig. 1(D)). The highest concentration of plastic strain at the screw tips leads to a crack initiation. As the crack propagates vertically upwards a vertical plastic zone develops ahead of the crack tip. Further crack propagation leads to full separation of the bone between the screw threads (Fig. 1(E)) leading to complete pullout and exposure of the fractured surface. A maximum screw pullout force of 2.46 kN is computed during the pullout simulation.

4. Discussion
The live imaging technique developed in this study provides novel insight into failure mechanisms during screw pullout. While earlier studies have reported a similar final fracture surface [3], the evolution of material failure during screw pullout has not been previously uncovered. The process of element deletion to replicate crack propagation is a predictive method and does not predefine the crack pathway. Predicted crack evolution correlates closely with experimental observation. Future work will involve developing a cohesive zone formulation to incorporate screw pullout in macro scale 3D models of PHF repair to replicate clinical failure modes.

5. References

6. Acknowledgements
IRCSET, ICHEC.
Simulating Actin Cytoskeleton Remodelling in the Shearing of Chondrocytes

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Abstract
In this study, the role of actin fibres in the response of chondrocytes to shear is experimentally determined. An active model that describes the assembly of the actin cytoskeleton in response to cell signalling, and the dissociation of the actin cytoskeleton in response to a reduction of intracellular tension is used to simulate the experimental measurements.

1. Introduction

The actin cytoskeleton, formed via the polymerisation of actin filaments and phosphorylation of myosin motors, play a crucial role in the response of cells to mechanical stimuli. In vitro investigations of the response of cells to mechanical stimuli provide limited insight into these mechanisms without the use of active computational modelling.

2. Methods

Experimental: Chondrocytes were isolated from bovine articular cartilage tissue, seeded onto glass slides and positioned adjacent to a tungsten probe. A piezoelectric motor then drove the probe laterally, leading to deformation of the cell. This shear event was video-recorded using a CCD camera. Beam theory was used to determine the reaction force of the cell at various strain levels. An additional series of shear experiments were carried out on cells following the disruption of actin fibres in the cells by the addition of cytochalasin D (2 µM) to the media.

Computational: The contractile response of the actin-myosin fibres is captured using a sliding filament model. The formation of contractile actin-myosin fibres is parameterised by the activation level $\eta$, which is governed by a first order kinetic equation:\[1\]:

$$ \dot{\eta} = [1 - \eta] \frac{C \bar{k}_f}{\theta} - \left[ 1 - \frac{\sigma}{\sigma_o} \right] \eta \bar{k}_\sigma \frac{\theta}{\theta} $$

This equation describes the assembly of actin-myosin units in response to a signal $C$ and dissociation due to a reduction in tension $\sigma$. 3D cell geometries are recreated from in vitro images (Fig.1a).

3. Results

A plot of probe force versus probe indentation is shown in Fig. 1b. Firstly, considering the experimental results: for untreated cells in which actin fibres are intact, the reaction force increases dramatically upon initial probe indentation. A yield point is reached, after which further indentation leads to a lower increase in force levels. In contrast, cells in which actin fibres have been disrupted, do not exhibit such yield behaviour. Instead a linear force-indentation relationship is observed, with forces being considerably lower than untreated cells.

The active cell model captures very accurately the characteristic yielding shape of untreated cells. In contrast, a passive hyperelastic model accurately represents the response of cells in which actin fibres have been disrupted. Simulations also reveal that there are greater stresses in the cell nucleus in the case of the active model (Fig. 1a).

Figure 1 (a) Contour plots of the stresses (kPa) experienced by the nucleus after 7 µm of probe indentation. (b) Probe force versus probe indentation curves for sheared cells.

4. Discussion

The yielding behaviour observed experimentally is captured in the active computational model. This response is due to the actin-myosin sliding filament behaviour and the dissociation of actin fibres at the front of the cell due to a localised reduction in tension. The present study shows that active remodelling and contractility of the actin cytoskeleton plays a critical role in the deformation of chondrocytes. Furthermore, a passive computational model of cell behaviour cannot be used to accurately compute stresses in a cell or the evolution of the actin cytoskeleton.

5. References & Acknowledgements


IRCSET; SFI-RFP (SFI-RFP/ENM1726); ICHEC.
Modelling Corrosion in Bioabsorbable Metallic Stents

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Abstract
The design of bioabsorbable stents, tiny absorbable scaffolds that are used in the treatment of heart disease, is highly challenging due to the complex mechanical and chemical interaction between them and their surroundings in the body. The aim of this work is to facilitate the development of these devices through the development and experimental calibration of a finite element based stent assessment and design tool.

1. Introduction
A new generation of stents that are gradually absorbed in the body are showing great promise in terms of reducing long-term health risks associated with permanent metallic implants [1]. However, the corrosion of these devices in the body is still not well understood, making their design difficult.

Computational modelling is extensively used in the design of conventional, permanent stents [2]. The ability to include the effects of device corrosion in a finite element (FE) based stent design framework will greatly facilitate the development of absorbable metallic stents (AMS). This ability is developed in this work through the creation on a novel FE corrosion model and its calibration based on the results of experimental corrosion studies on a bioabsorbable alloy.

2. Methods
The corrosion behavior of thin biodegradable alloy (AZ31) foils is determined in simulated physiological solution, including a determination of alloy corrosion rate and the effects of mechanical loading on alloy corrosion behavior.

A FE based corrosion model is developed and calibrated based on the results of the experimental corrosion tests. The model captures the effects of corrosion through the simulation of a stochastic pit growth process and the use of a corrosion damage parameter.

The model is applied in simulating the corrosion of a 3-D AMS geometry in a three-layer artery and is used in predicting the reduction in stent mechanical integrity over time due to corrosion.

3. Results and Discussion
A localized, pitting corrosion attack is observed experimentally in the alloy, resulting in a significant reduction in specimen mechanical integrity with relatively little mass loss. The effects of loading and corrosion on foil integrity are captured very well by the FE model, as shown in Fig. 1.

Fig. 1 – The experimental and simulated results of a constant load immersion test on AZ31 alloy.

The FE AMS model, shown in Fig. 2, predicts a localized pitting corrosion in the stent, resulting in a greater reduction in scaffolding support than that predicted in the ideal (homogeneous) corrosion case. This predictive capability is significant in both the selection of effective candidate alloys for AMS application and in the optimization of AMS geometries for improved long-term scaffolding support.

Fig. 2 – A FE stent, delivery system and artery model with simulated corrosion pits shown in a single hinge. An SEM of a corrosion pit is also shown.

4. Acknowledgements
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5. References
Computational Analysis of Transcatheter Bioprosthetic Valve Design

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Abstract

Transcatheter Aortic Valve (TAV) replacement is an endovascular alternative to conventional heart valve surgery whereby a new aortic valve is implanted through a minimally invasive approach. TAV replacement substantially lowers patient risk and results in a shorter recovery time, particularly in the treatment of elderly patients or patients at high risk. However despite this the long term outcomes of TAV are as yet unknown. The objective of this study is to develop a comprehensive computational model of an implanted TAV for preclinical assessment of the lifetime behavior of the implant.

1. Introduction

TAV’s consist of a bioprosthetic valve, composed of animal derived pericardium, which is mounted onto a self expandable frame and deployed into the aortic annulus against the native stenosed valve. Successful TAV function is dependent on a number of factors including deployment geometries and tissue-frame-annulus interactions. Preexisting calcium deposition on stenosed valves can cause distortion of TAV geometries resulting in paravalvular leakage, while incorrect tissue-frame-annulus interactions can lead to leaflet stress concentrations and possible device embolisation. The durability of TAV has not been proved by long term clinical studies and their fatigue resistance may be affected by degradation of the leaflets occurring primarily due to calcification and leaflet tearing. The objective of this study is to develop a comprehensive computational model of the TAV in the physiological environment to investigate the stress distribution across the leaflets and monitor leaflet fatigue preclinically.

2. Methodology

A generic TAV model has been developed consisting of three symmetrical leaflets in a relaxed configuration, similar to previous studies. A mesh was generated for the initial relaxed geometry in ABAQUS using 2048 large strain elements with the assumption of a uniform 0.25 mm pericardium thickness. Leaflet tissue was assumed to be linear isotropic for this preliminary model. Contact between the leaflets was modeled using the master-slave contact pair interaction with the coaptation surfaces defined as the ventricular side of the leaflets. Nodes situated on the leaflet-frame attachment line were constrained in all three transitional degrees of freedom with no radial frame displacement assumed. Leaflets were subjected to a uniform transvalvular pressure of 120mmHg exerted on the aortic side of the leaflets and leaflet stress distribution and deformation were analyzed from an unloaded to a fully loaded physiological state.

3. Results

Stress distribution across the valve was higher in the circumferential direction than in the radial direction at frame attachment sites, particularly at the distal end of the commissures edges, see Figure 1. Concentrated peak stresses were observed at this location in both directions. Twisting of the valve free edge was observed resulting in pinwheeling of the valve.

Figure 1: FE models (A) Open valve in relaxed configuration and (B) & (C) Circumferential and Radial stress distribution at valve closure.

4. Discussion

Preliminary results indicate high stresses and pinwheeling of the valve, resulting in increased flexion and peak stresses at the leaflet free edge at coaptation, which may have adverse effects of leaflet fatigue. Future studies will include biaxial cyclic testing of pericardium derived from TAV’s prior to and 3 months after in vivo implantation to examine the change in mechanical properties of the TAV leaflet tissue due to the in vivo environment. Tissue properties from these studies will be implemented using a generalized Fung-elastic model to provide a realistic material model of the TAV leaflet, and FE analysis will be performed to monitor the long term effects of tissue properties of the function of the valve.

A probabilistic finite element tool is also being developed to allow for the variation of input factors such as valve crimping, dilation conditions and suture density and monitor their affects on the stress distribution on the valve leaflets and durability. This research will provide a preclinical design tool, for the development of next generation transcatheter bioprosthetic valves.

5. References

An Investigation on the use of Silicone to Model Arterial Tissue Behaviour in the Carotid Bifurcation

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Abstract
This paper presents the investigation of an analogue material to represent arterial tissue behaviour. This study computationally compares the mechanical behaviour of arterial tissue and a silicone material model in an idealised carotid bifurcation model. Results demonstrate that silicone does not have similar mechanical behaviour as arterial tissue under a normal physiological pressure load.

1. Introduction
The development of atherosclerosis in the carotid bifurcation (CB) of the cardiovascular system has been the subject of much investigation. The CB is a prevalent area for atherosclerotic plaque build-up. Bhardvaj et al. [1] dimensioned an idealised ‘Y’ shape model of the CB, which is the gold standard of dimensions for the CB in numerical studies (Hariton et al. [2]). However, Smith et al. [3] developed an updated CB idealised geometry that better represents the CB called the tuning fork model. A study by Thomas et al. [4] illustrated and validated the improvements in this model. Experimentally, silicone material is used primarily to mimic the mechanical behaviour of arterial tissue. This study aims to compare the mechanical behaviour of silicone material to arterial tissue using finite element analysis (FEA). These materials will be applied to the idealised CB tuning fork model.

2. Material and Methods
The numerical model was developed using FEA to model the mechanical behaviour of a silicone material and compare this material behaviour to the carotid arterial tissue. The silicone material was modelled using a reduced polynomial strain energy function (SEF) characterised and validated by Corbett et al. [5]. The arterial tissue material model was applied using a SEF developed by Gasser et al., (HGO) [6]. This HGO SEF is a histological and phenomenological SEF that includes the effect of collagen fibres within the tissue. To determine if the HGO SEF does represent the mechanical behaviour of the carotid arterial tissue, and whether silicone behaves similarly, the numerical results are compared to the biaxial mechanical properties of common carotid arteries from Sommer et al., (2010) [7].

3. Results
The HGO SEF is compared to experimental data on the mechanical properties of carotid tissue from Sommer et al. [7] as seen in figure 1. This was carried out to validate the HGO SEF and confirm that it predicts the arterial tissue behaviour.

Figure 1 illustrates that the HGO SEF is comparable to experimental data under the same pressure loads. There is a difference in material behaviour after a 7% circumferential stretch. Figure 1 also compares the HGO SEF material behaviour to the silicone model showing a significant difference in mechanical behaviour between the material models.

4. Discussion
The results from this study confirm that the HGO SEF is a good representation of arterial tissue to published experimental material properties, even when applied to a complex geometry such as the carotid bifurcation. The results from the numerical models illustrate the difference in mechanical behaviour between the silicone and arterial tissue. Silicone does not represent arterial tissue mechanical behaviour undergoing a pressure load. Therefore questions arise as to whether silicone is truly an analogous material of arterial tissue.

5. References
An *In vitro* Shear Stress System for the Study of Cell-seeded Scaffolds: 
A Molecular Biology & Computational Analysis

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**Abstract**

Novel materials for vascular graft applications are continually emerging from research. To attain comprehensive pre-clinical evaluation, cell-seeded scaffold materials require exposure to physiological shear stresses mimetic of those produced in vivo. This field of testing allows the shear-resistance of the endothelial layer to be assessed while also providing indication of anticipated host response to shear through gene expression analysis. An *In vitro* methodology was developed to assess 3D scaffolds in terms of cellular compatibility under physiological flow conditions. To ascertain the feasibility of this system computational and cellular studies were conducted.

1. **Introduction**

   Cellular mechanotransductive pathways are known to be highly regulated by the mechanical and chemical properties of the underlying scaffold, thus heightening the need to assess the cell-material interactions of each particular material. This highlights the need for an *in vitro* platform which facilitates the analysis of 3D scaffolds under physiological wall shear stress (WSS) profiles.

2. **Bioreactor Characterisation**

   The original cone and plate bioreactor design (Fig 1), with the capacity to deliver a controlled uniform SS distribution [1], was modified and validated to allow for the analysis of 3D cell-seeded materials [2]. The effect which porous materials induce on the WSS distribution across the complex surface was investigated.

   ![Fluid Flow](image)
   ![Press Scaffold](image)
   **Figure 1. Cone and plate bioreactor for 3D substrate analysis.**

   The fluid flow and resulting WSS distributions were visualised using computational models of alternating geometries to correspond with height variations present within porous topographies. To determine the biological effect of the varying height parameter; monolayers of HAECs were subjected to steady shear stress under five geometric parameters to determine critical tolerance of the bioreactor design. HAEC monolayers were analysed using microscopy and RNA was extracted. Through PCR analysis, RNA expression of the established WSS biomarker (VCAM) was investigated against a reference gene and subsequently normalised against static controls.

3. **Study Outcomes**

   The PCR data suggests a critical height tolerance exists, outside of which the spatial WSS gradient significantly influences VCAM expression which is exacerbated by a corresponding decrease in mean WSS. Following extensive studies, the maximum potential WSS gradients induced by the local topography height variations of the materials studied were within the critical range deemed suitable from the computational and PCR data obtained. Thus the cone and plate test facility was deemed suitable for ECM and other porous 3D substrates. Consequently ECM materials were seeded with endothelial cells and exposed to physiological WSS to determine the shear resistance of the formed endothelial layer. The metabolic activity pre and post shear was analysed using AlamarBlue® reagent and visualised using confocal microscopy.

4. **Conclusions**

   The methodology described and the experimental system employed provides an ideal platform for analysis of various materials. This test methodology may serve to enhance the graft material selection process prior to clinical testing through the facilitation of accurate *in vitro* simulation and analysis to predict the *in vivo* performance of materials.

8. **References**

The Elasto-Plastic Properties of Trabecular Bone and Polyurethane Foam: An Experimental and Computational Characterisation

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Abstract

During compressive loading trabecular bone can undergo extensive inelastic deformation reaching strains up to 60 % prior to ultimate failure. Previous bone plasticity studies have considered a number of pressure dependent constitutive formulations including the Drucker-Prager (DP) and Mohr-Coulomb (MC) models. The crushable foam (CF) plasticity model has been used to model polymeric foams but has not been investigated for trabecular bone.

1. Introduction

The current study entails a detailed experimental and numerical investigation of the inelastic behaviour of bovine trabecular bone (BTB) and a commercially available trabecular bone analogue material (PU foam, sawbones). Material behaviour under conditions of unconfined and confined compression is determined and a suitable inelastic constitutive formulation is identified. Specifically the following constitutive formulations are investigated: DP; MC; isotropic crushable foam (CFiso); volumetric crushable foam (CFvol). Following this, we investigate the surgical implantation of a tibial component (Genesis II, Smith&Nephew) into a sawbone tibia (composed of PU foam to replicate trabecular bone) to identify if material yield occurs.

2. Materials and Methods

Experimental: 15 mm cubic specimens of PU foam (ρ = 0.16 g/cm³) and proximal tibial BTB were tested destructively in unconfined and confined (custom rig) uniaxial compression at a rate of 5 mm/min (Instron 4467, Instron Corp., USA).

Computational: 3D FE confined and unconfined uniaxial compression tests of PU and BTB were simulated (Abaqus v6.8). A 3D FE model was created to simulate surgical tibial component implantation into a sawbone tibia (#3402) (Fig.1B). Frictionless contact was assumed between the components.

3. Results & Discussion

Experimental and computational results for PU foam and BTB are shown in Fig.1A. Unconfined experimental results for PU (E = 35 MPa, σy = 1.5 MPa) and BTB (E = 364 MPa, σy = 10 MPa) are within the reported range for human trabecular bone. Simulation of tibial component implantation results in a maximum computed stress of ~14 MPa (Fig.1B-C).

In unconfined compression all 4 plasticity models are calibrated to the experimental results (Fig.1A). Under both loading conditions only the CFiso and CFvol models demonstrate reasonable correlation with experimental results. The pressure dependent yield criteria in both CF models allow for accurate simulation of the inelastic behaviour of PU and BTB under confined compression. Our investigations suggest that for confined compression the MC and DP models are not appropriate for trabecular bone as the perfect plasticity type behaviour cannot be captured post yield.

6. Conclusions

To the authors knowledge these constitutive formulations have not previously been applied to trabecular bone and this is also the first study to investigate plastic deformation caused during tibial component implantation. Simulation of tibial component implantation results in trabecular stresses in excess of the σy of PU, highlighting the importance of modelling elasto-plastic material behaviour.

8. References and Acknowledgements


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Development of a Micropipette Aspiration and Microscopy System to Investigate Active Cytoskeletal Remodelling

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Abstract
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 the response of cells to micropipette aspiration [2-4]. However, the active response of the actin cytoskeleton has not been considered. This study will investigate changes in the actin cytoskeleton during micropipette aspiration of spread and round cells. The experimental results will be used to guide the development of an active formulation of cytoskeletal remodelling in response to external loading [5]. Detailed examination of the actin cytoskeleton will also provide insight into remodelling mechanisms.

1. Introduction
In order to elucidate the key biochemical processes underlying the experimentally observed phenomena, it is necessary to characterise dynamic changes in the cytoskeleton. Micropipette aspiration in tandem with a novel imaging technique will examine the evolving cell microstructure under mechanical stimuli.

2. Materials and Methods

Computational: A finite element parametric study of micropipette aspiration of viscoelastic cells was performed. The effect of micropipette diameter, nucleus diameter and vacuum pressure on cell aspiration length was investigated.

Experimental: Cells will be aspirated with micropipettes of 5, 10 and 20 µm internal diameter attached to a custom built pressure control system. The vacuum pressure applied to the micropipette is generated from the pressure head difference between points 1 and 2 on Fig 1.A. The pressure applied will be controlled by adjusting the height Δh with a micro-manipulator. A damping chamber is used to link this pressure to the micropipette so that fluctuations in pressure are minimized.

A protected silver mirror (Thorlabs, Ltd., Cambridgeshire, UK) will be aligned at 45° to provide an optical path that enables visualisations of micropipette aspiration (Figure 1.B). A long range objective lens accounts for the total distance between the microscope (Olympus, IX-71 inverted microscope) and the cell.

Osteoblast cells (MC3T3-E1) transfected with the pGFP2-actin vector will be used to visualise the changing actin cytoskeleton in real time during the experiment. Cells will be seeded onto glass slides for 0.5 and 3.0 hrs to examine the role of the cytoskeleton in round and spread cell geometries respectively.

Figure 1: Schematic diagram of experiment setup (A) including enlarged representation outlining the optical path (B) and micropipette aspiration (C).

3. Results and Discussion
Computational results indicate that a micropipette diameter greater than the nucleus diameter is desirable, as well as vacuum pressure greater than 200 Pa.

Upon initial calibration of the pressure control system, micropipette aspiration of spread and round adhered cells will be completed. The experimental results will be compared to a recent computational model that includes active remodelling of the cytoskeleton [5] Detailed examination of the actin cytoskeleton will provide insight into cellular mechanotransduction.

4. References

Acknowlegments
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Investigating the Potential of Off-the-Shelf Tissue Engineered Cardiovascular Graft Materials

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Abstract
Effective vascular tissue replacements for the treatment of cardiovascular disease are still an unaddressed worldwide problem. Naturally derived biological scaffolds offer huge potential although a major problem of using such scaffolds is storage, particularly in a hydrated and stented configuration, which can result in biomechanical changes in the scaffolds. 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
Established treatment modalities for cardiovascular diseases include arterial substitutes and synthetic graft materials but these have associated issues such as low patency and compliance mismatch. Currently, there is a shift towards a tissue engineering approach in the form of acellular extracellular (ECM) based vascular grafts with such materials offering 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.

2. Methodology
Multilayered ECM scaffolds (UBM and SIS) 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 with dog-bone specimens pre-conditioned to align the material fibres and loaded until failure. Cell culture evaluation was carried out using human aortic endothelial cells (HAEC). Cellular metabolic activity and proliferation was examined using alamarBlue cell viability reagent for up to 96-hours in culture. Furthermore, the concentration of various nucleic acids and proteins leached during storage were analysed utilising a NanoDrop spectrophotometer.

3. Results
Upon deployment, uniform radial loading of the stent on the ECM samples was verified. Favourably, the average UTS of all ECM samples evaluated were noted to be above the average aortic tissue failure strength. Cellular performance analysis indicated that stored ECM scaffolds exhibit a positive cellular bioactivity when compared with the lyophilised controls.

4. Discussion
Upon storage, naturally derived scaffolds are susceptible to degradation resulting in altered micro-structure and mechanical properties. 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. Thus, based on the findings from this study, ECM materials such as SIS and UBM have potential as treatment modalities for cardiovascular disease. Furthermore, such tissue engineered scaffolds offer great potential as an off-the-shelf implant and for use in minimally invasive treatments approaches.

8. References
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A Computational Test-Bed to Examine the Effects of Arterial Curvature and Stenosis Severity on Coronary Stent Deployment

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Abstract

Stenting appears as a panacea for atherosclerosis, however in-stent restenosis remains a problem for clinicians. This work presents a geometrical test-bed that examines the in-silico deployment behaviour of two stent designs. Through greater knowledge of the implantation process one can design for a better performing stent in-vivo.

1. Introduction

The need for an improved coronary stent design is clear from published reports on in-stent restenosis. More comprehensive evaluation of stents in the design phase is a step towards this goal. Current computational stent models are primarily focused on evaluating stent performance in patient-specific anatomical environments. However, this work has the objective of using finite element modelling to devise a geometrical test bed which is capable of assessing stent performance for a broad range of the population. Using a spectrum of representative arterial geometries (encompassing a wide range of tortuosity and stenosis) a comprehensive evaluation of stent performance can be achieved.

2. Materials & Methods

3D finite element models representative of the Cypher and Multi-Link stents were deployed, by applying a pressure directly to the stent surface and using a semi-compliant balloon, in straight and curved three-layer unstenosed and stenosed arteries. The inelastic constitutive model was described by a Von Mises-Hill isotropic plasticity model. The Young’s Modulus was 200GPa, the Poisson’s ratio 0.28 and the yield strength 264MPa.

The anisotropic behaviour of each arterial layer was described by an exponential hyperelastic constitutive model as described in the work of Gasser et al\textsuperscript{1}. The lesion was modelled as a homogenous cellular isotropic body governed by a third order hyperelastic strain energy function\textsuperscript{2}. Standard material properties from literature were applied to the nitinol guidewire, nylon balloon and HDPE catheter\textsuperscript{3}.

3. Results

Straightening of all curved vessels was predicted after implantation of the stent, for example see figure 1. Results also indicate that the level of lumen gain is affected by increasing level of stenosis and also the level of recoil within the stent increases for increasing level of stenosis. Significant tissue damage was predicted within all stenosed models. Explicit balloon modelling was deemed be more appropriate in accurately capturing the implantation process based on the results of this study.

Figure 1. Stages of implantation of a Cypher stent in a moderately curved three layer artery

4. Discussion & Conclusion

The application of this geometrical test-bed successfully captured stent deployment in nine arterial models. To the author’s knowledge this study provides the first comprehensive test-bed for stent design and analysis. The proposed research methodology will offer a novel insight into the optimisation of stent design for specific arterial geometries and stenosis levels, providing invaluable information for the design engineer and clinician.

5. Acknowledgements

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6. References

Effects of Knee Flexion on Stented Peripheral Arteries – A Computational and In Vitro Study

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Abstract
As stenting in the SFA is not only dependent on stent-artery contact but also on the relative movement and contact of the surrounding muscles of the leg, dramatic geometrical changes of the SFA and PA occur, leading to high failure rates of stents in these locations. The goal of this work was to accurately model stent-artery interaction in the SFA by including the effect of the surrounding muscles during a 90° knee bend using a computational finite element model. Furthermore, an in vitro model of the SFA in a system that is capable of replicating the haemodynamic and biomechanical environment of the SFA using tissue-engineering principles was developed. The purpose of the model was to determine the effect of bending on cell viability, morphology and orientation in a stented curved vessel.

1. Introduction
The femoropopliteal (FP) artery is a branch of the femoral artery, the main artery in the upper leg, providing blood to all muscles and superficial tissues in the thigh. It is the largest of the femoral artery branches, composed of the superficial femoral artery (SFA) in the proximal region and popliteal artery (PA) in the distal region which runs below the knee. It is characterised by its tortuous geometry, associating a high atherosclerotic plaque burden with it. Due to the dynamic forces of the SFA and PA, peripheral stents are reported to have the highest failure rates, predominantly due to bending [1]. Worst case bending can be seen in regions of the SFA/PA behind and just above the knee [2] and this is detrimental to stent patency.

2. Methods
3D models of the stented SFA, surroundings muscles (adductor longus, rectus femoris, biceps femoris, vastus medialis, vastus lateralis and sartorius) and bones (femur and tibia) were created by importing CT scan data into MIMICS® software (Materialise NV, Belgium), constructing anatomically accurate 3D models using each axial slice. These were then used to create finite element mesh representations for import into ABAQUSS/explicit. The stent used for the model was based on the Cordis SMART™ Nitinol Stent (OD 7mm, length 20mm). The analysis involved an initial step where the stent was deployed in the straight SFA and then a second step where the knee model (consisting of stented artery, bones, muscles) was bent to 90°. Medical-grade silicone was used to produce silicone tubes that were seeded with endothelial cells to produce pseudovessels. The tubes were coated with human fibronectin and seeded with HAECS. The pseudovessels were rotated for 24 h to allow cell adhesion. Following seeding, a SMART™ Stent (Cordis) was deployed in the pseudovessel. The stented model artery was then transferred into the bioreactor flow loop by attachment into a specially designed support chamber which imposed a 50° bend on the tube (the worst case bend that can be imposed in the tube before kinking occurs). This chamber was then incorporated into the flow loop which mechanically conditioned the stented model artery for 24 hours by applying physiological levels of pressure and flow (120/80 mmHg and 300ml/min respectively) in an incubator at 37°C [3].

Figure 1. Finite Element Model of Knee Anatomy (a), femoropopliteal artery (FP) (b) and SMART stent (c)

3. Results and Discussion
The results of the finite element model provide great insight into the behavior of the artery due to the surrounding muscles during a knee bend cycle. Furthermore the incorporation of the stent into the analysis allows the resulting stress concentrations in the artery due to the combined in vivo and stent loading to be realized. Worst case locations of stress in the stented artery after knee bending can be easily recognized in the distal SFA region with worst case stress locations of the stented portion of the artery occurring at the ends of the stent due to the stiffness mismatch between the ends of the stented portion and arterial tissue. In the stented straight control pseudovessel localized endothelial cell denudation was observed along the regions where the stent struts were removed. Cells in between stent strut regions were seen to have altered cell alignment in comparison to the straight unstented control which showed all cells in the stimulated model artery to orient in the longitudinal direction. Comparison of the response and behaviour in a straight model artery with that of the cells in the bent model artery highlights the effect of the bend on cell viability, orientation, morphology and effects of stiffness mismatch in the stented portion.

4. References
Computational Modeling of Ceramic-based Bone Tissue Engineering Scaffolds

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Abstract
Biomaterial bone scaffolds are required to have a unique combination of stiff mechanical properties and high porosity to ensure cell differentiation. In this work, a finite element analysis is conducted to determine the effects of varying scaffold material properties and geometry on scaffold performance.

1. Introduction
Tissue engineering biomaterial scaffolds have the potential to facilitate the regeneration of damaged or diseased bone tissue. For effective scaffold performance, high porosity and pore interconnectivity are required to ensure cell penetration; in addition, adequate mechanical properties to support physiological loads during tissue regeneration are required.

The aim of this research is to address the need for detailed micro-structural design of these scaffolds to optimize their performance, by using high-resolution computational modeling in combination with experimental analysis of manufactured bone scaffolds for validation.

2. Methods
High resolution finite element models of repeatable scaffold geometries [1], see Fig. 1, were modeled under 1% compression using Abaqus finite element (FE) software. Two different scaffold geometries (labeled the 0/90 and Luxner geometries [1]) were modeled, and each was run with three different material properties (PCL, PCL-Ha and Ha). The maximum and minimum principal stress and strain distributions were analyzed to compare the performance of the different geometries and materials.

3. Results
The results of this analysis show a very similar strain distribution with mode values at -0.3% and +0.2% for maximum and minimum principal strain distributions respectively for both geometries. The compressive stress results for both 0/90 and Luxner scaffolds are shown in Fig. 2. Both tensile and compressive stresses in the Luxner PCL-Ha scaffold were further away from the material strength than for other materials, and stresses were more evenly distributed in the 0/90 PCL-Ha scaffold compared to the other materials.

4. Conclusions
These results indicate that the strains experienced by the scaffolds may not be very different. As the strain experienced by cells seeded on scaffolds has been shown to influence cell differentiation [2], this may mean that cell differentiation in this case would be independent of material or geometry.

Increasing the ceramic content of the scaffolds should, by rule of mixtures, increase scaffold stiffness. The results show this to be true for the 0/90 scaffold but not for the Luxner scaffold. The reasons for this result need to be studied further.

Luxner PCL-Ha scaffold stresses were shown to be further away from the material strength than for the other materials indicating that it is less likely to fail and therefore more suitable for scaffold fabrication. Stops [2] has shown that stress concentrations in a scaffold can lead to failure. This suggests that failure is less likely to occur in the 0/90 PCL-Ha scaffold than for the other materials.

7. Acknowledgements
EMBARK scholarship from the Irish Research Council for Science, Engineering and Technology.

8. References
A Comparative Study on the Evaluation of OHS in SME Meat Plants

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Abstract
This paper describes a comparative study of Occupational Health and Safety (OHS) in Meat plants in the West of Ireland. The original study was undertaken in 2008 and a follow up study was undertaken in 2011. A brief description of the methodology used and an outline of the overall pattern which emerged from the comparison are presented. This paper will specifically address the level of compliance with the minimum legislative requirements in the meat plants.

1. Introduction
The aim of this study is to measure the improvements if any in the approach to Occupational Health & Safety management in small & medium enterprises (SMEs) in Ireland between 2008 and 2011 and to note the perceived barriers to OHS implementation. The meat industry is an important industry sector in Ireland, according to Bord Bia, Ireland's agri-food industry remaining a key component of her modern economy. It accounts for some eight per cent of GDP and a similar proportion of total employment, amounting to almost 160,000 jobs. It accounts for a major proportion of exports of Irish-owned enterprises and its products are sold in over 170 markets around the world. Despite an economic recession, the Irish Meat and Livestock Sector experienced an increase of 9% in 2010 with the value of exports increasing to €2.44bn (http://www.bordbia.ie/).

Daly (2009) reports that, in Ireland, more than 90% of the approximately 700 food manufacturers are SMEs. An evaluation of OHS in SMEs carried out in 2008 concluded that the level of Health & Safety awareness, implementation and practice was very poor in this sector. It was found that the larger meat plants did have a good awareness of OHS legislation and they did have documented OHS systems, but there was a definite question mark over the level of implementation and practice of the systems. The medium meat plants were aware of their legal obligations with regard to OHS but it was found that it wasn’t regarded as a priority. The smaller meat plants were found to be completely unaware of their legal obligations (Jordan, 2008).

2. Methods

This paper will illustrate, through a comparative analysis, the level of compliance with OHS in meat industry SMEs in the West of Ireland and identify the perceived barriers and impediments to the implementation of OHS by SME owners, managers & operatives. The SMEs were first visited in 2008 and an evaluation of the OHS systems and OHS practice was carried out. A sub-sample of these was selected for the follow-up study. This sample was selected for accessibility and does not include all six organisations surveyed in the original study. A qualitative evaluation research approach was adopted, which allowed for the use of a combination of data collecting tools and methods of analysis. Following the methodology adopted in the original study, the evaluation was carried out in the field and the data was collected using checklists, open ended interviews and direct observation of practices. An evaluative inductive analysis was employed as the data gathered was very descriptive with a lot of text.

3. Results & Conclusion

The overall pattern that emerged from the study was that the approach to OHS management in 2011 is similar to that observed in 2008. It was evident that no attempt had been made to implement OHS systems in any of the SMEs visited; however all of those visited were now aware of their obligations. SME owners & managers interviewed reported that the main impediments to implementing OHS were time, money and a lack of knowledge in the area. It was found that a number of operatives & managers regarded the SME managing directors as a barrier to OHS compliance, with attempts at raising the issue of health & safety having been disregarded. The managing directors interviewed couldn’t see any benefit in implementing OHS and regarded OHS management as ‘a lot of red tape that would cost money’. Further, more detailed study of OHS implementation, management, safety climate and culture is required. The author intends to extend the research to SMEs in the food & drinks industry to collect data that will be used to inform the development of a best practice system that can be easily and inexpensively implemented by Food & Drink Industry SMEs.

1website accessed 16-03-2011
Multi-Scale Computational Modelling of Physiological Loading on Bone Cells

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Abstract
Bone is an adaptive material that can alter its structure in response to changes in the mechanical environment. It is possible to enhance bone regeneration in vitro by manipulating the mechanical environment. However the mechanical environment necessary to regulate bone growth is not fully understood. The objective of this research is to use computational methods to predict the mechanical micro-environment of bone cells in healthy, structured bone and thereby inform tissue regeneration approaches that can mimic the native mechanical environment to optimise bone regeneration in vitro.

1. Introduction
Bone is an adaptive material, which is particularly responsive to mechanical loading. Mechanobiology refers to the ability of biological cells to sense and respond to extracellular mechanical stimuli. It is believed that the pathogenesis of diseases such as osteoporosis, arthritis and diabetes may be correlated to the mechanobiology of bone cells. Additionally it has been demonstrated that it is possible to manipulate cellular responses using mechanical loading regimes, with such advances paving the way for developing clinical treatments to address many diseases. However the precise mechanical environment that regulates normal bone growth in the body are not fully understood, because experimental studies to quantify this are unfeasible.

2. Materials and Methods
Computational models were generated using ABAQUS® finite element software, with three complimentary levels of analysis of stimuli in vivo:
Organ-Level: The geometry was generated from CT (256µm resolution) scans of a femur bone, with material properties obtained from literature (E=17GPa, ν=0.38).[3] Loading conditions were applied at the femoral head, imitating forces generated during normal walking. The bone was constrained at the distal end.
Tissue-Level: A trabecular and cortical bone tissue model was generated from µCT (5µm resolution) scans of a tibia bone using a custom-designed voxel-meshing software (FEEBE)[4] developed at NUIG. The material properties and mechanical loading was defined from the organ-level model to simulate stress during normal walking.
Cellular-Level: An idealised geometry of the lacunar-canicular system was generated, with mechanical loading defined from the tissue-level to represent stress and strain in the bone matrix surrounding the bone cell. A model of the osteocyte cell membrane (E=100kPa, ν=0.5)[5] and the surrounding interstitial matrix has also been developed, allowing the mechanical stimulation of the cell by its environment to be quantified.

3. Preliminary Results
A preliminary computational analysis of mechanical loading has been carried out using a multi-scale approach (see Figure 1) to explore the boundary conditions at the cellular level using homogenised loading from higher levels. We have been able to calculate the loading conditions from the organ scale, to define the conditions at the tissue and cellular level.

4. Discussion and Future Work
Multi-scale modelling allows homogenisation between different length scales, and this approach allows us to converge on physiological loading at the cellular level, based on organ-level loading experienced by a femur bone. Future studies will incorporate confocal microscopy scans and TEM images to generate more accurate FE models at the cellular-level. These models will include the cell membrane and the cytoskeleton, as these are crucial for accurate understanding of cell mechanics in vitro. These models will allow us to predict the mechanical environment surrounding osteocyte cells in vivo. Using the information derived from these studies tissue differentiation algorithms will be developed to predict bone formation on tissue engineering scaffolds in response to various regimes of mechanical stimulation.

5. References
Development of Four Three-Dimensional Strain Transducers with Application to Analysis of Cement Mantle in a Femoral Model of a Total Hip Replacement Prostheses

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Abstract
The strain tensor, principal strains and precision of the estimates of these values are derived for a range of different patterns of three-dimensional (3D) strain rosettes. These values are based on the Monte-Carlo technique applied to experimental work which was carried out on transducers tested in the same laboratory. The estimates of precision are determined theoretically and compared with results based on experimental findings. A new design of a miniature tri-rectangular tetrahedral rosette was manufactured and tested. Results suggest that this transducer does not perform as well as the rectangular patterns.

1. Introduction
The life-span of cemented implants is a cause for concern, and to better understand this, testing of the cement mantle must be undertaken experimentally [1]. Experimental models can use either surface strain gauges or embedded 3D strain transducers. Three-dimensional strain gauge rosettes are made up by an array of at least 6 single strain gauges. This can be a combination of single and/or stacked rosettes. Measurement uncertainty and reliability of rosettes are critically affected by the shape of the array of strain-gauge grids [2].

2. Research Methods
To predict which is the best transducer of those assessed it was necessary to embed four different 3D rosettes into the same epoxy prismatic bar (Figure 1) and test them under identical conditions in the same laboratory.

Several studies have previously been conducted to predict the response of various designs of 3D embedded strain rosettes and the most precise embedment technique. Researchers [3] developed the nine-gauge 3D rosette as shown in Figure 2. This configuration consisted of a plane rectangular rosette lying in each of the three orthogonal planes. Investigators [4] further developed this rosette design by rotating the rosettes on each plane through 45° to avoid duplication of strain measurements. Further more [5] developed a nine-gauge rosette based on a double-tetrahedron (60°angle). A further development of the double-tetrahedron (90°angle) was created by [4].

An experimental evaluation of the transducer designs was conducted by embedding all four patterns within a single CT1200 prismatic bar of length 370mm and 70mm square cross-section and simultaneously measuring the strain values recorded by each when the bar was subjected to a compressive load. By rotating the bar about its vertical axis and repeating the measurements in each position at 90°, 180°, 270° and 360°, it is then possible to fit sine waves to the data at maximum load. The angle of embedment of the transducer is offset from the principal axis so as to yield new results from that of the previous studies. These results are then compared with theoretical results and based on these findings, the most accurate 3D strain transducer for application in the cement mantle is proposed.

3. References
Development of a mixed-mode cohesive zone model for stent and cell applications

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Abstract

Cohesive zone models have been commonly used to simulate coating delamination from a substrate and crack propagation in certain material types [1]. In this study we develop a path-dependent cohesive zone model (CZM). The CZM is then applied to two distinct case studies: (i) mixed-mode cell debonding during cyclic substrate stretching and (ii) mixed-mode overclosure of a stent coating during stent deployment. Unphysical mixed-mode behaviour is computed for cohesive zone model formulations derived from an interface potential function.

1. Introduction

In this study we present a potential-based, coupled cohesive zone formulation which has been used to describe many mixed-mode delamination processes. We propose an alternative, path-dependent cohesive zone model in an effort to simulate physically realistic mixed-mode behaviour at an interface.

2. Materials and Methods

A path-dependent CZM is developed whereby interface tractions, $T_i$, are related to interface separations, $U_i$, by

$$ T_i = A_i U_i \exp(-U_i) \exp(-U_2^2) $$

where $i=1,2$. Subscripts 1 and 2 refer to normal and tangential directions respectively. The constants $A_i$ define the independent interface strengths in the 1 and 2 directions.

Simulations are also performed using a potential-based cohesive zone model whereby tractions are derived from an interface potential function [2], $\phi(U_1,U_2)$:

$$ T_i = \partial \phi(U_1,U_2) / \partial U_i $$

This requires the definition of $\phi_n$ and $\phi_t$; the work of normal and tangential interface separation, respectively. Cohesive zone formulations are implemented by means of UINTER user-defined subroutine in Abaqus software.

3. Results

Repulsive normal tractions develop during mixed-mode cell separation following application of potential-based model. The cell is forced away from the substrate at 0% substrate strain, preventing the formation of new bonds (Figure 1(a)). Application of the path-dependent model produces a more realistic result where bond formation occurs at the end of each strain cycle (Figure 1(b)). Application of the potential-based model produces unrealistic coating overclosure and no coating buckling occurs (Figure 2(a)). Overclosure is prevented when path-dependent model is used with significant buckling.

4. Discussion

Unrealistic repulsive tractions are computed for mixed-mode cell separation when a potential-based cohesive zone model is applied at a cell-substrate interface. Unrealistic mixed-mode coating overclosure is computed when a potential-based model is applied at a stent-coating interface. Implementation of a path-dependent model leads to more physically realistic mixed-mode behaviour.

8. References

FATIGUE OF NITINOL: EXPERIMENTAL AND COMPUTATIONAL ANALYSIS ON THE EFFECT OF STENT CRIMPING

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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. Nitinol self-expanding endovascular stents are effective in the treatment of peripheral artery disease, including the superficial femoral, carotid, and renal arteries. However, fracture rates of 65.4% in stents used in the superior femoral artery have been reported [1]. 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 supplied by Veryan Medical. Excess material at both ends, along with support struts, were 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, 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.

Ultimately, it is hoped these models will be capable of predicting the constitutive fatigue behaviour of Nitinol and will ultimately aim to contribute to the developments in design rules for optimising the fatigue performance of Nitinol medical devices.

4. References

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Active Computational Modelling of Cytoskeletal Remodeling During Compression and Spreading

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Abstract
Cell spreading is governed by two cooperative cellular processes: the formation of focal adhesions, and the active remodeling of the actin cytoskeleton as the cell spreads 1. The interaction between these two processes is poorly understood, and previous computational models have only examined each process in isolation. We demonstrate that a novel formulation that captures key biochemical processes can accurately capture experimentally observed measurements.

1. Introduction
In the present study an active constitutive formulation for the remodelling and contractile behaviour of the actin cytoskeleton and focal adhesions 3,4 is used to simulate cell spreading on a flat substrate. Additionally this modelling framework is used to predict the response of round and spread cells to compression.

2. Materials and methods
The actin-myosin cytoskeleton is formed via the assembly of myosin and actin filaments into contractile stress fibre (SF) bundles. This is captured in our constitutive model by allowing SFs to assemble in any direction at any point in the cell. The contractile behavior of SFs due to the cross-bridge cycling of the actin-myosin pairs is described by a Hill like equation:

\[ \frac{\sigma}{\sigma_0} = 1 + \frac{k_c}{k_v} \left[ \frac{\varepsilon}{\varepsilon_0} \right] \left[ \frac{1}{1 - \frac{\varepsilon}{\varepsilon_0}} \right] \]

The signal induced formation and tension dependent dissociation of the actin cytoskeleton is captured using a first order kinetic equation. This equation gives the dimensionless activation level of a SF bundle, η,

\[ \dot{\eta} = \left[ 1 - \eta \right] \frac{C \dot{\varepsilon}}{\sigma_0} - \left[ 1 - \frac{\sigma}{\sigma_0} \right] \frac{k_b}{\dot{\sigma}} \eta \]

where C is an exponentially decaying signal. This formulation has been implemented in a finite element user-defined material. A model that accounts for the mechano-sensitivity of focal adhesions based on thermodynamic considerations is coupled with an exponential cohesive zone model to simulate spreading.

3. Results
SF evolution during spreading is shown after 5 mins and after 25 mins in Fig. 1A. SFs form at the base of the cell and form distinct bundles leading over the nucleus. A band of stress fibres also forms at the periphery of the cell. Focal adhesions are predicted to cluster at the outer edge of the cell.

Compression of round (Fig. 1B) and highly spread (Fig. 1C) cells is also simulated. Significantly more SF are computed in spread cells prior to compression. Following compression to 70%, compression forces for the active model show very good agreement with experimental data 2, with the spread cell requiring 6 times more force. In contrast, using a hyperelastic material only gives a 1.5 fold increase (Fig. 1D).

![Figure 1 SF evolution in a spreading cell after 5min and 25min (A), and in cells before compression (C&D). Compression forces for cells using passive & active models and experimental data.](image)

4. Discussion
The model presented here predicts the development of SFs during active spreading similar to experimentally observed behaviour. Spread cells are shown to have more SFs than round cells. This causes the higher compression forces observed experimentally, which have been captured by our model. Traditional cell models cannot capture these phenomena and therefore it is essential to include the active remodelling of the cytoskeleton in numerical models.

5. References & acknowledgements
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The use of personas to design sustainability into new products from the early concept stage

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Abstract
With an ever increasing need to design and manufacture sustainable products there are increased demands put on product and industrial designers to ensure that their concepts and designs are environmentally stable. At present there are only a handful of tools created for Design for Sustainability and many of these can only be applied at the manufacturing and end of life phase of a product. The purpose of this study was to investigate whether personas can be used as a tool for sustainable design at the concept stage of the design process. Personas have been widely proven as a usability design tool, but little has been done to test if they are suitable in a sustainable design context. Personas are hypothetical archetypes of an actual user. Although they are not real people they must be based on data from real people in order to represent the target markets needs and goals. A total of 521 Irish adults participated in a study investigating environmental attitude and environmental behaviour patterns. The objective was to study how people felt and behaved towards the environment and environmental products. Based on these data participants were segregated into nine different attitude and behaviour groups. These groups were based on a positive, neutral or negative environmental attitude combined with a positive, neutral or negative behaviour pattern. The four extreme combinations of positive attitude-positive behaviour, positive attitude-negative behaviour, negative attitude-positive behaviour and negative attitude-negative behaviour were the focus for the second stage of the research. The second phase focused on the development of personas targeting the environmental attitudes and behaviours of the four groups. Interviews were conducted with 16 participants from each of the four specific attitude-behaviour combinations. These interviews focused on purchasing behaviour patterns, purchasing goals and emotions, identity and attachment to products, and purchasing patterns relating specifically to environmental and sustainable products in order to provide realistic goals and ideals. This data was used to develop environmental attitude/behaviour specific personas, which, when applied in product development are proposed to result in products with appeal to the respective groups but each with high levels of sustainability. These personas were applied through a series of design workshops with Product Design & Technology students at the University of Limerick to test whether the personas can provide designers with the information needed to design sustainable and user specific products which will appeal to their targeted attitude-behaviour combination. Findings to date suggest that the use of these environmental personas increases the ability of the designer to create more sustainable design concepts at the early stage of the design process when compared to designers who were not given personas. Current research is focused on validity testing of the personas through testing with consumers.
Modelling the Management of Medical Equipment in Healthcare

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Abstract
This paper introduces a systematic approach to the management of medical equipment in healthcare. Specifically, the paper demonstrates how modelling this management system creates a solid foundation for the development of an effective management standard.

1. Introduction
In healthcare, effectively maintained medical equipment is an important asset central to patient care. Hospitals hold a vast array of medical equipment ranging from small inexpensive items such as infusion pumps, to complex items such as linear accelerators which have a high purchasing cost and involve substantial on-going costs.

The Health Service Executive provides a high level framework, for managing medical equipment in Irish hospitals [1]. This framework, however, gives direction on a macro level only. For example, the document states that ‘all medical devices are properly maintained and repaired’, it does not however expand on this requirement. This leaves the implementation of procedures at a micro level unregulated. In such an environment best practice may not be followed, potentially leading to inefficient practices in terms of equipment utilisation, usability, servicing and performance. These inefficiencies add extra cost to the HSE and ultimately can adversely affect patient safety.

2. Methods
In order to develop a comprehensive and effective system for managing medical equipment it is necessary to understand, at a micro level, the typical lifecycle of medical equipment. Modelling the medical equipment lifecycle clearly presents the sequence of activities to be considered. In creating this model best practice procedures in other safety critical industries, i.e. aviation, nuclear, medical device manufacturing and the military, were benchmarked. The model also considers guidance given by relevant international standards, such as IEC 61508, ISO 60601 and ISO 14971.

3. Results
As is shown in Figure 1, the phases of the medical equipment lifecycle were found to be the following: Planning, Procurement, Commissioning, Performance Measurement, Maintenance and Decommissioning. The model developed shows that Risk Management, Patient Safety, Quality Assurance and Environmental aspects are the key considerations underpinning the lifecycle. The model also shows that Lean Sigma, as a best practice business management strategy, underpins all activities, ensuring that all practices add value to the management system.

4. Conclusion
Understanding and accurately representing the medical equipment management model creates a foundation from which a systematic and effective management standard can be developed, utilising the ethos and toolkit of Lean Six Sigma.

5. References
Abstract
Customer focused innovation (CFI) describes the direct engagement of enterprises with their customer/end users, to satisfy unmet customer needs through the design and development of new products. However, published research in the area of CFI is mostly prescriptive and fails to provide enterprises with a best practice model or tool kit. This research addresses that gap by conducting an empirical study of CFI use and contribution to new product development (NPD) in the Irish MedTech BioPharma sector to generate a best practice model from the collected data. The study is timely and contributes to research in the area of both CFI and NPD.

1. Introduction
In this research new product innovation and in particular customer focused innovation (CFI) is under investigation, where enterprises engage directly with the customer/end user, capturing their requirements and building on their expertise in the design and development of new products. Therefore, CFI is also a driver of innovation as new products are developed to satisfy those requirements and unmet needs [1, 2]. Many enterprises have already recognised the potential that exists within their customer/end user base and are taking measures to capture this potential [3, 4]. Focusing on the Irish MedTech BioPharma sector the study identifies enterprises engaged in CFI, the contribution CFI makes to NPD and the systems currently employed. In the process this research addresses the following questions: Is CFI currently used in the innovation of new products in the Irish MedTech BioPharma sector? Which firms use CFI and how is it implemented? What are the systems and interfaces required to support CFI and its related knowledge transfer in the modern firm?

2. Aim of the Research
The main aim of this research is to generate a best practice model for the successful employment of CFI in the Irish MedTech BioPharma sector. Empirical studies identify the enterprises successfully engaging with customers to this end, together with the systems, processes and supports necessary for the successful employment of CFI at enterprise level.

3. Methods
The research begins by synthesising the literature relating to CFI and new product development. Empirical field work, including survey, question led interviews and case studies identify enterprises within the Irish Medtech BioPharma sector who are currently involved in new product development through CFI. In depth interviews with educational institutions, government bodies and other stakeholders, add to the data collected and lay the foundations for generating a CFI best practice model. The study builds on previous research in other sectors and considers cross sector application of the model generated.

4. Outcomes
By conducting this research the author raises awareness and generates debate regarding the employment of CFI as a means of increasing new product development in the Irish MedTech BioPharma context. The initial identification of firms engaged in NPD through CFI provides valuable data for future research. Finally, the research findings and CFI model generated provide enterprises with a vehicle to drive innovation by responding to the expressed needs of their customer/end user through the development of new products.

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A Real-Time Tweet Diffusion Advisor for #Twitter

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Abstract
In this paper we describe our novel Twitter assistant called Tadvise. Tadvise helps users to know their Twitter communities better and also assists them to identify community hubs for propagating their community-related tweets.

1. Introduction
Twitter is the current big thing with hundred millions of users so called twitterers, who tweet more than 140 million times per day [2]. In such environments, where there exist massive information flow, users require personalized assistance to help them to get the most relevant information and at the same time limit non-relevant information. To this end, we developed a novel Twitter assistant that helps users to know their followers better and also to find potential topic-sensitive hubs, who can efficiently propagate a tweet further in the network. In the following, we briefly describe Tadvise and its functionalities.

2. Tadvise: Twitter Assistant
To register for Tadvise, a twitterer u simply chooses to follow the Tadvise Twitter account (i.e., @Tadvise). Once notified, Tadvise crawls the social network of u and builds appropriate user profiles. After completing these steps, which are performed offline, Tadvise sends a direct message to u, indicating that it is ready to provide advice. By visiting the Tadvise homepage, u can benefit from advice and/or tweet a message directly to Twitter. Tadvise uses a traffic light metaphor to indicate its advice. A green light advises users to (re)tweet a message. The red light advises users not to (re)tweet a message. The amber light indicates that we cannot decide either way and the decision is left to the user. The user can over-ride the recommendation at any time.

Tadvise has three main components: The Crawling component of Tadvise gets a seed as input and uses Twitter API and white-listed Twitter accounts for crawling twitterers. The User Profile Builder component builds appropriate user profiles based on crawled information. Finally the Advice Engine component gets the user profiles and a tweet as inputs and provide real-time advice based on the traffic light metaphor. It also adds potential hubs to the tweet automatically. Such hubs, if retweet an original tweet, help to propagate a tweet more efficiently in Twittersphere.

Schafer et al. [1] argue that it is useful to persuade users that the provided recommendations are useful. In order to convince end users that our recommendations are relevant, we provide simple text-based explanations. Our explanations originate from the processes that we use for giving advice. In other words, we show the list of potentially interested Twitter users at distances of 1 and 2 of a seed (i.e., followers plus followers of the followers of the seed) and also justify how our recommended hubs can propagate a tweet further in the network. We also present a ranked list of potentially interested Twitter users at distance of 2 of the seed, who can not receive the tweet via the recommended hubs. The seed can freely add such (top-ranked) Twitter users to the tweet (i.e., direct message), in order to attract their attention.

Our evaluation shows that Tadvise helps users to know their followers better and also to find better hubs for propagating their tweets.

A video that describes functionalities of Tadvise can be accessed at [3].

Acknowledgements
This work is partially supported by Science Foundation Ireland (SFI) under Grant No. SFI/08/CE/I1380 (Lion-2 project).

References


Improving Twitter Search by Removing Spam and Ranking Results

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Abstract
With the ability to post real-time status updates, Twitter is an excellent source of first hand news. Twitter search is widely used for retrieving real-time information. However, with such high spam content on Twitter, search results often return multiple spam Tweets. With this in mind we aim to identify and remove spam and to rank remaining Tweets promoting high Tweet content and novelty in the answer set. We analyse Twitter data to identify a set of features to detect spam. We aim to improve the quality of a search result set by ranking Tweets based on a number of identified heuristics.

Introduction
Twitter is a real-time information network. Since its launch in July 2006, Twitter has acquired 175 million registered users posting 95 million tweets and performing 900,000 search queries per day. Twitter posts or Tweets are short text messages a maximum of 140 characters in length.

Twitter Spam
Spam is the electronic transmission of messages, in large volume, to people who do not choose to receive them. Spam accounts have multiple behaviors including, posting harmful links to malware and phishing web sites, repeatedly posting duplicate Tweets, posting misleading links or following and un-following accounts to draw attention [1]. Twitter provides limited spam removal. Spam accounts can be reported to Twitter. These accounts are reviewed and investigated for abuse and any account showing spamming behavior is permanently suspended. However, this method will not prevent spam Tweets appearing in search results and spam is getting worse as Twitter becomes more prevalent [2].

Approach
Our research focuses on correctly identifying spam Tweets. Our approach involves gathering a data set of Twitter records. A sample of 11,000 records was gathered based on various keywords. The Twitter Streaming API was used to gather the data. Each record consisted of information related to the Tweet along with user account detail, necessary to our research.

Heuristics
Based on literature and our own preliminary analysis, we identified a set of heuristics which we use for spam detection and data ranking. Some of these include, Follower Count, Account Age, Hash Tag Count URL Count which refers to the no. of URLs present in a Tweet, Status Count referring to the no. of Tweets posted from an account, List Count which refers to the no. of lists/groups an account belongs to, Duplicate Tweets referring to duplicate records present in a record set etc.

Following analysis of these heuristics we were able to identify the techniques proving most successful for spam detection. Some of our results can be seen below:

<table>
<thead>
<tr>
<th>Heuristic</th>
<th>Results</th>
<th>Spam</th>
<th>% Spam</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 Followers</td>
<td>93</td>
<td>65</td>
<td>65%</td>
</tr>
<tr>
<td>Acc Age &lt; 1 day</td>
<td>145</td>
<td>55</td>
<td>63%</td>
</tr>
<tr>
<td>Hash Tags &gt; 8</td>
<td>23</td>
<td>22</td>
<td>95%</td>
</tr>
</tbody>
</table>

Initial analysis showed that individual heuristics can be used to detect spam. Further analysis showed that combination of particular heuristics detected spam more accurately e.g. an account created within 24 hours with 40 friends returns only spam Tweets.

Analysis confirmed that one of the main characteristics of Twitter spam is repetition. Spam accounts repeatedly post the same Tweet in an effort to be seen. We explain the use of the Levenshtein distance to measure the similarity between Tweets and removed very similar Tweets. The results show that 20% of our dataset comprise of duplicate or near duplicate Tweets.

Future Work
To date we have been concerned with identifying heuristics to give high precision. We are now working towards measuring recall of these heuristics.

Following this we aim to develop a ranking algorithm which will give a score to the remaining Tweets and accurately rank them as a measure of time and query relevance.

References
Using Linked Data to Build Open, Collaborative Recommender Systems*  

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Abstract  
While recommender systems can greatly enhance the user experience, the entry barriers in terms of data acquisition are very high, making it hard for new service providers to compete with existing recommendation services. We propose to build open recommender systems, which can utilise Linked Data to mitigate the new-user, new-item, and sparsity problems of collaborative recommender systems. To demonstrate the validity of our approach, we augment the data from a closed collaborative music recommender system with Linked Data, and significantly improve its precision and recall.

1. Problem statement  
Most real-world recommender systems employ collaborative filtering [1], which aggregates user ratings for items and uses statistical methods to discover similarities between items. The high entry barriers of providing good recommendations can be characterised by the data acquisition problem [4]: providing recommendations for (a) new items or for (b) new users is a challenge if no data about the item or user is available. If the number of ratings is low compared to the number of items then (c) sparsity of the data will lead to ineffective recommendations.

We propose an alternative to building closed recommender systems: by utilising open data sources from the Linking Open Data (LOD) community project, it is possible to build open recommender systems, which can mitigate the challenges introduced by the data acquisition problem.

2. Background: Linked Data  
Linked Data refers to a set of best practices for publishing and connecting structured data on the Web [2], by making semantic information about things and concepts available via RDF and HTTP. They have been adopted by a steadily growing number of data providers which form the LOD cloud, e.g. DBpedia provides data from Wikipedia pages, and both the US and UK governments have converted data sets to RDF.

Social Web sites provide data, which is modeled after the principle of object-centered sociality: it connects individuals not just directly into communities, but also indirectly via objects of a social focus, such as a music act. Sites, which use the Friend-of-a-Friend (FOAF) vocabulary to publish such data, include MySpace and LiveJournal.

3. Methodology  
Figure 1 shows the steps of processing Linked Data for collaborative recommendations: (1) integrating the data about user-item connections from different sources to a common vocabulary. (2) Transforming the representation of the data from an RDF graph to a user-item matrix. (3) Applying a specific collaborative filtering algorithm on the user-item matrix.

This approach allows us to “fill in the gaps” in local data, by using data with user-item connections from external sources, thus mitigating the data acquisition problem.

4. Evaluation  
We have augmented the data from the closed Smart Radio streaming recommendation service (190 users, 330 musicians) with Linked Data from MySpace, adding 11000 users and 25000 new connections.

We evaluated a binary cosine similarity for the CF algorithm, by using Last.fm as a “gold standard” [3]. The result of adding external data was an improvement of precision from 2% to 14%, and recall from 7% to 33%.

5. References  

* This extended abstract is based on B. Heitmann and C. Hayes, “Using Linked Data to Build Open, Collaborative Recommender Systems”. AAAI Spring Symposia, 2010, and funded by Science Foundation Ireland under Grant No. SFI/08/CE/I1380 (Lion-2).
String Matching In Large Data Sets
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Abstract
The goal of this research is to create a search engine that correctly ranks search results in terms of phonetic, semantic and orthographic string similarity. Existing and custom matching algorithms are combined and then measured to find the greatest level of performance and accuracy.

1. Introduction & Commercial Application
This project is being undertaken with contributions from both NUI Galway and a privately owned company, Enterprise Registry Solutions Ltd (ERS). ERS are primarily involved with building electronic registries for government agencies worldwide such as the Companies Register Office in Ireland. One common concern with company name registration is trying to ensure similar names are not registered to operate in the same jurisdiction.

A failure to enforce distinctiveness among registered business names within the same jurisdiction can lead to a number of problems: identity theft, complexity when tracking cross border mergers or groups, and deliberate misrepresentation in order to gain market share and damage competitors.

With the growth of the EU it is common for businesses to register and trade in multiple regions. In response to this and to ensure transparency there have been calls for a European wide Central Companies Register [1]. The recent activity in this area highlights the need for a scalable and accurate search engine. The proposed system is labelled the Registered Organisation Search Engine (ROSE).

2. String Searching Background
Fundamentally this project is an examination of the performance of data retrieval methods within a specific problem domain. The string similarity measures such as Hamming Distance, Levenshtein Edit Distance and Jaro Winkler all return similarity scores integral to the ultimate ranking of results.

The hamming distance between two strings can be computed by determining how many characters must be substituted to transform one string to match the other. Levenshtein Edit distances are similar but allow addition, subtraction, substitution and transposition between strings.

The Jaro Winkler Distance gives additional weighting to terms with matching leading substrings. The distance \( dj \) of two given strings \( s_1 \) and \( s_2 \) can be computed as follows

\[
dj = \frac{1}{3} \left( \frac{m}{|s_1|} \cdot \frac{m}{|s_2|} + \frac{m - t}{m} \right)
\]

where \( m \) is the number of matching characters and \( t \) is the number of transpositions.

3. Problem & Approach
The ROSE system will attempt to unify some common algorithms and apply them in a unique way to improve the current state of the art used for company name searching.

In addition to traditional string matching approaches (based on syntax) the system adopts other approaches based on semantic similarity of company names. Given a query term (proposed company name), we can rank similar existing company names based on spelling, meaning and other factors. Matching algorithms will run sequentially with phonetic (double metaphone) and semantic (synonym substitution) methods to compute an overall similarity score between terms. By applying all of these techniques the accuracy of the system can be improved over traditional approaches. A test data set has been collected and is used to measure the effectiveness of each algorithm. Furthermore, by separating the main matching engines into distributed services performance and scalability can be ensured.

4. Architecture & Design
System performance and scalability are considered of high priority in the success of the ROSE system and the architecture has been designed to maximize this by

- Utilising the .Net frameworks CLR integration to compile complex C# code as managed code within the database
- The most CPU intensive procedures have been designed as separate services that can be run independently of each other and on separate machines. This greatly increases scalability.

5. Conclusion
To date, competitive performance (accuracy) and efficiency has been achieved on several of the individual components. Methods to combine evidence from the multiple approaches are currently being evaluated.

6. References
Reconstruction of Threads in Internet Forums
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Abstract

Online discussion boards, or Internet forums, are a significant part of the Internet. People use Internet forums to post questions, provide advice and participate in discussions. These online conversations are represented as threads, and the conversation trees within these threads are important in understanding the behaviour of online users. Unfortunately, the reply structures of these threads are generally not publicly accessible or not maintained. Hence, we introduce an efficient and simple approach to reconstruct the reply structure in threaded conversations. We contrast its accuracy against an existing and a baseline algorithm.

1. Introduction

Internet forums are an important part of the web for questions to be asked and answered and for public discussions on all types of topics. In forums, conversations are represented as a sequence of posts, or threads, where the posts are replies to one or more earlier posts. Links exist between posts if one is the direct reply to another. However, the reply structure of threads is not always available. For instance, the structure is not maintained by the provider, or lost. We propose a new method to reconstruct the reply structure of posts in forums. It uses a set of simple features and a decision tree classifier to reconstruct the reply structure of threads. We evaluate the accuracy of the algorithm against an existing and a heuristic baseline approach.

2. Methodology

Definitions

A post in a thread provides us with the following, basic information: creation date, name of author, quoting: name of the quoted author and content. The creation date of posts establishes a chronological order. From that ordering we can compute the distance of one post to another. Distance means how far away is a post to its reply. If there is no other post between a post and its reply, then they have a post distance of 1. If there is another post in between, then the distance is 2, and so forth.

Note that the data we use stores the reply interaction in the way that each post can only reply to one other post at once. Although a user can reply to several posts at once, and our approach is able to return more than one reply candidate, we limit replies to one target post in our evaluation.

Baseline approaches

In our data, we found that 79.7% of the replies have a post distance of 1, i.e. they follow directly the post they refer to. Hence, our first baseline approach is to link each post to its immediate predecessor, called “1-Distance Linking”.

Wang et al. 2008 [1] introduced a thread reconstruction that relies on content similarity and post distance. That serves as our second baseline approach.

Features

Based on the information a pair of posts provides, we extract the following features for our classification task: reply distance, posting-time difference, author quoted and cosine similarity. The cosine similarity compares the contents of two posts and returns a similarity score from 0 to 1, where 0 means not similar and 1 means exactly equal.

Classifier

As a classifier, we investigate the widely used C4.5 decision tree algorithm. It handles huge amount of data very efficiently due to its relative simplicity which is important for our task to present a fast and efficient way of reconstructing threads.

3. Evaluation

For the evaluation we use a subset of our Boards.ie dataset. Namely 13,100 threads, consisting of 133,200 posts in total.

In order to compare classification results of the approaches, we use the measurements precision, recall and F-score where F-score is the harmonic mean of precision and recall. For training the classifier, we applied a 10 fold cross validation to minimise bias.

Table 1 shows the comparison between our classification algorithm “ThreadRecon” and the two baseline approaches.

<table>
<thead>
<tr>
<th>Wang et al. 2008</th>
<th>1-Distance Linking</th>
<th>ThreadRecon</th>
</tr>
</thead>
<tbody>
<tr>
<td>44.40%</td>
<td>79.70%</td>
<td>85.70%</td>
</tr>
</tbody>
</table>

Table 1: F-score comparison between ThreadRecon and baseline approaches

An extended version of this work will be published in “Reconstruction of Threaded Conversations in Online Discussion Forums”, International Conference on Weblogs and Social Media 2011

8. References

Generalized Blockmodeling

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1. Introduction
As online social network data become increasingly available and popular, there is a ongoing need to analyze and model them in a scalable manner. To understand these large networks, it is useful to be able to reduce and summarize them in terms of their underlying structure. Popular approaches include community finding [1] and blockmodeling [2], both of which aim to group the strongly associated vertices together. Our research is focused on the latter approach.

2. Generalized blockmodeling
Generalized blockmodeling [3] decomposes a network into partitions and assigns a relation type to each pair of partition (called a block), which describes the relationship between the partitions. A major component to the generality of this method comes from the use of regular equivalence as a defining feature of the blocks. The previously well-studied structural equivalence proved to be somewhat too restrictive to describe real-world networks which led to the proposition of regular equivalence [3].

Up to now, the generalized blockmodel analysis of social networks has not received much attention, partly due to the computational demands of the existing algorithms. Therefore, we have designed approaches based on genetic algorithms (GA) and simulated annealing (SA) to fit generalized blockmodels. We have found both approaches are at least two orders of magnitude faster than the existing method.

3. Improving algorithms
In [3], they proposed the greedy KL-based approach to fit blockmodels. This algorithm considers the solution neighborhood of each vertex, and then greedily makes a move that minimizes the objective cost. A neighborhood move as a vertex moves from one partition to another, and the swapping of two vertices in different partitions were also considered. However, there was no description as to how to optimize the blocks types themselves. Therefore, we also introduce an additional step, where the blocks types are optimized after the partitions are optimized.

3.1. Results
We evaluate the efficiency and optimization performance of three algorithms – the proposed KL-based, and two aforementioned ones, SA and GA. To measure the scalability and optimizing ability of the algorithms, we generated synthetic datasets using a community generating algorithm and he results indicate that for larger networks, if speed is important, than the SA algorithm should be used, but if accuracy is more important, than the GA should be used.

To demonstrate the importance of increasing the scalability of fitting generalized blockmodels, we fitted blockmodels to the Enron and flight route datasets that could be not be fitted before because of the limitations of the KL algorithm. We used the GA algorithm to explore the Enron dataset over three time periods - prior, during and after the crisis. As a guide to the communications between the employees we used results found by [4] to help us construct our blocks. The best-fitted blockmodels summarized the roles, the key relationships (block types) between the different roles.

For the flight route dataset, we decided to use European airlines as it was shown that a hub-and-spoke/hierarchy model existed. For this data, we found that an addition of a ‘density’ block to be a fruitful addition to the nine types specified by [3].

4. Improving the objective function
The current definition of the objective function proposed by [3] is somewhat naive. It is essentially a simple count/percentage of the number of deviations of an element from its ideal block. We are currently investigating methods to improve upon this definition.

5. Future work
We aim to investigate additional ways to measure and rank discovered blockmodels, such as improving the objective function and defining other block types.

6. References
Finding and Representing Interesting Tweets
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Microblogging has become a popular way to communicate, and Twitter’s popularity has grown dramatically. Filtering is important [1]: users are motivated to seek information [2].

While Twitter’s collective value is being mined in various ways, we lack an overall sense of the discussion topics, concerns, and personalities of everyday users, whose messages can be aggregated only by topic or location. Instead of a public timeline with messages from all users, the Twitter homepage promotes celebrities, “Top Tweets”, and trending topics.

Interacting with people from diverse backgrounds should be easy [3], yet Twitter users and followers tend to be similar [4]. One of Twitter’s early successes was in bringing users a “social sixth sense”[2]. To extend this sense of peripheral awareness beyond a user’s own social circle, we seek to redevelop a public stream which is diverse yet interesting to read. We investigate four related research questions, as follows:

1) Which tweets are consistently rated as interesting?
2) What are the characteristics of these interesting tweets?
3) How can we represent tweets using existing SemanticWeb standards and activitystrea.ms?
4) How should we display interesting tweets to users?

We collected data on 210 tweets from 42 users who rated 10 tweets each on one of 21 questionnaires. Tweets originated from Twitter’s public timeline API[3], translated by the Google Translate API[4]. Questionnaires, answered by 2 users, asked:

- “Did you enjoy reading this tweet?” (“Yes”, “No, because I don’t like the topic”, “No, because I don’t know the people”, “No, because I couldn’t understand the words”)?
- “What category (from [5]) best fits this tweet?”

In a formative evaluation, 10 users answered a brief questionnaire about interfaces for displaying interesting tweets.

36 tweets (17%), including 10 translated tweets, were considered interesting (e.g. Table I) by both raters, while 44 tweets (21%) were considered uninteresting by both raters. Although we expected a correlation between the category and the interestingness of a tweet, no such correlation was found. Category assignment varied between raters, and depended on the category as shown in Table 2.

Table 1 A Selection of Interesting Tweets

<table>
<thead>
<tr>
<th>Agreed Tweets</th>
<th>Disagreed Tweets</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>Anecdote (AN)</td>
</tr>
<tr>
<td>23</td>
<td>51</td>
<td>Information Sharing (IS)</td>
</tr>
<tr>
<td>12</td>
<td>38</td>
<td>Me now (ME)</td>
</tr>
<tr>
<td>8</td>
<td>36</td>
<td>Opinions/Complaints (OC)</td>
</tr>
<tr>
<td>3</td>
<td>16</td>
<td>Presence Maintenance</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>Question to followers (QF)</td>
</tr>
<tr>
<td>4</td>
<td>18</td>
<td>Self Promotion (SP)</td>
</tr>
<tr>
<td>20</td>
<td>68</td>
<td>Statements and Random Thoughts (RT)</td>
</tr>
</tbody>
</table>

Table 2 Tweet Categories

References
1. Introduction

Claims for progress in a scientific community are generally assessed using cumulative citation measures. However, the analysis of the life-cycle of a community provides much greater explanatory power for the progress and potential of a scientific field. While previous work has examined scientific networks through co-citation and textual analysis, there is relatively little work on analysing the dynamics of cross-community behaviours, particularly where closely related communities are competing for scientific, funding and industrial capital.

![Figure 1 Community shift (left) and merge (right)](image1)

Inspired by Thomas Kuhn’s work [1], we identified several interesting cross-community phenomena, which we then mined in an automated manner. For example, a new community with a distinct topic can emerge from an established research community, where the emerging topic can be based on a novel approach or method. We call this phenomenon a community shift (see Fig 1). Similarly, a community can merge with another one. A community can also move in time from broader topics to more specific ones, which we call community specialization.

2. Methodology

We extracted co-citation network of 5772 scientists from papers published between 2000-2009 in two related disciplines in computer science: Semantic Web (SW) and Information Retrieval (IR). We then divided the network into ten overlapping time-slices and identified communities in each slice using Infomap [2] and Louvain [3] methods. The communities were matched across the slices according to the highest Jaccard coefficient, and important ancestors and descendants were identified for each community using measures derived from Jaccard coefficient.

Additionally, keywords were extracted from the papers, for which the text version was available, resulting in nearly 70% coverage of the network by the content.

Finally, we applied several specifically tailored measures combining both structural and content features in order to detect the interesting phenomena.

3. Results

An emergence of a trans-disciplinary community (community 15) that bridged the Semantic Web and Information Retrieval fields was detected between 2004-2007. This community was formed mainly by former members of Semantic Web community 0 depicted with red colour in the left part of the snapshots in Fig 2. We identified that the main research topic of community 15 had been Semantic Web until 2006–2008, during which time information retrieval became one of its core topics. At the same time this topic disappeared for its ancestor community. In 2007 the whole community moved between the SW and IR communities (see Fig 2), which is supported by investigated rise of its normalized group betweenness from 0.09 in 2004 to 0.27 in 2007. Therefore, whereas community 0 kept its focus on the core SW-related topics, it also formed a new interdisciplinary community, which has functioned since then as a mutual intermediary between SW and IR communities.

Analysis of different overlap measures revealed that an effort to establish this interdisciplinary collaboration came mainly from the SW community. Our approach uses community-finding techniques in combination with different overlap measures, special visualisations and automated metadata extraction and has enabled us to identify several other similar cases to support the hypotheses introduced above [4].

![Figure 2 Network snapshots in 2004 (left) and 2007 (right). Note the central position of the transdisciplinary community 15 (violet).](image2)

4. References


Acknowledgements

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A Corpus Framework For Cross-Lingual Search

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1. Introduction

Cross-lingual queries on text documents based on specialized domain vocabularies are complex and depend on the semantic, terminological and linguistic (STL) features of the vocabulary and language. The challenge for a cross-lingual search is to retrieve corpus objects which best match the user query based on these features. Therefore both the corpus and the query need to be STL enriched [1].

2. Method

In this work we present a framework to carry out a STL enrichment process for document, sentence and token corpus objects. The implementation is based on the blackboard architecture pattern with the corpus as a blackboard and S, T and L annotators acting on the corpus to perform the STL enrichment process (fig. 1).

We implemented L and T annotators for NLP processing such as tokenization or part-of-speech tagging for English, German, Spanish and Dutch processing and a S annotator enriching the corpus objects with vocabulary annotation. On the query side we manually implemented a set of queries with different STL features as shown in table 1.

3. Data-Set

We have constructed a multi-lingual finance data set consisting of financial reports from Wind Energy companies (UNLP Wind Energy Corpus) and vocabularies for English, German, and Spanish. The corpus comprises 96 financial reports and 1421 news texts from 9 different wind energy companies. We also used two financial vocabularies with STL enriched terms. The first vocabulary is the International Finance Reporting Standard (IFRS), which used worldwide to create financial reports in XBRL (eXtended Business Reporting Language) format. The second vocabulary is developed by the xEBR (XBRL European Business Registers) group to describe legal enterprise entities within Europe.

4. Future work

For the future we plan to develop a broader set of annotators and evaluate our approach on the UNLP Wind Energy corpus with queries constructed from the IFRS and the xEBR vocabulary. In particular we want to explore different combinations of S, T and L features of the queries using the framework.

We also plan to extend the framework STL enrichment on the vocabulary side based on the lemon (lexicon model for ontologies) Generator1, as developed by the MONNET project2 to facilitate richer STL searches.

5. References

[1] Wunner, T., Buitelaar, P., O’Riain, S., Semantic, Terminological and Linguistic Interpretation of XBRL. In Proceedings of the Workshop on Reuse and Adaptation of Ontologies and Terminologies at the 17th International Conference on Knowledge Engineering and Knowledge Management (EKAW), Lisbon

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1 http://monnetproject.deri.ie/Lemon-Editor
2 http://www.monnet-project.eu/
dcat: Searching Public Sector Information Across Borders
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Abstract
Opening public sector information has recently become a trend in many countries around the world. Online government data catalogues act as one-stop data portals providing description of available government datasets. However, these catalogues remain isolated from each other. Potential benefits from federating geographically overlapping or thematically complementary catalogues are not realized. We propose dcat - an RDF Schema vocabulary - as an interchange format among data catalogues and as a way of bringing them into the Web of Linked Data, where they can enjoy interoperability among themselves and with other deployed datasets.

1. Motivation
“Open Data” and “Open Government”—these terms describe a recent trend towards more openness and transparency in government, a development that has recently been embraced by some administrations. This development promises social benefits through increased transparency and openness, and economic benefits through realising the full potential of data that has already been produced as part of the administration’s day-to-day operations and paid for by the taxpayer. Sharing this data leads to cost savings for the private sector and enables the provision of new innovative services that the government cannot or will not provide.

Data catalogues such as data.gov in the US and data.gov.uk in the UK have recently appeared as one-stop web portals that facilitate access and increase findability of such data by providing lists of government datasets along with metadata.

It is common for the data catalogues themselves to be available in some format that is amenable to machine processing. We propose a standardised interchange format for such machine-readable representations of government data catalogues. The adoption of such a format enables embedding machine-readable metadata in web pages which increases findability by next-generation search engines. It also empowers decentralised publishing and aggregation into national or super-national (e.g., EU-wide) catalogues. Federated search over catalogues with overlapping scope, such as the catalogues for San Francisco, California, and the entire US becomes possible when interoperable description of catalogues are available.

2. Model
Based on our survey, we have developed an RDF Schema vocabulary that allows the expression of data catalogues in the RDF data model. We have chosen RDF because (i) most of the use cases considered in Section 1 involve querying of aggregated data, which is well-supported in RDF; (ii) re-use and extension of existing metadata standards such as Dublin Core is straightforward in RDF; and (iii) for compatibility with Linked Data. The figure below shows the basic model. Full documentation is available online 1.

3. Adoption
Work on dcat is pursued under the W3C e-gov Interest Group with a number of stakeholders involved (http://www.w3.org/egov/wiki/Data_Catalog_Vocabulary).

dcat was recently utilized by the Open Knowledge Foundation in the UK to enable searching public sector information across Europe through a faceted searching interface available at: http://publicdata.eu
data.gov.uk also uses dcat in their RDFa annotation.

Acknowledgment
The work presented in this paper has been funded in part by Science Foundation Ireland under Grant No. SFI/08/CE/I1380 (Lion-2).

1 http://vocab.deri.ie/dcat-overview
Mobile applications, physical activity and online social networking.
A match made in heaven?

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Abstract
This research aims to create/leverage correlations between online social networking and effective exercise motivation and adherence. There is a substantial body of research regarding social networking and increased physical activity, but little regarding the effective usage of advanced web technologies to address exercise adherence (very important since 50% of people drop out of exercise programs within six months). We propose to incorporate semantic technologies in exercise-oriented social networks to provide an interoperable historical record of one’s exercise adherence. This can be exchanged between trusted peers, and can also be used to power collaborative feedback mechanisms.

Keywords
Physical activity, online social networking, Twitter

1. Introduction
Obesity and lack of physical exercise continues to be a drain in today’s society, adversely affecting human health and thus leading to the necessity of medical care and a destructive impact on human well-being and productivity [1]. Medical research has shown the correlation between physical inactivity and several medical conditions and health problems [2].

2. Background
Christakis and Fowler (2009) [3] suggest that “people are inter-connected and so their health is interconnected. Inter-personal health effects in social networks provide a new foundation for public health”. As online connections between people become ever more interweaved with offline real-world interests, social networking methods are moving toward simulating real-life social interactions, including physical activity, health and disease management: rather than randomly approaching each other, people meet through things they have in common [4].

Since many aspects of health promotion professionals involve interdependent actors, social networks are of increasing interest to health services researchers [5]. The creation of a social network map of a person’s social network can help visualize and thus better understand the strengths of the social ties of the network [3].

While there are various personal devices that monitor/track a person’s exercise characteristics (e.g. Body Media, Fitbit, MapMyFitness, Nike+, etc.), the effectiveness of online sharing via social networks of one’s physical activity is limited in scientific research. Studies have indicated that “lack of motivation” is a key factor in why a person does not exercise. One factor to address is the relationship between participant and provider (i.e. personal trainer) and/or participant and social network, including their influence. People join gyms not only for health and fitness, but also for the social atmosphere. To fully understand the power of combining social networking and exercise adherence, the physical barrier of the four walls of an exercise facility is removed and technology is used that enables a measurable improvement towards one’s fitness goals.

3. Research Objectives
This study will research how the use of social and semantic technologies can effectively address the lack of motivation excuse and thus increase exercise adherence/general health. To achieve this goal, our research will consist of:

1. State-of-the-art review of systems used by providers with regards to exercise adherence;
2. Analysis of social networking and the Semantic Web as a means to provide an additional tool for providers with regards to exercise adherence;
3. Analysis of improved health/fitness measures;
4. Analysis of feedback mechanisms and economic improvements in health (both individual and group).

4. References
The Effect of User Features on Churn in Social Networks

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Social sites and services rely on the continuing activity, good will and behaviour of the contributors to remain viable. There has been little empirical study of the mechanisms by which social sites maintain a viable user base. Such studies would provide a scientific understanding of the patterns that lead to user churn and the community dynamics that are associated with reduction of community members – primary threats to the sustainability of any service. By churn we refer to the loss of users, as one indicator for decreasing community value, implicitly encoding the idea that a user no longer finds a service useful or valuable and has moved elsewhere. In this paper we explore the relation between a user’s value within a community - constituted from various user features - and the probability of a user churning.

In studies of churn behaviour of customers of telcom networks, a user’s probability of churning has been linked to the churning behaviour of neighbours in his/her social network. This has recently also been observed in online social networks [1]. These effects are illustrated in Figure 1, showing an individual’s probability to churn in relation to the number $k$ of his neighbours that already churned. In absence of explicit friendship links in forum data, an intuitive network of influence can be based on reply-to relations between users. Each of the reply graphs represents different definitions of who is considered as a neighbour.

![Figure 1. Network effects on the probability to churn in an online discussion forum. Four different reply graphs represent different definitions of influence. The labels with \textit{out} refer to influence being based on uni-directional communications, while \textit{bid.} refers to influence being based on bidirectional communications. The numbers ($\geq 2$ and $\geq 5$) represent two levels of influence based on volume of communications.](image)

In this paper, we examine relationships between user value and churn. Definitions of user value [2] refer to a collection of user features. The following are examples of user features that we have identified from the literature that contribute to user value:

- \textit{Structural and Social Network Features}: in-degree and out-degree exponents, centrality and betweenness
- \textit{Reciprocity Features}: average reply time to posts
- \textit{Persistence/productivity Features}: average post per thread and frequency of posting
- \textit{Popularity Features}: number of in-neighbours, the percentage of replies to posts
- \textit{Sentiment Features}: average polarity of posts

In our previous work [1], we explore the correlation between the above features and churn probability and influence, identifying key indicators of churn within a community. For our experiments over a year’s worth of data, we profile contributors in an online bulletin board by extracting the above salient behavioural and structural features, which are used to describe user value. Our approach employs time-series analysis, identifying links between certain user value features and their evolution with time, and the probability of an individual leaving the community. Our hypothesis is that users which display different behavioural, content and structural characteristics in the underlying social network will tend to have different influence on churn. By this we identify features of contributors that are implicitly recognised by other users as contributing to the value of the community. This provides an important contribution to the analysis of the relationship between user value, user churn and community value in general. It produces an understanding of the behavioural patterns associated with the loss of community members, eventually enabling community hosts to identify, early-on, that users may leave the community.

References


Personalised Document Corpora Exploration
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Abstract
In our research, we explore ways of enhancing personalised retrieval of relevant documents in open text document corpora. While a lot of research has been done in document retrieval, most approaches look at ways of improving single-step query answering. Because the users might have more complex information needs than they can express in a short query, our scope is to research how a system can actively assist the users in their exploratory search over a sequence of steps (i.e., queries).

1. Introduction
Internet has become one of the main information access points on the planet due to the great amounts of text documents it provides. Two types of information search have been identified: (i) look-up search (e.g., fact retrieval) and (ii) exploratory search (e.g., learning, investigation, analysis) [1]. Our focus is on enhancing exploratory search with machine learning techniques.

Currently, there are very few approaches towards information exploration, while most of research in the area of personalised search focuses on the look-up search [1]. However, since many users come to a search engine for exploratory search, our research is directed towards a system which is able to assist the user in his “exploration” over an unlimited sequence of queries.

An important challenge is that new information items become available every day and the system must be able to accommodate any dynamic corpus of documents in unsupervised fashion. Moreover, different users need different information even when they ask the same query, so user modeling is crucial for our work.

2. Our Approach
2.1 Domain modeling
In order to be able to guide the user towards information items of interest, the system must keep a “browsable” domain model, and constantly map the user’s state to that model.

In our approach, the text documents are firstly processed for extraction of probabilistic topic models. Latent Dirichlet Allocation (LDA) is a well-known algorithm for this purpose which we explore in this setting. The obtained topics are then used to label and cluster the documents. Many algorithms have been researched for document clustering. Still, one challenge is to identify for each user the level of granularity he can internalise or is interested in. For example, the level of details an expert feels comfortable with is not the same with that of a beginner in the same subject.

Documents are also connected based on their citation and bibliographic networks. The resulting network structure enables the navigation of documents based on authors and their citations. The bibliographic links enable the identification of communities, which is currently a highly researched topic. However, these communities are created based on citations, and at the same time, one of the most common ways of scientific data exploration is by following citation paths. Thus, by traversing only bibliographic paths, the users can get stuck into the point of view of one community. Our aim is to use the available research in the direction of community detection and make the user aware of the different communities dealing with his topics of interest.

2.2 Trace models and trace based reasoning
This model captures the “interaction traces” between the user and the system. Trace-based reasoning (TBR) has its root in case-based reasoning, as it solves new problems by adapting past solutions (i.e., user traces). Past traces can be used to infer the context of a user’s search, which is very important for assessing relevance of information. At the same time, machine learning can be used on the repository of traces, in order to identify patterns of information requests. The idea behind this is that if some documents or queries are constantly accessed together by various users, they might be related.

2.3 User modeling
User modeling is very much related to trace modeling as each user has assigned his past traces. As well, the system will try to capture the user’s level of expertise and his topics of interest, through a mixed initiative approach.

3. Conclusions
Exploratory search is still an under-studied area of personalised information retrieval. In order to address this topic, we plan to use machine learning for (i) creating a browsable hierarchical structure of the domain, (ii) inferring the user’s expertise, (iii) and to identify latent document relations. This knowledge is then used to guide the user and recommend documents suitable to his information needs.

4. References
User Similarity and Interaction in Online Social Networks

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Abstract

Online social networks like Facebook and Twitter are defined by connections between users, and by interactions between users. We analyse OSN user connections and interactions in novel ways to gain greater insight into the complex dynamics of these networks, and into the users of such networks. We uncover hidden graphs in such networks and develop new methods of analyzing these graphs, with direct implications for better social search and recommender systems algorithms. We conduct new forms of empirical analysis into OSN data to analyse user similarity, combining this with social graph analysis for a new perspective on the ‘birds of a feather’ phenomenon in OSNs. We also investigate what happens to user similarity as a function of network distance, with an associated novel graph-generation simulation mechanism to build social graphs based partially on similarities between users, and not merely on the traditional model of preferential attachment.

1. A weighting mechanism for interaction graphs

There are hidden graphs inside the overt social graph described by ‘follower’/’following’ relationships in OSNs, notably the graph described by user interactions: posting on friends’ Facebook walls, replying to other users etc. These interaction graphs are potentially more useful in discerning the true nature and strength of ties between users, and are thus valuable in social search algorithms and recommenders.

An effective weighting mechanism is necessary for effective analysis of these graphs. Such a mechanism should incorporate normalization for the varying levels of a user’s interactions, the frequency with which a user interacts with a particular other user, and temporal aspects to reflect strength for more recent interactions. Practical computational aspects should also be considered for maintenance of these highly dynamic graphs. We are developing a weighting mechanism for dealing with these issues, which can likely be applied to interaction graphs in other areas such as biological networks.

2. “Birds of a feather” in Twitter data

To gain an empirical measure of similarity between a set of Twitter users, we create a document for each user comprised of all of their aggregated posts. We convert these documents to n-dimensional vectors, using tf-idf weighting for each of the unique terms present in the document. In this way we convert documents to vectors of equal dimension, which can be compared for a measure of similarity in vector space.

We compare these vectors using cosine similarity to attain an empirical measure of similarity between any two users.

Using this metric, we analyse user similarity based on various graph-based criteria. We find that users who are linked in the overt social graph are more similar than those who are unlinked: birds of a feather do indeed flock together. We analyse similarity in a time-slice analysis, and in light of the second-order social graph comprised of user interactions, and in other ways.

3. User similarity as a function of network distance

Nodes in a graph lie at a network distance of one if they are directly linked, at a network distance of two if they share a common friend, a distance of three if they are two nodes removed in the graph, and so on. Work by ourselves and others[1] shows that users at a network distance of one are more similar than users who are not directly linked, but the relationships between similarities over higher network distances remains an open question.

We hypothesise that similarity between users as a function of network distance decays in some predictable logarithmic fashion, asymptotic towards some lower bound dictated by the properties of the network. Knowledge of this similarity distribution and lower bound would likely have applications in fine-grained recommender systems and social search algorithms.

Our approach to uncovering these network properties is simulation: we create network nodes with an array of p parameters, representing node attributes (in an OSN like Facebook these correspond to use characteristics like user age, location, career area, hobbies etc.). We then build the network graph iteratively, adding edges based on the traditional preferential attachment model, augmented by similarity between users. We analyse the networks so-generated to investigate node (user) similarity as a function of network distance.

References

Using Social Media to Spread Science and to Engage Readers in Conversation

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Abstract
In this work, we examine “the top 20 Most Popular Science Websites” as established by eBizMBA (eBusiness Knowledgebase) in July 2010, based on three major traffic ranking websites. These top 20 websites includes magazines, blogs aggregators, a press release aggregator, research institutes, academic journals and so on. We aim to understand how popular science websites use the Web and its social features to communicate science and to engage the readers in conversation. We analyse these top 20 sites by focusing on how they display their information and use social media to interact with their readers. Moreover, we complete this study by analysing their behaviors on Twitter. Finally, we discuss our findings and how science websites spread information and stay connected with their readers.

1. Introduction
The Web 2.0 eases the dissemination of information by allowing anyone to publish, share and comment content on the Web. However, this raises some issues on how to retrieve the relevant content and to give credibility and trustworthiness to a science website. The Pew Internet Survey [1], conducted in USA, has found that the Web is users’ first source to search for specific scientific information. However, more than a research tool, Web 2.0 allows also users to react to what they read. Therefore, we were then interested in understanding how the most popular science websites use Web 2.0 features to provide their readers with opportunities to comment and share information.

2. Methodology
We analyzed the top 20 most popular science websites established by eBizMBA1 (eBusiness Knowledgebase) in July 2010. Their ranking is based on the average of the three following traffic rank websites: Alexa, Compete and Quantcast. In order to figure out how sites display their content and use social media to interact with users, we manually read and analysed between 10 and 15 random news items from each science website, leading to a total of 253 news analysed2. We selected articles from different categories such as "top stories", "technology feature", "favorites", "editor's choice", etc. We also studied the website’s blog, if any. We followed a similar process for each sites. We mainly observed (1) the general information displayed (author, date, contact), and (2) the social aspect it provides, such as comments, integration with Web 2.0 sites like Facebook and Twitter (we will describe these sides in section 4.2), etc.

Finally, we observed the Twitter account of these science websites. By studying the conversational patterns (such as replies) of these websites on Twitter we could establish why and for which purposes they use it, i.e. to interact with others or simply to spread information.

4. Analysing how they engage users in conversation
We observed how readers can be engaged in conversation, by studying the comment section of news items and their integration with social media services such as Facebook and Twitter. In addition, we studied the Twitter account of these science websites.

5. Conclusion
In this study [2] of the top 20 science websites, we outlined the current tendency by users to visit websites not only written by science writers, but also sites that distribute sources such as academic papers and press release. Moreover, the presence in the top 20 of sciencebogs.com shows also the popularity of news written directly by researchers to a broader audience. Furthermore, readers seem to prefer engaging conversation using social media services where they have an account, rather than directly on the website. We also observed that the Twitter accounts of science websites are mainly used as a mean to reach more readers than to engage with users.

6. References

1 http://www.ebizmba.com/articles/science-websites (July 2010)
Improving Categorisation in Social Media using Hyperlinked Object Metadata

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Abstract
Categorising social media posts is challenging, since they are often short, informal, and rely on external hyperlinks for context. We investigate the potential of external hyperlinks for classifying the topic of posts. We focus on objects with related structured data available. We show that including metadata from hyperlinked objects significantly improves classifier performance. We use the structure of the data to compare the effects of different metadata types on categorisation.

1. Introduction
Hyperlinks are often a vital part of online conversation. Users share videos or photos they have seen and point to products or movies they are interested in. These external resources can provide useful new data such as author information for books, or genre information for movies. Often the post cannot be fully understood without knowing these details. Many of the hyperlinks point to websites that provide metadata for objects, e.g., videos (YouTube) or products (Amazon), and publish this data in a structured format via an API or as Linked Data. Structured data is useful since it allows relevant data types to be identified. Fig. 1 gives an example of a post where useful information can be gleaned from the metadata of a hyperlinked object. Some data such as the author is redundant, but the book title and categories are new. The title and categories can be useful for classifying the post, e.g., under a ‘Rugby’ topic.

Fig. 1: Enriching a post with metadata from hyperlinks

2. Experimental Setup
We use two datasets, one from a Forum (or message board) and one from Twitter (a microblogging site). We identified hyperlinks to sources of structured data, and retrieved the HTML pages as well as the relevant metadata. We used a Naïve Bayes classifier to compare classification based on post content (with and without URLs), hyperlinked HTML pages, external metadata from hyperlinked objects, and combinations of these. We experimented with different methods of combining sources and report the best results. Results shown are micro-averaged F1 score (± 90% confidence interval).

3. Experimental Results
Table 1 shows results for both datasets. Classification based on HTML pages alone gives poor results. Classification based on metadata alone increases F1 for Forum but decreases F1 for Twitter. Combining content and HTML pages improves F1, and combining content and metadata gives even better results.

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Forum</th>
<th>Twitter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content (baseline)</td>
<td>0.811 ± 0.008</td>
<td>0.759 ± 0.015</td>
</tr>
<tr>
<td>HTML</td>
<td>0.730 ± 0.007</td>
<td>0.645 ± 0.020</td>
</tr>
<tr>
<td>Metadata</td>
<td>0.835 ± 0.009</td>
<td>0.683 ± 0.018</td>
</tr>
<tr>
<td>Content+HTML</td>
<td>0.832 ± 0.007</td>
<td>0.784 ± 0.016</td>
</tr>
<tr>
<td>Content+Metadata</td>
<td>0.899 ± 0.005</td>
<td>0.820 ± 0.013</td>
</tr>
</tbody>
</table>

Table 1: F1 score for each post representation

Table 2 shows the results of classification based on individual metadata types in Forum compared to post content. For posts that link to Wikipedia, the article descriptions and categories provide a better indicator of the post topic than the post itself. For posts that link to YouTube, the video title, description and tags provide better indicators of the post topic than the original post.

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Wikipedia</th>
<th>YouTube</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content (baseline)</td>
<td>0.761 ± 0.014</td>
<td>0.709 ± 0.011</td>
</tr>
<tr>
<td>Object Titles</td>
<td>0.685 ± 0.016</td>
<td>0.773 ± 0.015</td>
</tr>
<tr>
<td>Object Descriptions</td>
<td>0.798 ± 0.016</td>
<td>0.752 ± 0.010</td>
</tr>
<tr>
<td>Object Categories</td>
<td>0.811 ± 0.012</td>
<td>0.514 ± 0.017</td>
</tr>
<tr>
<td>Object Tags</td>
<td>N/A</td>
<td>0.838 ± 0.019</td>
</tr>
</tbody>
</table>

Table 2: F1 score for metadata types in Forum

4. Conclusion
Our results show that categorisation in social media can be significantly improved by including metadata from hyperlinked objects. Different metadata types vary in their usefulness for post classification, and some types of object metadata are more useful for classification than the actual content of the post. We conclude that hyperlinks to structured data sources, where specific metadata can be identified and extracted, are a valuable input for post categorization.

8. References
Using Social Networking Platforms for eParticipation

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Abstract

Recently we can observe a massive growth of participation of electronic forms of governing at multiple stages and among multiple levels of state policy making around the world. Terms like eGovernment, which involves eParticipation, eVoting and other branches, are becoming more and more popular. We can observe a natural trend to utilize modern technology to enhance state policy making process[1]. We would like to present a way to realize eDeliberation concepts over popular social networking platforms, taking advantage of the great society reach and engagement of the platforms.

1. Introduction

Citizen Participation becomes harder and harder while the complexity and number of state policies grows constantly. Citizens face large number of institutional and psychological barriers[2]. Well-known democratic models such as Liberal, Republican or classic Aggregative model don’t seem to be sufficient anymore. The Deliberative model, which focuses on opinion-formation processes and is built over web technologies is considered the golden solution for the future of policy making[3].

2. eParticipation

eParticipation as a part of eGovernment is considered to be one of the key tools to provide effective state to citizens communication, which is demanded by Deliberative democracy model. Decision makers are encouraging discussions where citizens are presenting their opinions and solutions for posted issues. Constructive feedback provided by the society and policy change management leads to a deliberative style of governing and as a result introduces some elements of deliberative democracy.

3. Dedicated ePart Solutions vs. Social Networking Platforms

Multiple projects have been funded around the globe. Several European Union initiatives led to creation of platforms for eVoting and eParticipation. Even though solutions were well designed with high relevancy of the structure and the content, still most of them seem to suffer from serious sustainability problems and lack of engagement from the society[1]. In contrary, the Social Networking Platforms experience a real golden era with exponential growth in the number of active users. Reports from UK and Australia reveal that Social Network Traffic started to overtake popular search engines visits, thus becoming a very powerful medium that has to be taken under consideration by decision makers. The popular platforms are well established, present good sustainability and, being ubiquitous, engage a wide range of people by reaching most of the digitally included society. As Social Networking Platforms seem to miss the main eParticipation platforms issues it is reasonable to make a thesis that merging those two solutions could potentially be very beneficial.

4. eDeliberation over Social Networking Platform

We present some ideas and contributions towards bringing eParticipation, in particular eDeliberation, elements to Social networking Platforms such as Facebook or Twitter. We take advantage of a great reach and engagement provided by these platforms and combine them with eParticipation solution’s principles using state of the art Semantic Web technologies. Like this broad society could easily and effectively interact with decision makers at every stage of the policy-making process.

We will first investigate how existing platforms such as Facebook or Twitter can be used for eParticipation and identify missing elements for possibly complete eDeliberation over these platforms. We will define relevant expansions for the platform and Semantic Web based mechanisms for effective data interchange to support easy exploration of deliberation data. Finally we will elaborate on browsing and visualization techniques to present gathered data in a valuable and useful form for decision makers.

5. References


6. Acknowledgments

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Natural Language Queries on Enterprise Linked Dataspaces: 
A Vocabulary Independent Approach

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Abstract
This work describes Treo, a natural language query mechanism for Linked Data which focuses on the provision of a precise and scalable semantic matching approach between natural language queries and distributed heterogeneous Linked Datasets. Treo’s semantic matching approach combines three key elements: entity search, a Wikipedia-based semantic relatedness measure and spreading activation search. While entity search allows Treo to cope with queries over high volume and distributed data, the combination of entity search and spreading activation search using a Wikipedia-based semantic relatedness measure provides a flexible approach for handling the semantic match between natural language queries and Linked Data.

1. Introduction
Linked Data brings the promise of incorporating a new dimension to the Web where the availability of Web-scale data can determine a paradigmatic transformation of the Web and its applications. However, together with its opportunities, Linked Data brings inherent challenges in the way users and applications consume the available data. End-users consuming Linked Data on the Web or on corporate intranets should be able to query data spread over potentially a large number of heterogeneous, complex and distributed datasets. The freedom and universality provided by search engines in the Web of Documents were fundamental in the process of maximizing the value of the information available on the Web. Linked Data consumers, however, need previous understanding of the available vocabularies in order to execute expressive queries over Linked Datasets. This constraint strongly limits the visibility and value of Linked Data. Ideally a query mechanism for Linked Data should abstract users from the representation of data. This work focuses on the investigation of a query mechanism that could address this challenge providing a vocabulary independent natural language query approach for Linked Data.

2. Description of the Approach
In order to address the problem, an approach based on the combination of entity search, a Wikipedia-based semantic relatedness measure and spreading activation is proposed. The combination of these three elements in a query mechanism for Linked Data is a new contribution in the space. The center of the approach relies on the use of a Wikipedia-based semantic relatedness measure as a key element for matching query terms to vocabulary terms, addressing an existing gap in the literature. Wikipedia-based relatedness measures address limitations of existing works which are based on similarity measures/term expansion based on WordNet.

The final query processing approach provides an opportunity to revisit cognitive inspired spreading activation models over semantic networks under contemporary lenses. The recent availability of Linked Data, large Web corpora, hardware resources and a better understanding of the principles behind information retrieval can provide the necessary resources to enable practical applications over cognitive inspired architectures.

3. Evaluation
A prototype, Treo, was developed and evaluated in terms quality of results using the QALD Workshop DBpedia training query set [1] containing 50 natural language queries over DBPedia. Examples of queries present in the dataset include: “who was the wife of president Lincoln?” and “which capitals in Europe were host cities of the summer Olympic games?”. Mean reciprocal rank, precision and recall measures were collected.

The proposed approach was able to answer 70% of the queries and the final values for the collected measures are mrr=0.492, precision=0.395 and recall=0.451. The relatedness measure was able to cope with non-taxonomic variations between query and vocabulary terms, showing high average discrimination in the node selection process (average difference between the relatedness value of answer nodes and the relatedness mean is 2.81 σ).

The results for each query were analyzed and queries with errors were categorized into 5 different error classes. The removal of the queries with errors that are considered addressable in the short term (Partial Ordered Dependency Structure Error, Pivot Error, Relatedness Error) defines estimated projected measurements of precision=0.64, recall=0.75 and mrr=0.82.

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1st Workshop on Question Answering over Linked Data (QALD-1), //www.sc.eit-ec.uni-bielefeld.de/qald-1, (2011).
A Citation-based approach to automatic topical indexing of scientific literature

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Abstract

Topical indexing of documents with keyphrases is a common method used for revealing the subject of scientific and research documents to both human readers and information retrieval tools, such as search engines. However, scientific documents that are manually indexed with keyphrases are still in the minority. This work proposed a new unsupervised method for automatic keyphrase extraction from scientific documents which yields a performance on a par with human indexers. The method is based on identifying references cited in the document to be indexed and, using the keyphrases assigned to those references for generating a set of high-likelihood keyphrases for the document. We have evaluated the performance of the proposed method by using it to automatically index a third-party testset of research documents. Reported experimental results show that the performance of our method, measured in terms of consistency with human indexers, is competitive with that achieved by state-of-the-art supervised methods. The results of this work is published in [1].

1. Citation-based keyphrase extraction

A significant portion of electronic documents published on the Internet become part of a large chain of networks via some form of linkage that they have to other documents. In relation to scientific literature which is the subject of our work, the citation networks among scientific documents have been successfully used to improve the search and retrieval methods for scholarly publications, e.g., see [2]. These studies have successfully shown that citation networks among scientific documents can be utilized to improve the performance of three major information retrieval tasks; namely, clustering, classification, and full-text indexing. In our opinion, the results of these studies indirectly suggest that the content of cited documents could also potentially be used to improve the performance of keyphrase indexing of scientific documents. In this work, we have investigated this hypothesis as a new application of citation networks by developing a new Citation-based Keyphrase Extraction (CKE) method for scientific literature and evaluating its performance. The proposed method can be outlined in three main steps:

1. Reference extraction: this comprises the process of identifying and extracting reference strings in the bibliography section of a given document and parsing them into their logical components.
2. Data mining: this is a three-fold process. In the first stage, we query the Google Book Search (GBS) to retrieve a list of publications which cite either the given document or one of its references. Then, in the second stage, we retrieve the metadata records of these citing publications from the GBS database. Among other metadata elements, these records contain a list of key terms extracted from the content of the citing publications. In the final stage of the data mining process, we extract these key terms along with their numerically represented degree of importance from the metadata records of the citing publications to be used as primary clues for keyphrase indexing of the given document.
3. Term weighting and selection: this process starts by searching the content of the given document for the set of key terms collected in the data mining process (step 2 above). Each matching term would be assigned a keyphraseness score which is the product function of seven statistical properties of the given term, namely: frequency among the extracted key terms, frequency inside the document, number of words, average degree of importance, first occurrence position inside the document, frequency inside reference strings, and length measured in terms of the number of characters. After computing the keyphraseness scores for all the candidate key terms, a simple selection algorithm is applied to index the document with a set of most probable keyphrases.

2. Experimental Results

Our CKE algorithm clearly outperforms its unsupervised rival, Grineva et al. algorithm [3]. In comparison to its supervised rivals, the CKE algorithm significantly outperforms KEA [4] under all conditions. However, it yields a slightly lower averaged inter-consistency score (≤1.1%) compared to Maui [5].

3. References

Studying Forum Dynamics from a User Experience Perspective

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Online forums provide extensive conversation records of users across time. An analysis that specifically addresses the temporal dimension can reveal patterns that are not obvious from the statistics aggregated over time. Such an analysis can facilitate the mathematical modeling of conversations and the administration of forums. In this paper, we focus on studying the temporal characteristics of users' behavior in forums.

There has been a number of studies on forums [1, 2], but most of them do not focus on experience of individual users over time. The experience of users can be visualized with AuthorLines [3], but with this method it is hard to compare the temporal patterns across many users.

We propose to represent a user's communication experience as a path in a space of user features. In this paper, we focus on two features -- the number of posts made and the number of replies received. In this case, a user path is a line in the 2D space. The path starts at point (0, 0) and whenever a user makes a post the path moves one unit right. Whenever the user receives a reply the path moves up one unit. The path can be interpreted as shown in Fig. 1. The dynamics of a forum can be captured with the paths of participating users.

We applied our method to users in forums from Boards.ie, a large multi-topical Irish forum board, and report 3 main findings. First, we found that straight line can be used as an approximation to a user path. This observation has a direct implication for modeling of user experience over time. Note that aggregated post/reply ratio statistics is not sufficient to discover this pattern.

Next, we found that there are “dead zones” in the feature space: e.g., users did not go far to the right along x-axis. This observation can help in establishing normative user behavior and discovering outliers (e.g., spammers in “dead zones”).

Last, we found that we can use the paths for an interpretable visualization and categorization of forums. This is done by extracting macro features that summarize forum appearance, such as the mean length and slope of user paths.

While previous forum visualizations [3] have their advantages, our plot is more straightforward to interpret in terms of reciprocity of communication. For example, a path closer to x-axis contains longer consecutive posting sequences. Such a path can be classified as a “monologue”.

We emphasize the flexibility and generality of our approach, since it can be applied to other domains, such as email or phone communications, replacing the numbers of posts and replies by the numbers of sent and received emails or outgoing and incoming calls respectively. Further, the paths can be constructed using different user features. Finally, our analysis can be performed on the collective experiences of communities rather than individual users.

References
Detecting Topics and Events in Video Content via Synchronized Twitter Streams

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Abstract
This work is an attempt to annotate event videos from contextual sources, in this case from user tweets. The problem involves two subtasks, 1) Identifying interesting entities and events 2) aligning the detected entities to the recorded video. Combination of linguistic processing statistical data and domain knowledge helps to get high quality result for a time stamped concept based annotation of various event videos. To evaluate our approach we studied four live events in two different domains.

1. Introduction
Being able to automatically annotate videos on the social web is a complex problem to solve. It usually requires combinations of expensive content-processing algorithms, speech recognition techniques or expert manual annotations, but not scalable. To address the above problem, we explored a unique yet extremely lightweight approach by leveraging user-generated tweet streams to annotate event videos. Our proposed approach involves the detection of interesting topics using various combinations of statistical and natural language processing techniques, and the synchronization of topics to a video timeline using simple heuristics. A similar approach has been reported in [1] for detecting audience sentiment during US presidential debate.

2. Methodology
2.1. Data processing
The experiment started with data collection from 4 different events using various related keywords and hashtags. Cleaning of data started with pre-processing, segregating hashtags, usernames and identifying relevant tweets from the non-relevant.

2.2. Feature Selection
Features selection includes statistical features such as Twitter volume, unique users etc, linguistic features such as name variations, hashtags and some domain knowledge such as event name and participants (conference) and player’s name (sports) were used.

2.3. Entity and Topic Detection
The entity and topic detection performed using multiple approaches including burst detection, tf-idf measure and feature based classification of tweets.

3. Result
The experiment was evaluated using IR measures such as recall, precision and F-measure against the manually-annotated ground truth.

4. References
Provenance in the Web of Data: a building block for user profiling and trust in online communities

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Abstract

Online collaborative knowledge bases such as Wikipedia provide an extensive source of information, not only to their readers, but also to a wide range of applications and Web services. For example, DBpedia, one of the largest datasets on the Web of Data, is widely used as a reference for data interlinking and as a basis for applications employing Semantic Web Technologies. Yet its dataset, directly derived from Wikipedia articles, could contain errors due to inexperience or anonymity of the contributors. By analysing the Wikipedia edit history and the users' contributions we provide detailed provenance information for DBpedia statements and we make this information publicly available on the Web of Data. The dataset we provide is then fundamental for analysing users' activities/interests and computing trust measures.

Collaborative websites such as Wikipedia have recently shown the benefit of being able to create and manage very large public knowledge bases. However, one of the most common concerns about these types of information sources is the trustworthiness of their content which can be arbitrarily edited by everyone. The DBpedia project[1], which aims at converting Wikipedia content into structured knowledge, is then not exempt from this concern. Especially considering that one of the main objectives of DBpedia is to build a dataset such that Semantic Web technologies can be employed against it. Hence this allows not only to formulate sophisticated queries against Wikipedia, but also to link it to other datasets on the Web, or create new applications or mashups. Thanks to its large dataset and its cross-domain nature DBpedia has become one of the most important and interlinked datasets on the Web of Data. Therefore providing information about where DBpedia data comes from and how it was extracted and processed is crucial. This type of information is called provenance and it describes the entire data life cycle, from its origin to its subsequent processing history.

Having provenance information about Wikipedia data allows us to identify quality measures for Wikipedia articles and estimate the trustworthiness of their content. Then, since the DBpedia content is directly extracted from Wikipedia, the same trust and quality values can be propagated to the DBpedia dataset. We apply this process to DBpedia, but this is just one particular use-case, the same considerations about provenance are suitable for every dataset on the Web of Data. The benefits of using data provenance to develop trust on the Web, and the Semantic Web in particular, have been already widely described in the state of the art. Provenance data provides useful information such as timeliness and authorship of data. It can be used as a ground basis for various applications and use cases such as identifying trust values for pages or pages fragments, or measuring users' expertise by analysing their contributions and then personalize trust metrics based on the user profile of a person on a particular topic. Moreover, providing also provenance meta-data as RDF and making it available on the Web of Data offers more interchange possibilities and transparency. This would let people link to provenance information from other sources. It provides them the opportunity to compare these sources and choose the most appropriate one or the one with higher quality. In our specific context of DBpedia for example, by indicating by whom and when a RDF triple was created (or contributed by), it could let any application flag, reject or approve this statement based on particular criteria.

In our work [1][2] we propose a modelling solution to semantically represent information about provenance of data in DBpedia and an extraction framework capable of computing provenance for DBpedia statements using Wikipedia edits. The framework consists of: (i) a lightweight modelling solution to semantically represent provenance of both DBpedia resources and Wikipedia content, (ii) an information extraction process and a provenance-computation system combining Wikipedia articles' history with DBpedia information, (iii) a set of scripts to make provenance information about DBpedia statements directly available when browsing this source, (iv) a publicly available web service that exposes in RDF as Linked Open Data our provenance dataset letting software agents and developers consume it.

References


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Supporting Online Shopping with Opinion Mining

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Abstract
Consumers often find product reviews very valuable. In online shopping, opinions that are expressed in product reviews are available in the form of unstructured text. Existing shopping websites offer search tools suited to structured product information, thus customers looking for product opinions are forced to perform time-consuming analyses manually. This work proposes a method for seamless integration of unstructured information available in product reviews with structured product descriptions using opinion mining. We demonstrate applicability of our approach with a used car product search tool using real data.

1. Introduction
Many online shopping decisions are made after consulting other customers’ opinions. This effect is especially visible in travel bookings (97.7%) where 77.9% decision involve the use of customer reviews as a source of information [1]. Consulting reviews requires significant amount of additional effort from customers. This work proposes new method for extraction of valuable product information from customer reviews and its integration with structured product descriptions.

2. The Method
An opinion mining system needs to fulfill three generic tasks [2]: identification of the product features, discovery of opinion phrases, and sentiment analysis. In our method (see [3] for details), the first of the tasks is performed using domain knowledge and data from popular websites offering semi-structured car reviews. We use a rule-based shallow-parsing method for extraction of potential opinion statements. The rules are constructed to extract a consistent fragment of the sentence that contains a feature and the sentiment about the feature. Opinion statements are further matched with lists of opinion words. In comparison to other approaches our method considers not only nouns as features and not only adjectives as opinions.

Our approach deals with sentiment analysis on three levels: word level, chunk level, and context dependant chunk level. To assess the sentiment we use an approach similar to [4], where lists of adjectives, nouns, verbs and adverbs with positive and negative sentiment were created, combining to the total word sentiment. Opinion context is modeled with utility theory [5] as the features were divided in three classes: cost-type - with preference toward lower values (e.g. price); benefit-type - higher values are preferred (e.g. reliability); neutral – the character of a feature is context dependant.

3. Conclusions
We presented an opinion mining system that extracts and integrates opinions about products and features from very informal, noisy text data (product reviews) using a hierarchy of features from a number of websites and domain knowledge. Our method is of value not only to shopping service providers and potential customers but also to product manufacturers.

4. References
Towards Social Descriptions of Services
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Abstract
This work aims to close the gap between two phenomenally contradictory service annotation paradigms: traditional semantic service models and the emerging social annotation of services. It aims to (i) extend service description models to include the bottom-up user-driven social descriptions of services, and (ii) facilitate the semantic interlinking between services annotated using different semantic models.

1. Introduction
The history of efforts to describe services in three successive eras: the syntactic, the semantic and the social one. Each of these eras took the expressivity of service descriptions one step further.

The ‘syntactic era’ dates back to the first days of SOA developments. The need for a standardized format for describing service interfaces and capabilities resulted in WSDL. But WSDL remains at the syntactic level and thus cannot incorporate rich service-related information that could be utilized in order to improve the quality of service provision.

The ‘semantic era’ emerged in the late 90’s influenced by the vision of the Semantic Web. Semantically-enhanced service descriptions promised to enable and to facilitate the dynamic discovery, invocation, execution, composition and monitoring of services. This led to the definition of various non-interoperable semantic service models such as OWL-S, WSMO, SA-REST and SAWSDL. However, their high complexity and cost have prevented to date the industrial adoption of semantic service descriptions.

Additionally, existing service descriptions (both syntactic and semantic ones) are provider-oriented constructs and leave the users’ perspective outside. They assume that the user has a passive role, limited to the consumption of the services, and that the semantic description of the service is created exclusively by the service provider.

The ‘social era’ is largely related to the establishment of the Social Web as a new computing paradigm, which capitalizes largely on collective intelligence, with semantics emerging in a bottom-up fashion, directly from the users. This has a direct effect on the description of services as well.

2. The Service Description Metamodel
The service description metamodel (SDM) extends existing semantic service descriptions in order to include the user’s perspective. We proved that all semantic service models can be mapped to SDM.

SDM defines the following: A service provider provides a service. A service client uses a service. A service is described by an extended semantic description co-created by the service provider and the service client. The service description comprises of provider-driven and user-driven service aspects. There are five different types of provider-driven service aspects: information model, functional descriptions, non-functional descriptions, behavioural descriptions and technical descriptions. There is one type of user-driven service aspects: social descriptions.

3. The Reference Service Model
The reference service model (RSM) for the Web of Services facilitates the semantic interlinking between heterogeneous semantic services and the development of socially-aware semantic services.

RSM comprises of the following: service, service input, service output, service context, service logic, service provider, service client and service feedback.

A service provider provides a service. A service requires one or more service inputs. A service produces one or more service output. A service implements a service logic. A service is executed in a service context. A service receives service feedback. A service client consumes a service. A service client obtains the service output. A service client gives service feedback. A service client adapts the service context.

4. Expected Benefits
This work strengthens the position of the users in service provision by facilitating their participation in the co-creation of service descriptions. It contributes to the conceptual modeling of services, being the first systematic modelling effort to include social descriptions in service models. It lowers the semantic interoperability barriers and contributes to the reusability of existing services described using different semantic service models. Social descriptions provide new insights on service search and discovery, design, composition, recommendation, personalization and marketing. It is a technology-independent effort and can be combined with any (semantic) service model and with SOAP-based and RESTful services alike. It is thus expected to contribute to the uptake of semantic services and improve the quality of service provision.

Acknowledgments. This work is funded in part by Science Foundation Ireland under Grant No. SFI/08/CE/11380 (Lion-2).

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Making recommendations in Geo-Social Networks

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Abstract

This paper involves the collection and analysis of content from the geo-social network Foursquare. This geo-social network data is then analysed in order to develop and test new collaborative filtering techniques. These collaborative filtering techniques are used to make recommendations (venues, other users) to users of the foursquare network.

Keywords—Foursquare; Geo-Social Network Analysis; Collaborative Filtering; Social Media

Introduction

Geo-social networks are a new form of online social networks (OSN) in which geographic services and capabilities such as geocoding and geotagging are used to facilitate additional social interactions. Foursquare is a location-based social networking application for mobile devices. Users may “check-in” at venues and can also find out if any of their friends are in the same location or if they have checked into any nearby venues.

The idea behind geo-social networks such as Foursquare is to encourage real life physical interaction based on virtual interactions. Currently Foursquare is the largest pure geo-social network with over 4 million active users. This project involves gathering a dataset, analysing that dataset and investigating existing and novel collaborative filtering techniques in order to make predictions.

Research Approach

The method involved with this research is as follows:
1) Extensively trawling the Foursquare network, more specifically the most popular venues in New York (a city with a large number of Foursquare users)
2) Representing this data as a graph which represents relationships between people and locations and also between sets of people.
3) Establishing new collaborative filtering techniques to predict friends and venues that users will like.
4) Analysing the approaches with respect to the quality of the results obtained using different sources of evidence and different algorithms for research.

Data Collection

Foursquare presents a public API, which was used to gather the social network data under investigation. This data was collected using PHP and OAuth. The most popular venues in New York were analysed in relation to users who “liked” these venues. These users then acted as a seed group and from this we ascertained those users’ friends and the venues they frequently checked into.

Overview of data collected

The data set can be viewed as a bi-partite graph:

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<thead>
<tr>
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<th>Venues Summary</th>
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<tr>
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<td># Clusters</td>
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<tr>
<td>Max degree mode</td>
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<td>2</td>
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<tr>
<td>Clustering Coefficient</td>
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<tr>
<td>Graph density</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Current & Future Research

We are currently clustering users based on a number of different factors (venues that they “like”, their friends “likes” etc…). We will then make predictions using a number of different machine learning approaches and present our results.

References


# ENVIRONMENTAL ENGINEERING

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<th>Title</th>
<th>Page</th>
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Assessment of Impacts of Forest Operations on the Environment

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Abstract
The aim of this project was to assess experimentally the impact of clearfelling of forests and the effectiveness of buffer strips following clearfelling on sediment and nutrient release, acidification and greenhouse gas (GHG) emissions. Pre- and post-clearfelling data of surface and subsurface flow, soil testing and gas concentrations are now being collected. To date, results obtained show there is an increase in dissolved reactive phosphorus (DRP) concentrations moving from the forest edge to under a brash mat, which is located in a riparian area between the forest and a nearby river. This reduces closer to the river. Greenhouse gas emissions are highest in the riparian area and a virgin peat site, while the lowest emissions are measured in a standing and mature coniferous forest.

1. Introduction
Elevated levels of phosphorus (P) and suspended sediment (SS) in surface waters are becoming a major environmental issue both nationally and internationally. (Mainstone et al., 2008). During clearfelling of forests, there is the opportunity for a high runoff of P and SS to nearby water courses. Riparian buffers may have the ability to slow down and reduce the nutrient and sediment release from forests. In this project, which is being conducted in the Burishoole catchment in Co. Mayo, two types of riparian buffer are studied: (1) a naturally regenerated peatland buffer and (2) a standing mature coniferous forest. The forest area upslope of the study site is currently being clearfelled, allowing 4 years of regeneration on the riparian buffer zone.

2. Materials and Methods
Pre- and post-clearfelling data is being collected at the study site. The following parameters are studied: surface and subsurface water, various soil parameters and greenhouse gas (GHG) emissions. Piezometers and sampling tubes are installed across the site so that depth to water table can be monitored and subsurface water sampled. Sampling locations are at 1, 5, 10, 20, 30 and 40 m upslope of the river edge, before and after brash mats, and in the forest. Each set of 3 sampling tubes are positioned at 20 cm, 50 cm, and 100 cm depths below the soil surface. Surface water samples are also collected at these points. Surface and subsurface waters are sampled across the site regularly and during storm events, and chemically analysed for SS, dissolved reactive phosphorus (DRP), total phosphorus (TP), ammonium-N (NH₄-N) and nitrate-N (NO₃-N). Greenhouse gas emissions are being studied in four areas: (1) the naturally regenerated peatland buffer (2) the standing mature coniferous forest (3) a recently clearfelled coniferous forest and (4) a virgin peatland site. These are sampled using dark, static, manually sampled, stainless steel chambers (height 9–18 cm) equipped with butyl rubber septa for gas sampling, and are tested with a gas chromatographer. This data will be supplemented by a meso-scale study, comprising 3 hydraulically isolated plots each measuring 25 m-long by 3.5 m-wide. This will allow us to fully examine the flow, nutrients and sediment in and out of a hydraulically isolated area in a controlled manner. All samples were tested in accordance with the Standard Methods.

3. Results and Discussion
Initial results obtained on site show there is an increase in DRP concentration in the subsurface flow moving from the forest edge to under the brash mat. This reduces again closer to the river. This may be due to a sand layer located close to the river.

Greenhouse gas emissions are highest in the regenerated peatland buffer and the virgin peat site, while the lowest emissions are measured in the standing and mature coniferous forest.

4. Conclusions
Initial indications show that a revegetated buffer is successful in reducing P concentrations from the forest to the river bank. Greenhouse gas emissions are higher before planting and after clearfelling than when the peat is under forest cover. Further data will be collected post-clearfelling to assess the impact of forest operations, the effectiveness of two types of buffers, and GHG emissions.

5. Acknowledgements
The authors acknowledge the support from the EPA for funding this research under the STRIVE program.

6. References
Novel Agri-engineering solutions for amelioration of ground water at critical source areas

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(2) Teagasc, Johnstown Castle, Environmental Research Centre, Wexford, Ireland

Abstract
This project examines the potential of carbon-amended remediation trenches to intercept and remediate nitrate (NO₃) in subsurface waters. Laboratory-scale columns were constructed to examine the performance of the following materials in NO₃ removal: lodgepole pine woodchips (LPW), cardboard (CCB), lodgepole pine needles (LPN) and barley straw (BBS). Our results suggest that PRBs are a relatively inexpensive method to control NO₃ plumes.

Introduction
Point-source nitrate (NO₃) contamination of shallow groundwater can result in NO₃ plumes of high concentration. The best way to control reactive N is by managing denitrification. In situ permeable reactive barriers (PRBs) containing carbon (C)-rich materials may be used. In these systems, nitrogen (N)-rich wastewater flows through a C-rich mixture to reduce NO₃ concentrations to acceptable levels. The aim of this study was to investigate the best filter media to use in a PRB. In addition, the production of greenhouse gases (GHGs) as a by-product of the treatment process was also considered. This is commonly known as ‘pollution swapping’. Nitrate removal was defined as the % of NO₃ converted to di-nitrogen (N₂) gas. Pollution swapping by N therefore refers to the sum of all forms of N not resulting from complete denitrification to N₂.

Results and Discussion
The results from the study are presented in Table 1. Table 2 presents the results for the LPW and CCB columns, considering the removal rates with and without pollution swapping. Considering the removal of NO₃-N on the basis of the removal of that parameter only, approximately 99% denitrification occurred. However, if we consider NH₄-N, the NO₃-N removal decreases. This allows for a more accurate comparison of the effectiveness of the media. We also measured the average hydraulic retention time for the media. It was lower for the CCB columns because of the media characteristics and the higher compaction inside the column.

<table>
<thead>
<tr>
<th>pH</th>
<th>COD</th>
<th>NH₄-N</th>
<th>NO₃-N outlet</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg/L</td>
<td>mg/L</td>
<td>mg/L</td>
<td></td>
</tr>
<tr>
<td>LPW</td>
<td>7.98</td>
<td>447.33</td>
<td>6.44</td>
</tr>
<tr>
<td>(stdev)</td>
<td>0.23</td>
<td>300.06</td>
<td>4.23</td>
</tr>
<tr>
<td>CCB</td>
<td>7.88</td>
<td>616.51</td>
<td>4.99</td>
</tr>
<tr>
<td>(stdev)</td>
<td>0.54</td>
<td>374.78</td>
<td>4.12</td>
</tr>
<tr>
<td>CSO</td>
<td>8.17</td>
<td>43.84</td>
<td>2.84</td>
</tr>
<tr>
<td>(stdev)</td>
<td>0.15</td>
<td>34.66</td>
<td>2.42</td>
</tr>
<tr>
<td>LPN</td>
<td>5.84</td>
<td>6705.21</td>
<td>4.99</td>
</tr>
<tr>
<td>(stdev)</td>
<td>0.39</td>
<td>6430.76</td>
<td>5.54</td>
</tr>
<tr>
<td>BBS</td>
<td>7.75</td>
<td>1212.74</td>
<td>8.21</td>
</tr>
<tr>
<td>(stdev)</td>
<td>0.35</td>
<td>898.60</td>
<td>8.24</td>
</tr>
</tbody>
</table>

Table 2 Nitrate removal (%) with and without pollution swapping.

<table>
<thead>
<tr>
<th>Retention time</th>
<th>NO₃-N removal (steady state)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without</td>
</tr>
<tr>
<td>d</td>
<td>%</td>
</tr>
<tr>
<td>LPW</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>13.03</td>
</tr>
<tr>
<td>3</td>
<td>14.80</td>
</tr>
<tr>
<td>CCB</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>8.46</td>
</tr>
<tr>
<td>3</td>
<td>10.9</td>
</tr>
</tbody>
</table>

Conclusion
Taking pollution swapping into account, cardboard had the best nitrate removal and the columns containing barley straw had the worst. It is important to take pollution swapping into account to distinguish between media. We observed negligible nitrite-N (NO₂-N) and nitrous oxide (N₂O) concentrations in the effluent and that is the reason only NH₄-N is considered in Table 2.
Abstract

In this study, a horizontal flow biofilm reactor (HFBR) has been designed and is being investigated for its efficacy biologically treating nuisance gases associated with emissions from wastewater treatment plants, namely methane (CH$_4$), hydrogen sulphide (H$_2$S) and ammonia (NH$_3$). Recent results have shown CH$_4$ removal efficiencies (RE) averaging 50 – 65% with maximum RE of up to 80% observed. Experiments investigating removals of H$_2$S and NH$_3$ are underway with initial results focusing on biofilm growth and acclimation.

1. Introduction

Recent studies have identified numerous health and environmental problems that arise from emissions of greenhouse, toxic and odorous gases generated in wastewater treatment plants (WWTPs). New cost-effective, sustainable solutions are required to emissions such as CH$_4$, hydrogen sulphide (H$_2$S) and ammonia (NH$_3$) [1], [2]. In this study, laboratory scale horizontal flow biofilm reactors (HFBRs), a novel NUI Galway developed technology, have been constructed to examine the removal of CH$_4$, H$_2$S and NH$_3$ from waste gases.

2. Materials and Methods

The HFBR technology comprises a stack of horizontal plastic dimpled sheets across which the gas to be treated flows sequentially over. The HFBR units (Figure 1) are housed in an external temperature controlled laboratory. The temperature is controlled at 10°C, typical of on-site operating conditions.

Air and gas are mixed to simulate typical WWTP off gas concentrations. To provide sufficient substrate and moisture to the biofilm a synthetic wastewater (SWW) is also supplied to each HFBR unit. Nine laboratory scale HFBR units have been commissioned, 3 each to examine CH$_4$, H$_2$S & NH$_3$ removal. Each reactor was inoculated with microorganisms to expedite acclimation and optimise oxidation. Three of the HFBRs were seeded with a methanotrophic rich biomass. The remaining 6 units were seeded with activated sludge, which contained bacteria capable of oxidising H$_2$S and NH$_3$. CH$_4$ gas concentrations are analysed using Gas Chromatography. H$_2$S and NH$_3$ are monitored using handheld sensors. Samples of the biofilm are also analysed and microbial profiling of the system is being carried out using techniques such as Terminal Restriction Fragment Length Polymorphism (TRFLP) and Polymerase Chain Reaction (PCR).

Wastewater analysis is carried out using standard methods (APHA, 2005). This allows for precise mass balance analysis to be carried out.

3. Results

These reactors have a working volume of 20 litres (L) and a top plan surface area (TPSA) of 0.04 m$^2$. For the CH$_4$ reactors an air and CH$_4$ (1 % v/v) mixture is introduced at the top of each reactor. The empty bed residence time (EBRT) within these reactors is 50 minutes. Gas flows downwards concurrently with the applied SWW (8 L SWW/HFBR/day). The total gas flow rate to the CH$_4$ reactors is 1.2 m$^3$/m$^2$ reactor volume/hr and the CH$_4$ loading rate is 8.5 – 9.0 g CH$_4$/m$^3$ reactor volume/hr. Recent results show average CH$_4$ removals of 60 – 65% with maximum removals of 85% observed (Fig 2). The composition of the influent SWW has a significant effect on CH$_4$ removal rates. Various SWW combinations are being trialled.

The total gas flow rate to the H$_2$S and NH$_3$ reactors is 60 m$^3$/m$^2$/hr (30 m$^3$/m$^2$ TPSA/hr). The EBRT is 60 seconds. In each case the influent gas concentration is 100 ppm. The H$_2$S and NH$_3$ trials have just commenced and results are pending.

4. Conclusion

The results to date indicate that the HFBR has excellent potential to biologically treat greenhouse and noxious gases in an effective manner, reducing the carbon footprint of waste treatment facilities and making their presence more acceptable to the public. The system is extremely cost-effective requiring no mechanical moving parts and operated solely using pumps controlled by timers or simple control panels.

5. References


Evaluation of amendments to control phosphorus losses in runoff from pig slurry applications to land
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Abstract
If spread in excess of crop requirements, phosphorus (P) or nitrogen (N) losses from agriculture can lead to eutrophication of receiving waters. One way to reduce dissolved reactive phosphorous (DRP) loss from a soil surface after land application of pig slurry is to chemically amend the slurry. Batch experiments, wherein a chemical and slurry are mixed, are a good way to determine if chemical amendment is appropriate to reduce water extractable phosphorus (WEP) of slurry, but do not account for the interaction between applied slurry and soil. An agitator test, wherein an intact soil core, placed in a beaker, is overlain with continuously-stirred water, enables achievement of batch experiment results, but also simulates the situation in which slurry is applied to soil, allowed to dry, and then subjected to overland flow.

1. Introduction
The European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2010 (S.I. No. 610 of 2010), puts a limit on the amounts of livestock manure that can be applied to land. If spread in excess of crop requirements, phosphorus (P) or nitrogen (N) losses from agriculture can lead to eutrophication (Carpenter et al., 1998). According to Gburek and Sharpley (1998), P export from soil can be best managed by concentrating on P levels in hydrologically active zones, known as Variable Source Areas (VSAs), most likely to produce surface runoff. The use of chemicals or P sorbing materials (PSMs) may offer a potential solution to reduce P losses in these areas. The aim of this experiment was to identify and evaluate the most appropriate chemical amendments and PSMs to reduce DRP from land applied pig slurry.

2. Materials and Methods

2.1. Soil and slurry collection
Pig slurry from was taken from an integrated pig unit in Teagasc Research Centre, Moorepark, Fermoy, Co. Cork. Soil cores were taken from a high P-index site in Co. Galway (typical of a pig farm).

2.2. Treatment selection
Eleven different chemical amendments were trialed as part of the preliminary batch test. From this, six different chemicals were selected to be added at three different rates (low, medium and high) as part of the agitator test. Two more treatments (unamended slurry-only and grass-only) were also included. The slurry in all cases was spread at 19 kg total P (TP) ha⁻¹.

2.3 Agitator test
Prior to the start of the agitator test, the intact soil samples were cut to 45 mm and transferred into 1-L glass beakers. The slurry and amended slurry was then applied to the soil cores (t = 0 h), and left to interact for 24 h prior to the sample being saturated. At t = 24 h, the samples were gently saturated by adding deionised water to the soil over 24 h until water pooled on the surface. Immediately after saturation (t = 48 h), 500 mL of deionised water was added to the beaker. The agitator paddle was lowered to mid-depth in the water overlying the soil sample and the paddle was set to rotate at 20 rpm for 30 h to simulate overland flow. Water samples were taken throughout the 30 h of the test and tested for DRP. pH readings were taken at start and end of test.

3. Results
The most effective amendments at reducing DRP in overlying water were (in decreasing order of efficiency): alum (85%), flue gas desulphurization (FGD) by-product (73%), poly-aluminium chloride (PAC) (72%), ferric chloride (70%), flyash (56%) and lime (52%). FGD was the most costly of all treatments (€7.64/m³), whilst alum was the cheapest (€3.33/m³).

4. Conclusions
There is potential for use of chemical amendments to reduce P loss resulting from land application of pig slurry. As there are significant costs associated with the use of these amendments, it is recommended that they are used strategically in areas which are likely to have potential nutrient loss problems. As land surrounding pig farms tend to have high soil test phosphorus, the use of amendments may be deemed necessary.

5. References
Cycling Ireland to Work: Sustainable job creation through the construction of a National Cycling Network

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Abstract
A proposed National Cycle Network (NCN), connecting Ireland’s major urban centres and potentially opening up rural, recreational and commuter cycling routes, could lead to significant job creation in the construction, maintenance and tourism sectors. This study will develop a framework for the establishment of a NCN and carry out a feasibility study of one major route corridor – Galway to Clifden – investigating: (i) route selection (ii) materials and design and (iii) cost benefit analyses.

1. Introduction
Ireland is in the midst of an economic crisis; numbers directly employed in construction fell from 270,000 to 125,000 between 2007 and 2010 [1]. The tourism industry has also seen a sharp downturn with one million fewer tourists visiting in 2010 when compared to 2009 [2]. Meanwhile, cycle tourism is an established industry across Europe and it has been found that cycle tourists spend at least as much as other types of tourists [3].

On the Veloland Schweiz network in Switzerland, which is of similar length to Ireland’s proposed NCN, the initial investment of €6.3 million in the network was returned in 2-3 years [3]. In 2009, only 2% of tourists (114,000 people) cycled while staying in Ireland [3], however, in Germany and the Netherlands, this figure is above 20%. A study conducted by MORI found the main disadvantages of Ireland as a cycling destination to be infrastructural issues: dangerous roads, poor quality roads, lack of cycling network, bad signposting, unsuitable roads [4]. The construction of a NCN could create jobs in construction and maintenance and lead to the development of a significant cycle tourism industry.

In Ireland, 62% of people are overweight or obese [5]. One of the causes of this is a lack of physical activity – 86% children and 75% adults do not get the recommended amount of physical activity [6]. 1.1 million people drive to work (58%), meanwhile only 36,000 (2%) cycle [1] and 22% of Ireland’s CO₂ emissions are as a result of transport [7]. Cycling has extensive health benefits – increasing physical activity rates and outdoor exercise; and environmental benefits – reduction in motor vehicles and CO₂ emissions.

2. Route-selection
One factor impeding the development of cycle tourism in Ireland is the lack of safe, traffic-free cycle routes [3]. A combination of on- and off-road cycle tracks, possibly using existing paths along canal tow-paths and disused railway lines, e.g. the abandoned Galway-Clifden railway line could overcome these issues. In general, route selection will seek to balance the interests of commuters, tourists and leisure cyclists.

3. Materials and Design
Cycle lanes, unlike highway pavements, are not required to support large daily loads. Therefore, the pavement required can be comparably thin – 50mm surface/base course and a 200mm binder course [8]. Other factors to be considered during design include adequate drainage, the use of non-frost-susceptible material in the formation, the provision of emergency and maintenance access and the use of waste or by-product materials.

4. Conclusion
A NCN, and the Galway-Clifden corridor in particular, can have societal and economic benefits. Sustainable jobs will be created in the construction and maintenance works and a new, lucrative tourist industry will be developed. The infrastructure will also lead to extensive health and environmental benefits for local users. This study is an important step to developing guidelines to ensure sustainable and cost-effective design, development and implementation of the National Cycle Network.

Acknowledgements
The author would like to thank the National Roads Authority (NRA) and the Department of Transport Sustainable Transport Office for funding this project.

References
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

Designing a Community Engagement Strategy for Smarter Travel Limerick

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Abstract
This research encompasses a review of what is known and what has been documented about Smarter Travel to date, an investigation into how and why people in Limerick travel the way they do and a comprehensive study of exemplar Smarter Travel Cities internationally. This research has been carried out to find out how best to ensure that a plan for Smarter Travel Limerick is successful in developing a local culture of Smarter Travel, which involves the local community and delivers best practice behavioural change programmes based on experiences and lessons learnt from elsewhere.

Almost 7 out of 10 people in Limerick drove to work, school, or college in 2006. However in Groningen in the Netherlands, an average of 1.4 bicycle trips per person per day in the city were made by bicycle, making up more than 50% of the total journeys in 2008. Successful change has been implemented in particular cities in Europe, and more recently in UK and Australian cities, to reverse the effects of unsustainable travel. In Limerick 63% of residents commute a distance of 1 to 9km, this shows the potential for encouraging and achieving a Smarter Travel Limerick.

Figure 1 Limerick City Modal Split for Trips to Work (Census of Population, 2006) [1]

However, travel patterns are extremely complex phenomena and the reasons for individual travel behaviour vary significantly. Focus groups are employed to discover the reasons behind Limericks existing travel patterns. The design of a Smarter Travel program requires effective community engagement, recognising that it is essential to improve decisions and listen to and respond to community needs.

This research focuses on designing a set of interventions including physical infrastructure (also known as hard measures), to promote lasting travel behaviour change in five pilot zones in Limerick based on best international practice. Prioritising and promoting Smarter Travel in particular cycle traffic over cars plays an important role in building a reputation for Limerick City as a best practice demonstration Smarter Travel Irish City.

Figure 2 Cycling in Groningen

Being a relatively new field of study particularly in Ireland there is still much to be learned about Smarter Travel. All of the benefits are still unknown, but the benefits which have been documented cannot be ignored. Research is required to analyse how to design the optimum strategy for implementing Smarter Travel soft policy measures in terms of target groups, timing, methods etc. Research on an international scale is fully justified for determining how to maximise the synergy between hard and soft measures in designing a Smarter Travel strategy. The results on the potential travel behaviour change programmes offer are quite recent, and further research into how the potential disadvantages of induced traffic can be minimised and how travel behaviour change can be sustained is also justified.

References
Treatment of Piggery Wastewaters using Woodchip Biofilters

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Abstract

Twelve laboratory woodchip biofilters were analysed to determine their effectiveness in treating the liquid fractions of (i) raw pig manure (SR) and (ii) pig manure after anaerobic digestion (SAD). Two loading rates were examined: 5 l/m²/day (LLR) and 10 l/m²/day (HLR). Results of the study indicate that CODuf, CODf and NH₄-N removals were higher at the lower loading rate for both the SR and SAD biofilters (P < 0.05).

1. Introduction

The Nitrates Action Plan [1] has restricted the amount of land area suitable for the landspreading of pig manure. Treatment of pig manure would reduce the need for extensive landspreading. Pig manure contains high concentrations of nutrients that have the potential to cause environmental damage to receiving waters. The overall objective of this research was to investigate the use of aerobic woodchip biofilters for the treatment of (i) the separated liquid fraction of raw pig manure (SR) and (ii) the separated liquid fraction of pig manure after anaerobic digestion (SAD). Successful treatment of piggery wastewater using woodchip biofilters could reduce: (i) nutrients released into ground and surface waters, (ii) handling costs and (iii) mains water requirements on a pig farm through reuse.

2. Materials and Methods

A laboratory test apparatus containing twelve identical filters was set up. The woodchips were placed inside 225 mm diameter “corripipes” (polyethylene pipes). The filters had a wire mesh base to allow the passage of air through the filters so as to maintain an aerobic environment for the microorganisms. Lodgepole pine woodchips (0 – 30 mm) with a depth of 600 mm were used as the filter media. The logs were cut, debarked, chipped and dried to a moisture content of approximately 20 %. The liquid fraction of the raw pig slurry (SR) was obtained using a decanter centrifuge. Piggery wastewater digestate from a mesophilic anaerobic digester was separated using a belt press separator. The liquid fractions were collected and stored in a controlled temperature room at 11 °C. The SR and SAD liquids were applied to the biofilters twice daily for 350 and 390 days respectively. Two hydraulic loading rates were examined: 5 l/m²/d (LLR) and 10 l/m²/d (HLR). Each treatment was replicated three times. The effluent from the filters was tested twice weekly for suspended solids, chemical oxygen demand (COD) and nitrogen (Total N, NH₄-N, NO₃-N and NO₂-N). Tests were carried out in accordance with the Standard Methods for the Examination of Water and Wastewater [2]. Data was analyzed using repeated measures. The dependent variables were: SS, CODuf, CODf, TNuf, TNf, TON, NO₃-N, NO₂-N and NH₄-N. The fixed effects were treatment, day and filter. Day was the repeated measure.

3. Results

Table 1 shows the average percentage removals of suspended solids, chemical oxygen demand (COD), total nitrogen (TN) and ammonium nitrogen (NH₄-N) following a start-up period of 60 and 70 days for the SR and SAD biofilters, respectively.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>LLR (% removal)</th>
<th>HLR (% removal)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended Solids</td>
<td>59</td>
<td>43</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>COD unfiltered</td>
<td>64</td>
<td>47</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>COD filtered</td>
<td>63</td>
<td>51</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>TN unfiltered</td>
<td>30</td>
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<td>TN filtered</td>
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<tr>
<td>NH₄-N</td>
<td>60</td>
<td>44</td>
<td>&lt;0.05</td>
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4. Conclusions

A higher CODuf, CODf and NH₄-N removal occurred at the lower loading rate for the SR and SAD biofilters. Further analysis of the performance of on-site woodchip biofilters will aid in the development of design guidelines for a smart, efficient, low maintenance treatment system that can be adapted by the Irish pig industry.

5. Acknowledgements

The authors gratefully acknowledge funding from the Department of Agriculture and Food’s Research Stimulus Fund under the National Development Plan 2007 – 2013 (RSFP 07-543)

6. References

Assessment of the Suitability of Co-Mixed and Composted Separated Solids of Pig Manure for Use as a Solid Fuel

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Abstract

The aim of this project is to investigate the use of the solid portion of separated pig manure mixed with various bulking agents as a both a compost and a solid fuel. Composting experiments showed sawdust to be the best of the bulking agents studied. An initial carbon (C): nitrogen (N) ratio of 16:1 was used to produce stable compost using separated pig manure and sawdust. The three products of pyrolysis; biochar, bio-oil and gas are being investigated. The bio-oil and gases will be characterised as a fuel to provide the energy needs of the pyrolysis process. The biochar is being characterised as a fertiliser and soil addendum. The effects of composting of the swine manure solids before pyrolysis and the addition of C-rich bulking agents is also being investigated.

1. Introduction

Management of pig manure is becoming an expensive problem for pig farmers as new legislation to prevent environmental pollution reduces the spreadlands available. Practical and economically viable on-farm solutions for swine wastewater treatment are needed to tackle this growing problem. The aim of this research is to investigate (a) composting, (b) pyrolysis and (c) both composting and pyrolysis as methods of treating pig manure in an economically viable manner, while also providing environmental benefits. Composting stabilises organic matter, destroys pathogens, and decreases water content and odours. Pyrolysis of swine manure may reduce waste disposal costs and provide cost effective energy to be used on the farm. Pyrolysis is a process whereby a biomass feedstock is thermally degraded at high temperatures in an oxygen-free atmosphere. The products of this process are biochar, bio-oil and gases. The bio-oil and gases can be used as fuels or to provide the energy needs of the pyrolysis process. Biochar may also be used as a fuel, or as a fertiliser and soil addendum, for C sequestration and for gas scrubbing.

2. Composting Experiments

Four composting trials were undertaken using separated pig manure solids and a variety of C-rich bulking agents. Trials 1 and 2 investigated the effect of the addition of different bulking agents on the quality of compost produced. Greenwaste, sawdust, woodchip and straw were the bulking agents studied. Results showed that sawdust was the bulking agent which produced the best quality compost. Trials 3 and 4 investigated the effect of different quantities of sawdust addition. The aim was to show if a C:N ratio lower than the recommended 25-30 could be used to produce stable compost. It was found that an initial C:N ratio of 16 resulted in stable compost, thus reducing the cost of the process for farmers.

2. Characterisation of biochar

Proximate and ultimate analyses have been undertaken on feedstock and biochar from 24 different biomass mixtures. Six samples (anaerobically digested pig manure with added sawdust, both before and after composting) have been further analysed to investigate surface area, pyrolysis energy requirements and pore structure. Analysis has shown that pre-composting of biomass before pyrolysis results in decreased heating values, fixed carbon content and surface area. Product yield is also changed for pre-composted samples; biochar and bio-oil yield increases, while gas yield decreases. The addition of bulking agents to pig manure before pyrolysis results in increased heating values, fixed carbon contents and surface areas.

3. Ongoing experiments

Further studies investigating the fuel characteristics of the bio-oil and gases produced by the six feedstocks described above are ongoing. An energy balance will be conducted using experimental data from the separation, composting and pyrolysis studies. The aim is to identify the viability of an on-farm pyrolysis plant producing biochar from pig manure with the energy requirements provided by the bio-oil and gases. The impact of pre-composting will also be assessed in this energy balance. The effect of sawdust addition on the energy balance will show whether it is worthwhile for pig farmers to import sawdust onto their farm to use as a co-feedstock.

4. Future Experiments

Landspreading analyses are planned using pig manure, pig manure compost and artificial fertiliser with and without the addition of pig manure biochar under medium rainfall conditions. These analyses will quantify the nutrient leaching from the three fertilisers and also the nutrient retention capacity gained when biochar is added to soil.
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Extensions of SPARQL towards Heterogeneous Sources and Domain Annotations

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Abstract

SPARQL is the W3C Recommended query language for RDF. My current work aims at extending SPARQL in two distinct ways: (i) to allow a better integration of RDF and XML; and (ii) to define a query language for RDF extended with domain specific annotations. Transforming data between XML and RDF is a much required, but not so simple, task in the Semantic Web. The aim of (i) is to enable transparent transformations between these two representation formats, relying on a new query language called XSPARQL. On a different aspect, representing and reasoning with meta-information about RDF triples has been addressed by several proposals for representing time, trust and provenance. Building on top of Annotated RDF, we present an extension of RDF and the SPARQL language, capable of representing and querying triples with annotations.

1. XSPARQL

XML and RDF are the underlying representation and storage formats for the Semantic Web. For instance, in the Semantic Web Services domain, data represented in RDF needs to be converted to specific formats of XML (lowering) in order to be transmitted and the received data needs to be converted back to RDF (lifting). However, it is not easy to convert data between the two formats. These transformations, mainly the lowering it is not easy to convert data between the two formats. Transforming data between XML and RDF is a much required, but not so simple, task in the Semantic Web. The aim of (i) is to enable transparent transformations between these two representation formats, relying on a new query language called XSPARQL. On a different aspect, representing and reasoning with meta-information about RDF triples has been addressed by several proposals for representing time, trust and provenance. Building on top of Annotated RDF, we present an extension of RDF and the SPARQL language, capable of representing and querying triples with annotations.

2. AnQL – Annotated SPARQL

Another extension of SPARQL involves querying Annotated RDF, an extension of RDF towards domain specific annotations [4]. Some of my previous work [5], was to define an extension of Annotated RDF [6] towards supporting RDFS inferencing rules, along with the definition of the Temporal and Fuzzy annotation domains. The presented RDFS reasoning procedure which can be formulated independently of the specific annotation domain by being parameterised with operations any domain needs to provide. In order to support querying Annotated RDF, we developed an extension of the SPARQL query language towards domain specific annotations, called AnQL [4].

Annotated RDF, first presented by Udrea et al. [6], consists of extending an RDF triple (s, p, o) with an annotation, where the annotation is taken from a specific domain. For instance, in the temporal domain [7], a triple: 

```
```

has intended meaning “Nuno has worked for DERI from 2008 to 2010”, while in the fuzzy domain [8] the triple:

```
 :nuno :locatedIn room103 :0.9
```

has the intended meaning “Nuno is located in Room 103 to a degree of at least 0.9”. The annotation domain must define the elements of the annotations, a partial order between elements and operations for combining elements of the domain. Based on this, it is possible to define an extension of the RDFS rules where the inferences take into account the annotations of the triples by using these domain specific operations. Further details about our prototype implementation are available in our project webpage at http://anql.deri.org/.

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References


Enabling Federation of Government Metadata Repositories
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Abstract

Data models, taxonomies, ontologies, code lists and semantic data exchange formats are the key resources for creating interoperable data exchange. These resources exist in several national repositories that differ in scope and in target group they are addressing and they are implemented using different technologies and expose different user interfaces to the end user. However the semantic content they include can often be reused even bypass the domain they were originally designed for. Seamless data exchange has been the motivation to enable interoperability of these different repositories in order to reach a federation of repositories where users can search for resources or assets in all the available repositories using a unified user interface.

1. Introduction

Resources, such as data models and schemata, taxonomies, ontologies, code lists are the means for seamless data exchange. In the context of this work, we use the term asset to refer to these types of resources. When it comes to government data, assets exist in isolated national e-government metadata repositories that differ (i) in scope, (ii) in target group they are addressing, (iii) are implemented using different technologies and (iv) expose different user interfaces to the end user. The semantic content they include can often be reused even bypass the domain they were originally designed for. But the physical isolation of these repositories and the heterogeneity of the assets hamper the reusability of common concepts.

Hence, this research aims to (a) define a common data model to describe the assets of national e-government metadata repositories and (b) to develop a proof-of-concept prototype showcasing the added-value of federation through cross-repository asset discovery and retrieval using a single point of access.

2. Common Model Development

This section introduces the Asset Description Metadata Schema (ADMS) and discusses its implementation using linked data and Semantic Web technologies. Thus, ADMS is implemented as an RDF Schema vocabulary which includes the core elements and the attributes needed to model an asset. We reuse properties from existing linked data vocabularies (e.g. DCAT1, DCMI2) in the definition of an asset (Figure 1).

Figure 1. ADMS Model in RDF

3. Proof of concept Architecture

Figure 2 shows the proposed architecture where assets from different national e-government metadata repositories can be queried and retrieved through a single point of access (SPARQL endpoint). Value-added services, such as data mashups and faceted browsers, and third party applications can be built on top of this architecture. ADMS defines the administrative and descriptive metadata of the assets housed in the repositories. These assets can then queried and retrieved using querying API. Repositories can be connected to the federation and publish their assets’ metadata using the Publishing API and services.

Figure 2. Proof of Concept prototype

Acknowledgments. This work is a joint effort between JINIT, EC ISA, NUI Galway and the University of Macedonia. It is funded in part by Science Foundation Ireland under Grant No. SFI/08/CE/I1380 (Lion-2).

A Semantic Web Representation of a Product Range Specification in the Automotive Industry

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Abstract
Product Range Specification (PRS) in the automotive world is one of the most complex PRS that exists in industrial contexts. PRS plays therefore a key role in the information system of an automaker: related data pervades many systems, and numerous applications are using it. This is the case at Renault, where PRS is modelled as a Constraint Satisfaction Problem. In this paper, we study how to represent the objects, concepts and services related to such a PRS using Semantic Web standards. Plugging them into a Linked Data based architecture enables with new ways to access corresponding data and tools in the whole car manufacturing and selling process.

1. Introduction
In order to cut the cost of accessing data and exchanging it between systems both internally and externally, Renault, one of the world's largest automakers, is considering the use of Linked Data principles and Semantic Web technologies in its information system. Several prototypes were done in the past years [1], and the first operational application based on Linked Data at Renault was released in early 2010; enabling the vision of “Linking Enterprise Data” [2] in the company. To go one step further, Renault aims at building a Semantic Web compliant representation of the objects, concepts and services related to its Product Range Specification (PRS). In this paper, we study how to represent the objects, concepts and services related to such a PRS using Semantic Web standards.

2. Product Range Specification
PRS is used by Renault to specify all possible car configurations that an automaker can sell. It comes as a lexicon, i.e., a set of discrete variables representing the descriptive features or attributes of a vehicle (body type, engine type, gearbox type, color, etc.), together with a set of constraints that restrict the possible combinations of variable assignments. A particular vehicle is uniquely defined by a tuple of values, one and only one per variable. Constraints invalidate some of the possible car configurations to reflect industrial, engineering or marketing imperatives.

An RDF Schema vocabulary is introduced for describing the main PRS objects. This vocabulary can be used to represent both individual cars, a subset of the product range (e.g., “the set of all blue twingos with diesel fuel type”) or constraints on the possible combinations of values of the PRS variables. For example, Fig.1 shows the RDF representation of a particular car using this vocabulary. Fig.2 shows the RDF representation (in Turtle syntax) of a subset of the product range, namely all cars with manual gearbox and diesel type of fuel.

```
:myCarSet a csp:And ;
csp:and
  [csp:var :gearbox ; csp:val :Manual] ,
  [csp:var :fuel ;
```

4. Conclusion
In this paper, we studied how to represent the main objects related to Renault's Product Range Specification in a Semantic-Web compliant way. Such a representation helps bridging the gap between CSP and the Semantic-Web, and is believed to be a first step towards the reorganisation of Renault's information system around a Linked Data infrastructure, which should allow to cut down the costs of accessing data and exchanging it with the company's partners.

5. References
Curated Entities for Enterprise
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Abstract
We propose an entity consolidation system with user collaboration. First source data is converted into entity-attribute-value data model. Then system finds equivalence relationships at entity, attribute, and value levels. The confidence of relationships and data conflicts are kept as intermediate results. Users provide feedback on result iteratively. Finally corrected data with lineage and provenance information is updated in curated database of entities.

1. Introduction
The amount of data generated and stored in organizations is increasing with more automation of business processes. Often this data relates to specific entities of business interest like people, products, and customers. Users collect, integrate and standardize this data for analysis. Teams of analysts and skilled IT staff spend significant amount of time and effort to bring this all at one place.

2. Problem Statement
Integration of data from disparate sources generates uncertain results [1]. For example if an analyst integrates data about iPod from two sources, following types of uncertainty can occur for price of iPod:

- **Absence**: no price
- **Conflicts**: price is $150€ and also $160€
- **Vagueness**: price is given as High
- **Non-specificity**: price is between $150€ and $160€

3. Proposal
We propose to develop an entity consolidation system, which supports iterative cleaning of uncertain data with user feedback [2]. Figure 1 illustrates major process flow steps of our prototype.

3.1. Entity Consolidation
The process starts by converting source data in common entity-attribute-value format [3]. Followed by three associated tasks; mapping of schema attributes between sources, comparing individual entities for equivalence, and merging values of attributes for same entities.

3.2. Uncertain Data
Automated entity consolidation generates results with confidence scores for equivalence between entities. Conflicts of data values also exist between matched entities. All this information is stored in temporary database for resolution.

3.3. User Feedback
User provides feedback on uncertain data in two forms, either by validating possible choices or providing generic rules for repairs. Having people with domain expertise collaborate to improve quality of integration result adds value to overall process. This is similar to curation process of reference works and dictionaries by domain experts [4].

3.4. Provenance
Provenance information about data source, entities, and user feedback is stored for tracking lineage of data. This information serves as indicator of trust for entity database consumers, which can be further utilized to support data cleaning tasks automatically.

4. References
Continuous Query Optimization and Evaluation over Unified Linked Stream Data and Linked Open Data

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Abstract

In this poster, we present our Continuous Query Evaluation over Linked Streams (CQELS) approach which provides a scalable query processing model for unified Linked Stream Data and Linked Open Data. Scalability in CQELS is achieved by applying state-of-the-art techniques for efficient data storage and query pre-processing, combined with a new adaptive cost-based query optimization algorithm for dynamic data sources, such as sensor streams. In traditional Database Management Systems (DBMS), query optimizers use pre-computed selectivity values for the data to decide on the best execution plan, whereas with continuous query over stream data the data – and consequently its selectivity values – varies over time. This means that the optimal execution plan itself can vary throughout the execution of the query. To overcome this problem, the CQELS query optimizer retains a subset of the possible execution plans and, at query time, updates their respective costs and chooses the least expensive one for executing the query at this given point in time. We have implemented CQELS and our experimental results show that CQELS can greatly reduce query response times while scaling to a realistically high number of parallel queries.

In the past years, sensors have become ubiquitous, for instance in mobile phones (accelerometer, compass, GPS, camera, etc.), in weather observation stations (temperature, humidity, etc.), in the health care domain (heart rate, blood pressure monitors, etc.), in devices for tracking people’s and object’s locations (GPS, RFID, etc.), in buildings (energy measurement, environmental conditions, etc.), cars (engine monitoring, driver monitoring, etc.), and in the Web at large, with online communities such as Twitter and Facebook delivering (typically unstructured) real-time data on various topics (RSS or Atom feeds, etc.). The raw nature of the data produced by sensors – that is, the basic readings, without any metadata attached to it – limited the use of sensor networks to specific applications domains. Typically applications are still custom-built for specific cases and are to be classified as “information stovepipes”, i.e., integration of sensor data with other data sources is still a difficult and labour-intensive task, which currently requires a lot of “hand-crafting”.

Only recently, there have been a lot of efforts to lift sensor data to a semantic level, for example, by the W3C Semantic Sensor Network Incubator Group, Semantic Streams, Semantic System S, and Semantic sensor web. These projects make sensor data available following the Linked Data principles, a concept known as Linked Stream Data. Linked Stream Data aims at the seamless integration of sensor data with other data sources, such as found in the Linked Open Data (LOD) cloud and enabling a range of new, “real-time” applications, while also making this data accessible to the wide range of existing software. Exposing stream data according to Linked Data standards seems to be a promising way to “understand” this information through semantic enrichment. It can be easily integrated with existing data sets using established standards specifically designed for query-processing, and generally makes information accessible in a way which furthers its re-use and integration with data sets currently unthought of.

Current attempts in combining sensor and Linked Open Data suffer from scalability problems (for example, the Live Social Semantic experiment involved only 139 conference attendees), and therefore such solutions are not suitable for large-scale applications. Also, the real-time nature of data is often not covered and the generated data sets frequently are not available online but only offline through normal download specifically due to the lack of efficient query processing.

In this research, we address the problem of scalable query processing over Linked Stream Data integrated with Linked Open Data. We present our Continuous Query Evaluation over Linked Streams (CQELS) approach[1], an unifying processing model for scalable continuous query evaluation over combined Linked Stream Data and Linked Open Data. Scalability in CQELS is achieved by applying state-of-the-art techniques for efficient data storage and query preprocessing, as well as by deriving an adaptive cost-based query optimization algorithm for dynamic data sources, such as streams. Contrary to traditional query optimizers, where pre-computed selectivity values for the data are used to decide on the best execution plan, our CQELS query optimizer keeps a subset of the possible execution plans and, at query time, updates their respective costs and chooses the least expensive one for executing the query. We have implemented CQELS and show through experimental evaluation that our model achieves great performance in terms of query response time while scaling to a realistically high numbers of parallel queries.

References

Abstract
Citizen Sensing comprises the three entities of the Social, Mobile and Semantic Web and through implementing technologies from these three fields tries to extract meaning from Microposts. By harnessing, the power of services like Twitter, Semantic Web standards like SIOC, and frameworks like SMOB and then combining these with sensor/multi-sensor data from mobile devices, this work can aid in the creation of citizen-sensor-networks often where large sensor networks are not currently feasible. With these technologies, we can develop a new platform that can correlate posts that are linked through these networks by situation or event.

1. Introduction
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 around the world is posted before it can be reported on by traditional media and even by blog or blog-like services.

2. Mobile Devices
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. In relation to microblogging, at present GPS adds location to the data of the post made, but in the field of Context Awareness, researchers currently examine ways to augment devices with awareness of their situation and environment to add contextual understanding. As Gellersen et al. [2] asserts “Position is a static environment and does not capture dynamic aspects of a situation”, and this idea can be applied to most single sensor data but with multi-sensor context awareness the diverse sensor readings are combined and then with processing situational context can be derived.

3. Social Web
Twitter, a micro-blogging platform founded in 2006, which by October 2010 had roughly 175 million users and in June 2010 Twitter stated that on average 65 million posts per day were created. Twitter Annotations are additional structured metadata attached to Tweets. The annotation or metadata while structured is open to the user or developer to decide what additional information is attached to the Micropost.

4. Semantic Web
Twitter Annnotations while structured is open to the user or developer to decide what additional information is attached to the Micropost.

5. SMOB
SMOB is an open-source semantic microblogging framework built on recognised web standards technologies; it provides an open, distributed and semantic microblogging experience. SMOB aims to add semantic metadata to posts and use the power of Linked Data to ease information overload on the poster and on the subscriber/reader. SMOB is built using web standards like RDF and ontologies like SIOC and FOAF\footnote. When SIOC is extended to support sensor metadata to microposts then SMOB will automatically support it but the readings will not be usable by the poster or reader, the framework will need to be edited/rewritten to enable the data to be added to posts. SMOB is currently in re-development and the ability to add sensor data to posts will be implemented through the previously mentioned extension of the SIOC ontology.

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 events/situations accessible and to aid the information extraction process through attaching sensor/contextual data to tweets and blog/microblog posts.

8. References
Using the Web to Enhance Desktop Data

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Abstract

The Semantic Web and the Semantic Desktop provide frameworks to structure and interlink data, using similar stacks of technologies, but the integration of the resulting datasets is not straightforward. We describe a system that finds Web aliases for desktop resources and uses them to enhance the desktop information. The process is based on type and property mappings and matching the values found online with the known values from the desktop.

The Semantic Web proposes a common framework that gives meaning to the data so that it can be understood by machines, structured and interlinked better. With the emergence of Linked [Open] Data, the Semantic Web has gained momentum, and vast amounts of structured data became available online. The Semantic Desktop is the result of applying Semantic Web technologies on the desktop. It promised to bring elegant solutions to the problems of information overload and application data silos by using standard vocabularies and representation for the desktop data.

The Semantic Web and the Semantic Desktop provide solutions to interlink data in the two environments, but we have separate islands of knowledge, containing similar data, related to the same topics of interest to the user, but disconnected from each other. For instance, DBLP contains information about publications, authors and conferences. This information can be used to enhance the desktop information about a fellow researcher, or about a conference of interest. Other online data sources, like MusicBrainz and the BBC Music Project can help enhance the desktop information of the user's music collection. The challenge is to find links between these two systems and ultimately integrate them.

We describe here an approach to automatically find semantic web aliases for Semantic Desktop resources. An alias is a Semantic Web resource that represents the same real-world thing as the initial desktop resource. The type of information available about the aliases might differ between sources - e.g. for a person, the types of information include the email address and telephone number, homepage, blog URL and date of birth; for researchers, also affiliation, papers they authored and projects they are involved in. This information might not all be available from one source, but spread over multiple sources, each one containing overlapping information. Some information might only be available online, while some could only be found on the desktop.

The service we propose runs on the desktop. It uses the information available on the desktop about resources to find Web aliases for those resources. The process consists of three steps, as follows:

- **Gather local data** for the current resource on the desktop. This extends to all the values of properties of other connected resources that might be relevant.
- **Query Web sources** based on the label and type of the current resource. The Web sources can be Semantic Web search engines like Sindice, or accessible SPARQL endpoints like the one provided by DBpedia.
- **Filter the Web results** based on property matches. For this step we use a set of mappings between desktop and Web ontologies, and string matching algorithms to rank the results.

The set of vocabularies used on the desktop are different from those used on the Semantic Web, therefore we created the mappings for some of the most popular vocabularies, to reconcile the two systems. The mappings between the desktop ontologies and the vocabularies used on the Web are of two kinds: type mappings and property mappings. The type mappings say for each desktop resource type (e.g. pmo:Person) what possible types can be found online (e.g. foaf:Person, foaf:Actor, akt:Person). Property mappings specify the correspondence between desktop and Web properties of resources - e.g. nco:fullname corresponds to foaf:name. Composite properties are also handled.

We process the desktop resources for which there is a high probability of finding related information online, like people and events. For each, the result is a list of Web aliases and a score for each alias, to show how exact the match was determined to be. If the score is above a maximal threshold, the alias is saved. If the score is below a minimal threshold, the alias is discarded. For intermediary values, the user is asked to decide which alias to keep.

The system is designed to be modular, more Web sources can be plugged in at any time, and more mappings can be added.

Finding Web aliases for desktop resources helps enriching desktop data with new information from the Web, and provides a way to close the gap between the two knowledge islands.

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Engaging Citizens in the Policy-Making Process

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Abstract

The idea of a democracy implies a sharing of power and decision-making between the people. However in many of today’s representative democracies, the only decision that a citizen has to make is which politician to vote for every 3 or 4 years. For many reasons, including reducing transaction costs, increasing social inclusion or cohesion, and generating trust and social capital, governments are realising the importance of involving the public in the policy-making process [1]. Online Web 2.0 and social networking technologies are being utilised to engage people, with varying degrees of success. In this paper, I provide an overview of the barriers to adoption of current eParticipation tools, along with their potential in the context of a sociological solution.

1. Introduction

eParticipation refers to the use of ICTs, in particular the Internet and Web 2.0 technologies, in the participation process, with the implication that technology has the ability to change and transform citizen involvement in deliberation and decision-making processes [2].

2. Barriers to eParticipation

In a study carried out in [3], Governments report a number of reasons for people not wanting to participate in policy making. Over three-quarters of the respondents (78%) attributed a lack of interest in policy issues or politics as being an important factor. Just under half (48%) indicated citizens’ low levels of trust in how governments would use their input as a motivating factor. Other barriers that the community have identified include a large and diverse range of stakeholders, varying levels of technical skill, a lack of integration of eParticipation strategy into actual government organisation structures, language difficulties, privacy issues, etc. What is clear from many of these barriers is that the lack of adoption of eParticipation tools is not due to technological barriers, but with sociological or political obstacles.

3. Use of Argument Visualisation

Engaging users in the discussion and formulation of public policies, and then being able to create meaningful summaries of their contributions is a major challenge for eParticipation. Many opinions expressed on current eParticipation websites are structured in an informal, conversational format, and, as such, valid arguments, opinions, and debates are lost in the sea of forums, blogs, wikis and tweets. Utilising argument visualisation techniques, lowers the digital divide, as mind-maps, or lists of pros and cons, are all concepts that an average stakeholder would be familiar with from the real world. The WAVE Platform1 incorporates argument visualisation, Web 2.0, and social networking technologies to engage citizens in debate [4]. With over 7,000 users, the WAVE Platform has achieved moderate success.

4. Lessons Learned

Panopoulou et al. [5] carried out an extensive analysis of 40 eParticipation initiatives from 12 European countries, where they identified, among other things, the main lessons learned from current initiatives. Many of their findings concurred with the results from the WAVE project, including the necessity for a commitment by governments to support the participatory process, a simple and intuitive interface, a combination of both online and offline channels, and a thorough communication and promotion plan.

5. Inform, Consult, Empower

Building on these lessons learned, the Puzzled by Policy project2 aims to combine successful pre-existing eParticipation tools with new widget technologies to bring policymaking to the people through their existing social networking sites and mobile devices. However the technical platform is only one aspect of the solution, which will also include a thorough analysis of the policy-domain, stakeholder needs, and potential for policy-maker involvement.

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Extending BPMN 2.0 with Sensor Functions
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Abstract

The integration of business processes with sensor networks and smart devices will result in real-world aware business processes. Therefore, it is necessary to describe the physical information in the process modeling language from a functional perspective to promote the process management. More recently, Business Process Modelling Notation (BPMN) 2.0 defines the formal semantics of its elements and provides means for its extensibility. In this paper, we propose BPMN 2.0 extensions according to the ARIS architecture and Linked Data principles in order to achieve the above goal.

1. Introduction

Recent research efforts in the sensor networks and smart devices focused on making the sensors accessible in loose coupled manners in service-oriented and resource-oriented architectures [3, 5]. Both WS-* and RESTful services can be augmented with semantic descriptions and benefit from the Linked Data [1] to improve their interoperability. As sensors and smart devices become less expensive, more powerful and ubiquitous, it is not surprising to see enterprises looking into sensors and smart devices based automation. However, current approaches lack the abilities to model the device information as a part of the business functions in a business process model, and to express such information in an intuitive way for the business people. Bearing this in mind, we propose a business function model to import a sensor ontology and its instance data, associate it with the BPMN 2.0 [2] process model and make improvements in the business process management life-cycle.

2. Framework overview

As illustrated in Figure 1, we see the Business Process Management lifecycle as four phases in general: Design, Deployment, Execution and Analysis, in our approach the extended BPMN document are usually produced/annotated in the design phase. BPMN 2.0 elements provide a shallow information and in order to enable business process discovery, many BPMN 2.0 elements should be described in more details with respect to all the views of the ARIS house [4]. With such extended annotations we establish the links between the process model and the business functions, utilizing the linked data mechanism it can be further linked to the external open data, including the sensor ontology and its instance data. Such model can improve the integration of the logical process information with the real world infrastructure, and the process analyzing environments will be able to provide meaningful answers for the queries on the process models and instances with specific interests based on the automated observation and actions from the sensor networks.

3. Conclusion and future work

In this work we demonstrate our novel approach of embedding the sensor metadata into the process modeling language of BPMN 2.0, we use the RDF based business function model as a building block to establish a structured information model for the business functions, within which the concepts/data of the Semantic Sensor Network ontology can be integrated, hence we can leverage the BPMN 2.0 extension mechanism to insert links referencing from the tasks, subprocesses and groups to their functional view according to the ARIS house.

As a future work we plan to enable business process execution based on this framework. Expanding the links to other views in the ARIS house, i.e., control and data view, may also be part of our future work.

References

Preference-based Discovery of Dynamically Generated Service Offers *

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Abstract

Service discovery and selection are active research topics in Service Computing area. However, the majority of service discovery and selection approaches operate on coarse-grained service descriptions. We argue that dynamically created fine-grained service offer descriptions are far more beneficial to service consumers in contrast to coarse-grained service descriptions. We define a preference-based discovery model which operates on fine-grained search requests and dynamically generated service offers. Our search requests can express hard constraints, rich preferences, and flexible input parameters. We use a combination of utility functions and weighted rules for modeling users’ rich preferences. Our service model does not require background in logics and can be used by web developers. We apply our results to an international shipping scenario in the experiment to prove the feasibility and usefulness of our approach in a realistic scenarios. We also examine commercial potential of our approach.

1 Introduction

Service descriptions are core artefacts used in the service discovery and selection process. The quality of results relies on the quality of the provided descriptions. However, service descriptions are often underspecified and incomplete what hinders discovery process. We distinguish two types of service descriptions: coarse-grained service descriptions that represent service functionalities in terms of service category, execution effects, and types of input and outputs parameters, and fine-grained service offer descriptions that represent concrete service offers created for an individual service consumer. The majority of existing service discovery and selection approaches operate on coarse-grained service descriptions. From the point of view of service consumers, discovery of service offers is far more beneficial than discovery on the level of coarse-grained service descriptions. Only descriptions of service offers can satisfy the concrete needs of service consumers, while coarse-grained service descriptions require further, often manual examination.

2 Service Offer Discovery (SOFFD)

We define a novel discovery approach called Service Offer Discovery (SOFFD) that includes: (1) search requests which specify hard constraints and rich preferences as rules and utility functions, (2) service descriptions with rules describing relationships between service input and output parameters, (3) rule-based service interfaces for fetching service offer parameters at discovery time, and (4) discovery algorithm that utilises above mentioned search requests and service descriptions.

Over the last years we have observed a growing adoption of Linked Data principles and growth of datasets specified in RDF. Linked Data is the set of best practices for publishing and interconnecting structured data on the Web. Linked Data is published using RDF where URIs are the means for connecting and referring between various entities on the Web. Service Computing community can benefit from the Linked Data and we capitalise on the Linked Data by grounding our conceptual model in the combination of RDF and SPARQL. We use RDF as a lightweight language for describing and linking various entities, whereas we use SPARQL as a rule language. We argue that there is a strong need for lightweight RDF-based services in the Linked Open Data landscape.

For the evaluation purposes and as a running example, we use the shipping discovery scenario. In this scenario, the best choice of a shipping service depends on customer’s shipping preferences on detailed shipping service offers. We chose shipping services as they are highly configurable and their up-to-date, detailed descriptions cannot be easily provided. Service offers in our discovery approach are dynamically generated for individual service requests. We have qualitatively evaluated our approach against other service discovery approaches which tackled the same shipping discovery problems.

We demonstrate an application of proposed approach in an alpha prototype of a search engine comparing shipping rates and delivery options across several package carriers (FedEx, TNT, GLS, EcoParcel, AnPost and more). We discuss the business value of our approach, possible revenue model, existing competitors, and potential for commercialisation.

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Querying Live Linked Data

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1. Situation

A growing amount of Linked Data enables advanced data integration and decision-making applications. Typical systems operating on Linked Data collect (crawl) and preprocess (index) large amounts of data, and evaluate queries against a centralised repository. Given that crawling and indexing are time-consuming operations, the data in the centralised index may be out of date at query execution time. An idealised query answering system for Linked Data should return live answers in a reasonable amount of time, even on corpora as large as the Web. In such a live query system source selection - determining which sources contribute answers to a query - is a crucial step to avoid unnecessary fetch operations.

Most current approaches enabling query processing over RDF data are based on materialised based approaches (MAT). Centralised approaches provide excellent query response times due to extensive preprocessing carried out, but suffer from drawbacks like the freshness of the aggregated data or data providers have to give up sole sovereignty on their data. On the other end of the spectrum, distributed query processing approaches (DQP) typically assume processing power attainable at the sources themselves, which could be leveraged in parallel for query processing. Such distributed or federated approaches offer up-to-date query results, however, they cannot give strict guarantees on query performance and the response time is very slow compared to MAT approaches.

Our current research direction is based on 1) the investigation of a middle ground approach between the two extremes of MAT and DQP and propose the use of histogram-based data summaries [1] and 2) the studies of the dynamics of Linked Data sources [2], [3]. The results clearly show that a query approach which combines MAT and DQP allows a novel and powerful way to guarantee fast query response times and up-to-date answers. The remainder of this abstract highlights the next steps to enable novel ways to querying live Linked Data.

2. The System

Figure 1 depicts the proposed solution architecture which consists of three main components: 1) the query processor, 2) detecting dynamic patterns and 3) the source selection components. The system can be plugged on top of any RDF store which allows data access via the SPARQL protocol. The query processor decides during the runtime which parts of the query involve dynamic information and which parts of the query involve dynamic information and any RDF store which allows data access via the SPARQL selection component. The system can be plugged on top of processor, 2) detecting dynamic patterns and 3) the source which consists of three main components: 1) the query 2. The System enable novel ways to querying live Linked Data.

3. Dynamic Patterns

Our current research heavily focuses in detecting dynamic patterns in Linked Data sources which are then incorporated into the query processor and the source selection component (cf. “detect dynamics” in Figure 1). As a direct consequence, the next research step is to integrate the source selection component and the knowledge about dynamic patterns into the query processor to decide at runtime which parts of a query are evaluated over which sources (either local or Web sources). One of the crucial steps is to decide if we base our access decision on the knowledge about dynamic patterns or static patterns and how to represent such patterns.

4. Acknowledgement

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References

RDF On the Go: An RDF Storage and Query Processor for Mobile Devices
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Abstract
We present RDF On the Go, a full-fledged RDF storage and SPARQL query processor for mobile devices. Implemented by adapting the widely used Jena and ARQ Semantic Web Toolkit and query engine, it uses Berkeley DB for storing the RDF data, R-Trees for indexing spatial data indexing and a query processor that supports both standard and spatial queries. By storing and querying RDF data locally at the user’s mobile device, RDF On the Go contributes to improving scalability, decreasing transmission costs, and controlling access to user’s personal information. It also enables the development of a next generation of mobile applications.

1. Introduction
Mobile devices nowadays are equipped with powerful hardware and software, as well as data connectivity and sensing functionalities such as location and orientation. At the same time, the Semantic Web has been evolving and becoming the preferable choice for representing information, with its Resource Description Framework (RDF) for representing semantic data, and query languages such as SPARQL.

While currently most of the processing of semantic data is done in centralized workstations, there are many advantages in executing this processing on mobile devices: i) by distributing the computation among the large number of existing mobile devices, a great level of scalability can be achieved; ii) if the data generated locally on the mobile device such as the sensors, e-mails, calendar appointments can be queried remotely and only the final results need to be sent to another machine for further processing, the data transmission costs can be dramatically reduced; iii) the local processing of user generated data also contributes to the privacy matter, since raw data no longer need to be shared in order to be analysed.

Having such RDF processing capability on the mobile device also enables a new range of applications such as integrating personal information with the Linked data cloud, Semantic Mobile Augmented Reality and Mobile Semantic Context-based applications.

Although the processing power is on the rise in mobile devices, it is still far behind workstations, and current implementations of RDF storage and query processors for standard computers can not be directly ported to mobile devices, where these resources are still constrained.

While most of the available semantic based mobile applications have to ship their queries to a remote SPARQL Endpoint, some applications, such as micro-Jena, Androjena and i-MoCo, do store and query RDF data locally. However, they are tailored to specific application scenarios and offer only limited features.

RDF On the Go is the first application to offer a full-fledged RDF storage and SPARQL query processor. It adapts the widely used Jena and ARQ Semantic Web Toolkit and query engine to the constrained mobile device’s environment. The RDF data is stored in the B-Trees provided by the lightweight version of the Berkeley DB for mobile devices. Indexes are created for faster data access, where R-trees are used for spatial data indexing, and our lightweight query processor supports standard and spatial SPARQL queries.

2. Implementation details
For storage of the data, RDF on The Go uses a lightweight version of the Berkeley DB that is suitable for mobile devices, which provides a B-Tree implementation for accessing the RDF graphs. For each RDF node, the system employs dictionary encoding [2,3] where node values are mapped to integer identifiers. This reduces the space required to store each RDF node, since the encoded version of the nodes are considerably smaller than the original ones. Moreover, dictionary encoding also allows faster processing, since integer comparisons are cheaper. Fast lookups are achieved in a two-step approach: first, each triple node is stored in multiple ways with different orderings of the triple elements, simi- lar to [1,5]. Then indexes are built for every ordering of the triple pattern, as proposed in [4]. To support spatial data, we also use R-Trees indexes for storing URIs that have spatial properties. These indexes will output the bindings for spatial graph patterns which are pipelined to the query execution plan.

Currently we support all standard SPARQL operators except aggregation and sorting operators, and the following three spatial operators: “nearby”, “within” and “intersect”.

8. References
Generic Provenance Management for Linked Dataspaces
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Abstract
The emergence of Linked Data accelerates the demand for mechanisms which can support users in the assessment of data quality and trustworthiness on the Web. In this process, the ability to track the historical trail behind information resources on the Web plays a fundamental role in the Linked Data Web. Applications consuming or generating Linked Data on the Web need to become provenance-aware, i.e., being able to capture and consume provenance descriptors associated with the data. This brings provenance as a key requirement for a wide spectrum of applications. This work focuses on the creation of this infrastructure, describing a generic provenance management framework for the Web using Semantic Web tools and standards to address the core challenges of provenance management on the Web.

1. Introduction
The advent of Linked Data in the last years as the de-facto standard to publish data on the Web, and its uptake by early adopters, defines a clear trend towards a Web where users will be able to easily aggregate, consume and republish data. With Linked Data, Web information can be repurposed with a new level of granularity and scale. In this scenario, tracking the historical trail behind an information artifact plays a fundamental role for data consumers, allowing users to determine the suitability and quality of a piece of information.

To provide the additional provenance data, Linked Data applications will demand mechanisms to track and manage provenance information. This new common requirement is inherent to the level of data integration provided by Linked Data and it is not found in most systems consuming information from “data silos”, where the relationship among data sources and applications is, in general, more rigid. This work focuses on the provision of a provenance management infrastructure having as a motivation supporting Linked Data applications.

2. Description of the Approach
The central goal behind this work is to provide a set of core functionalities that enable users to develop provenance-aware applications, both from the consumption (discovery/query/access) and from the capture (logging/publishing) perspectives. The architecture of the proposed approach maximizes the encapsulation of provenance capture and consumption functionalities, separating provenance into a distinct layer.

Two strong requirements in the construction of the framework are the minimization of efforts in software adaptations (changes in the original system to make a system provenance-aware) and the provision of a expressive provenance model. To satisfy the requirements above, the proposed approach employed the following strategies:

- Provenance capture by software reflection and annotation.
- An Expressive and accessible API for provenance queries.
- Use of Semantic Web standards & tools.

The final solution includes a provenance management framework [1] (Prov4J) and a provenance ontology (W3P) [2]. Further details on both artifacts can be found in [1] and [2].

3. Evaluation
The framework was evaluated using a provenance dataset which was generated using aggregated business news and opinions collected from data sources on the Web. These data elements defined the ground artifacts which were further curated and analyzed in a financial analysis workflow simulator. Based on the generated provenance workflow, a provenance query set was created, covering 51 types of provenance queries. The framework was evaluated in terms of query expressivity and completeness, query execution time and coverage of the W3C Provenance Incubator group requirements for mapping Provenance on the Web [3].

The framework achieved high query expressivity (80% of the queries were addressed), with an average query execution time of 250 ms. The approach also presented a medium coverage in relation to the W3C Provenance Incubator group requirements.

References
Policy Modeling meets Linked Open Data
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Abstract
Policy modeling is a complex process that requires data to be collected and evaluated. At the moment, vast amounts of open data are published on the Web ranging from Social Media data to Government data. In addition, Semantic Web technologies and the linked data paradigm allow for easy re-use and integration of data from different sources. The use of linked open data will enhance policy modeling by allowing policy makers to sense societal needs, understand public opinion and predict public reactions and enabling citizens to contribute in an agnostic manner.

1. Introduction
Policy modeling is a complex and multidimensional process that deals with designing, formulating, implementing and evaluating new public policies. It requires data to be collected and evaluated in order to be able not only to formulate the policy but also to forecast the impact that this policy will have on the society and plan for corrective actions. This data may vary from prior values of economic variables to information regarding decisions taken and the impacts that these had on society. However, the lack of transparency in the way this data is selected and used is often considered a problem that could undermine the legitimacy of the policy making process. In addition to that, the fact that society has only limited participation in the policy modeling process, gives rise to the argument that political decisions are still taken by closed groups of people without actually listening to the real needs of society.

At the moment, vast amounts of data are being published on the Web using formats that enable re-use and policies that enable free access. This Web open data includes data disseminated through Social Media platforms such as Twitter and Facebook and Open Government Data (OGD) initiatives.

2. Microblog Data
Microblogging services are Web applications that enable the dissemination of short messages (microblog posts). The most popular is Twitter, which by early 2011 distributes more than 100 million tweets per day while is one of the most popular sites on the Web.

The last two years a number of works have been published on the collection and analysis of microblog data for understanding complex phenomena and predicting relevant trends. In particular, microblog data (coming mainly from tweets) have been successfully used to: forecast box office revenues for movies; spatiotemporally detect earthquakes and typhoons in real-time; predict election results; predict stock markets; analyze consumers reactions to specific brands; analyze and predict the belief that swine flu virus would become a pandemic; predict Oscar award winners; and predict changes in topics and identify key players and topics of discussion in live media events.

Microblog data is an important primary material for policy modeling that will (i) allow policy makers to sense societal needs, understand public opinion and predict public reactions; and (ii) enable citizens to contribute in an agnostic manner.

3. Open Government Data
OGD refers to making public sector information freely available in open formats and ways that enable public access and facilitate exploitation. Lately, a large number of OGD initiatives launched worldwide aiming to implement one-stop portals acting as single points of access to governmental data. These OGD portals mainly provide objective data including statistics, reports, geo-spatial information, every day incidents reports etc. in order to enhance transparency, enable economic growth, improve citizens’ every day life and support public administration’s function.

4. Semantic Web
The semantic annotation of microblog data has been recently introduced in the literature as a means to (a) alleviate the information overload problem created by the large quantities of new posts, (b) effectively query relevant data, (c) facilitate reuse across different microblogging services and (d) enable the mapping of tweets to other data. All these approach use linked data paradigm to realize their solutions. The central idea of linked data is to extend the Web with a data commons by creating typed links between data from different sources.

5. Proposed Solution
Citizens opinions expressed through microblogging services combined with objective data published by governments could create a solid base on top of which policy modeling services will be developed. The Semantic Web technologies will be the glue to join together the different datasets.

These policy modeling services will facilitate policy makers in the different stages of the policy modeling life cycle. These services could aim at societal problems identification, trends identification on specific policy areas, evaluation of specific proposed solutions or actions and timely detection of public reactions.

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E-Brainstorming in Support of Innovation Processes

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The aim of the project is to support Innovation processes with Social and Semantic Web technologies. To achieve this goal we discuss (i) the design of the brainstorming ontology and (ii) the implementation of semantics into real-time online text editors to perform E-brainstorming tasks for network Innovation processes based on Semantic Web technologies.

1. Motivations

Organisations are introducing Innovation aspects as part of their business processes. Innovation is understood as a consistent process where participants contribute their ideas to improve products, services, etc. New Innovation models are also understood as network Innovation models where they take advantage of applications and Web technologies.

A way to achieve Innovation is by fostering participation and collaboration among users. The proposed Innovation process [1] is based on 3 phases, idea generation, idea analysis and idea rating.

This research focuses on the first phase, idea generation, and brainstorming (BS) sessions are a good practice for this purpose. However, these activities can lead into difficulties when trying to gather and organise all ideas, track them or obtain conclusions based on participants and their contributions. We are aiming to make this task easier by structuring BS sessions with Semantic Web technologies.

Hence, we propose an approach of using electronic brainstorming (E-Brainstorming) [2] sessions. To perform this task we suggest using real-time text editors based on Semantic Web technology. Our project offers a real-time text editor based on brainstorm ontology to represent the information in RDF (Resource Description Language) and make it possible to query ideas and contribute in different BS sessions with related ideas.

2. Modelling brainstorm ontology

Brainstorm ontology offers a vocabulary for the idea generation domain and makes it possible for machines to interpret the generated information within this domain. The proposed ontology reuses existing social ontologies such as FOAF3 (Friend of a Friend), that describes connections between people in social Web sites, SIOC2 (Semantically-Interlinked Online Communities) that deals with online communities’ information or SKOS3 (Simple Knowledge Organisation System), which expresses knowledge organisation systems. In addition, we also import the Review4 and Tags5 ontologies. Reusing ontologies is a useful method to make it easier for systems to interact with other applications.

Brainstorm ontology links people, ideas and reviews done on these ones. On the one hand we combine FOAF’s human’s social network information and SIOC’s online communities’ information to obtain participant’s social network information. On the other hand we use SKOS to map BS as a SKOS Collection and Ideas as SKOS concepts, which are described as members of the collection. Review ontology expresses reviews and ratings, and combing it with FOAF information we obtain knowledge about participant’s interests on Ideas. Moreover, tagging action is also represented in the ontology by the Tag ontology that connects the person, the tagged idea and the tag definition.

3. Semantic Web real-time brainstorming

While BS sessions are team-based techniques carried out with physical presence, E-brainstorming offers the possibility to celebrate these sessions in a distributed and parallel way without any production blocking.

Gobby6 is a free collaborative text editor that runs in multiple operative systems. A Gobby server centralises all documents created in a same BS session and makes it possible for participants to collaborate on them simultaneously. Different colours are used to highlight each person’s contributions.

These files are then translated into RDF annotations obtaining structured information mapped by our brainstorm ontology. Enabling data access services the system will be able to query other BS and permit idea exchange enforcing user’s initial ideas.

To conclude, this project aims to generate a Semantic Web real-time text editor based on the proposed brainstorm ontology to perform BS sessions. It will offer an E-Brainstorm system for idea generation phases within organisations’ Innovation processes.

8. References

A Contextualized Perspective for Linked Sensor Data

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Abstract
With the advent of new sensing device and recent advances in the wireless sensor network technology, augmented reality application started to spread. However sensor networks still have a lot of problem that need to be addressed i.e. automatic identification and mining of live stream data, integration of data coming from different networks. Linked Data is a way to represent data as semantically annotated (and, then, machine understandable) data, meaningfully linked with external information. The Linking Open Data (LOD) cloud is an ensemble of all the datasets that are publicly accessible and whose data are represented as linked data. Linked Data and the LOD cloud might be useful to overcome some of the currently existing sensor network issues. They can facilitate the integration of sensor data generated from different networks as well as their retrieval and mining.

1. Introduction
Currently, basic aspects of sensor networks can be represented using concepts from existing sensor ontologies. Yet, there are still opportunities to enhance the representation of sensor data and to improve sensor discovery. We propose means to improve context-awareness of sensor networks, by applying a human cognitiveness emulation approach. To do so, we extend and align various ontologies, providing means to better define a sensor’s context using Semantic Web technologies and propose a system to mine it taking advantage of the LOD cloud as a knowledge base.

2. A contextualize cognitive perspective
One goal of sensors is to extend human awareness about reality. Hence, a way to satisfy human expectations about sensor data representation and filtering is to emulate the human way of representing and filtering this data. Humans can understand an event better when it can be associated with a similar past experience stored in memory. We try to use the same mechanism to let a sensor understand an event. This will improve/enable its understanding of what is happening around it (reality) and of what it is actually sensing (self-awareness).

Technologically, sensors can emulate these human cognitive and associative mechanism by searching for similar events from the past, using the Linking Open Data (LOD) cloud. As opposed to the human memory, the “memory” of the LOD cloud is virtually unlimited and a sensor acting like a human would be potentially able to understand what is hidden behind raw data, better than humans could do. This view provides the dual approach to the human acting like a sensor as proposed by [1] and further investigated by [2].

3. Design choices
To start achieving our goal, we are proposing an ontology to support a proper exposition of sensor self-awareness information. The ontology combines a domain-agnostic ontology to describe sensor-related concepts: W3C Semantic Sensor Network ontology; an ontology to describe events and their relations; an upper level ontology.

Thanks to the above concepts, whenever it becomes necessary to automatically understand the kind of data collected by a sensor, we believe that it would be possible to query the LOD cloud by searching for sensor data that is already topic-tagged and similar to ours with respect to not only the raw sensor data features, i.e., time-stamp intervals, real quantities intervals, etc., but also in respect to the sensor projects topics. For example, the probability of the two sensor data sets belonging to the same application domain could also be increased or decreased according to how often that application domain is related to that particular sensor type, i.e., water analyzer), while it obviously has to be justified by experiments, that we will conduct in the future.

4. Conclusions and Future Work
As a first step, we focused on the alignment of and some extensions to existing sensor ontologies to model this cognitive aspect of sensors. Future work will be on validating our ontology modeling choices by experiments. In addition, we plan to build a platform which enables the detection of sensor context and expose it (as well as the sensor data itself) as Linked Open Data. Finally, we aim at integrating users in the process, to collect feedback regarding the accuracy of sensor data recognition. That way, humans will act as a means to support sensor data discovery.

5. References
A Privacy Preference Framework for the Social Semantic Web
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Abstract
In this brief article we present a Privacy Preference Ontology (PPO) that enables users to define privacy preferences for RDF data. Moreover, we also present a Privacy Preference Manager (PPM) that enables users to define privacy preferences using the PPO that grants or denies other users requesting user profile information. The PPM demonstrates how privacy preferences can be created for the Social Semantic Web.

1. Introduction
Many Social Web applications are being developed to allow collaboration and sharing of information with one another on the Web. The Semantic Web community suggests to structure data published on the Web using RDF [1]. Vocabularies such as the Friend-of-a-Friend (FOAF) vocabulary aid to define terms in RDF data to describe what the data is about.

Although the Semantic Web has added value to the Social Web, privacy still remains a concern for most Web users. Current Social Web applications provide system default privacy settings whereby users specify either to allow or deny access to their personal information to all or a group of friends in their social graph. However, users require defining more complex privacy settings to restrict specific information that may be accessed by particular friends. Therefore we created a Privacy Preference Ontology (PPO) [2] that contains a vocabulary, which allows users to define fine-grained privacy preferences to RDF data. In order to demonstrate the use of the PPO, we are currently developing a Privacy Preference Manager (PPM) that enables users to create privacy preferences, which allow or deny access to other users requesting information.

2. Privacy Preference Ontology (PPO)
The Privacy Preference Ontology (PPO) describes privacy preferences that can restrict access to information represented as RDF Data. The vocabulary provides the ability to restrict access to: (1) a particular statement; or (2) to a group of statements (i.e. an RDF graph); or (3) to a resource, either as a subject or an object of a particular statement.

Access is restricted according to patterns which users (that want to access data) must satisfy, for instance having a particular interest or being a member of a group. We rely on the Web Access Control (WAC) vocabulary to describe the access privilege to the data:

```
1 FOAF: a vocabulary to describe user profile information - http://www.foaf-project.org
2 WAC - http://www.w3.org/ns/auth/acl
```

either Read, Write or both. Therefore, a privacy preference contains properties defining: (1) which resource, statement or graph to restrict access; (2) the type of restriction; (3) the access control type; and (4) a SPARQL query containing a graph pattern representing what must be satisfied by the user requesting information.

3. Privacy Preference Manager (PPM)
One way to use the PPO ontology is to define a personal Privacy Preference Manager (PPM), providing users with means to specify preferences based on their FOAF profile. The PPM can then be used to grant privileges to requesters that want to access the user's information. Figure 1 illustrates the related concept: (1) a requester authenticates to the other user’s PPM using the WebID protocol [3]; (2) the privacy preferences are queried to identify which preference applies; (3) the preferences are matched according to the requester's profile to test what the requester can access; (4) the requested information (in this case, FOAF data) is retrieved based on what can be accessed; and (5) the requester is provided with the data she/he can access.

This privacy manager will not be limited to only data described in FOAF, but to any RDF data since PPO is ontology-agnostic. For instance, it can be used to restrict microblog posts described using SIOC and other ontologies used in SMOB [4].

8. References
Improving discovery in Life Sciences and Health Care with Semantic Web Technologies and Linked Data

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Abstract

One of the most enticing outcomes of biological exploration for the quantitative-minded researcher is to identify the “mathematics of biology” through the study of the patterns and interrelatedness of biological entities. To move forward in that direction, many pieces need to be set in place, from the availability of biological data in forms that can be computationally manipulated to the automated discovery of patterns that would derive from integration of data in many and diverse endpoints. A computational system where researchers could securely deposit any type of data and have it immediately analyzed, traversed, annotated and merged with data deposited elsewhere is a dream not yet achieved but one which could revolutionize scientific discovery and, ultimately, help cure disease.

1. Introduction

“Science is organized knowledge”, said Immanuel Kant. Science in the Information Age has indeed been characterized by increasingly complex approaches to the organization and sharing of scientific knowledge to improve its discovery. A critical bottleneck in applying knowledge engineering to inform and improve biomedical discovery is the ability to align experimental data acquisition with knowledge representation models. Recent technological advances in genomics, proteomics and other ‘omics’ sciences, have flooded microbiology labs with unprecedented amounts of experimental data and were at the heart of a paradigm shift for researchers interested in its computational representation and analysis.

2. Knowledge Continuum for Life Sciences

The deluge of data in biology marked the beginning of the “industrialization of data production in Life Sciences beyond a craft-based cottage industry” [1]. The successful exploit of this new wave of data acquisition technologies created the need for multiple, overlapping, sub-disciplines of biology to cope with the increasing complexity of biological results. However, this became an obstacle to discovery because the answers to biological problems often span multiple domain boundaries and rely on the existence of knowledge continuums. Starting to address these challenges requires agreement on optimal strategies for publishing experimental biomedical data in interoperable formats even before they are made available to the community through peer-reviewed publication.

3. Architecture

The work presented here corresponds to the identification of the key requirements for supporting publication of experimental biomedical results in the Web of Data. With that purpose, the prototypical application S3DB (Simple Sloppy Semantic Database) was developed to fit the requirements of a Linked Data Knowledge Organization System (KOS) for the Life Sciences [3]. Reflecting our data-driven approach, the technological requirements and advancements in the S3DB prototype were iteratively devised through direct interaction and validation by biomedical domain experts, who interact with S3DB using graphical user interfaces (GUI). Application developers access and consume data in S3DB through a SPARQL application programming interface (API) whereas the interaction between multiple S3DB systems is ensured through a domain specific language, S3QL, which operates on S3DB’s indexing schema.

4. References

Abstract

This abstract introduces EEYORE web service. EEYORE is designed to help researchers exploring their domain’s scientific publications by extracting key technical concepts and relations between them from an arbitrary set of input publications. The proposed system uses linguistic analysis and Machine learning techniques to perform its task.

1. Introduction

There is a renewed interest in developing systems for exploring scientific publications. In this abstract we introduce EEYORE. EEYORE is based on generic linguistic analysis tools and machine learning techniques and extracts key technical terms and relation between them from an arbitrary input set of documents. In the proposed scenario, a researcher uploads a set of publications into the system and provides the system with a few examples of the topic of his/her own interest. EEYORE then analyzes the input set of publications and provides facts about technical terms similar to the ones provided by the user.

2. Methodology

The proposed research is built upon two major technologies: generic human language technology [1] and machine learning techniques [2]. Detailed steps to fulfill the task are as follows:

1. Text Extraction and Segmentation: In this process step, scientific publications in digital format such as PDF are converted to linguistically well defined units. In other words, the input PDF files will be converted to sections, paragraphs, sentences and words.

2. Linguistic Analysis: The system then linguistically analyzes the input publications. The analysis includes part of speech tagging [3] i.e. the process of marking up the words in a text as corresponding to a particular part of speech, based on both its definition, as well as its context, and dependency parsing [4] i.e. a form of syntactic parsing and denotes grammatical relations between words in a sentence.

3. Machine Learning based Classifiers: The generated information in the previous steps of the analysis, in addition to the user provided examples/information then will be used for developing machine learning based classifiers namely a classifier for concept identification and a classifier for relation discovery.

4. Applying Classifiers to the provided set of publications: In this step, the system will employ the classifiers to extract new concepts and relations from the user provided publications. In addition, the system may use user feedback to refine its model and to adapt itself to user information needs.

3. References

The Semantic Public Service Portal (S-PSP)
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Abstract
Governments have created online portals to enable citizens to find out about and utilise specific public services. While this is positive, most portals fail to engage citizens because they do not manage to hide the complexity of public services from users. Many also fail to address the specific needs of users, providing instead only information about the most general use-case. In this paper we present the Semantic Public Service Portal (S-PSP), which structures and stores detailed public-services semantically, so that they may be presented to citizens on-demand in a relevant, yet uncomplicated, manner.

1. Introduction
In order to effectively use a public service, citizens must identify which public services address their needs and find answers to questions regarding these services, e.g. “am I eligible for this service” or “which public agency provides the service”. Public services have complex structures and may be specialized into a variety of service versions. For example the issuing of a driving license public service, may have alternative versions if this is the first license of the applicant or if the applicant is over 60. It is therefore not enough for citizens to identify a public service in general, but they must also go one step further and identify the specific service version for which they are eligible. However, traditional governmental portals still follow a one-size-fits-all approach. Thus they cannot react differently and tailor the offered public services to the profile of each individual citizen. Moreover, the citizen has to figure out on their own whether they are eligible for the service by reading lengthy public service descriptions (which often include legal terminology).

To address these challenges, this paper introduces the Semantic Public Service Portal (S-PSP) [1], which:
• Informs citizens whether they are eligible for a specific public service;
• Personalizes the public service information according to the profile of the citizen and identify the specific public service version;
• Provides complete and well-structured information for the public service; and
• Allows citizens to invoke public services that are available online (if a service execution environment is in place).

2. Semantics in S-PSP
S-PSP structures and stores detailed semantic public service descriptions. It employs an ontology-based approach to enable automated and logical decision-making that takes place in the application layer of the portal, while the user remains unaware of its complexities. The different kinds of ontologies that are utilised by the S-PSP are: Service Tree Ontology (STO); Public Service Ontology; User Profile Ontology; and other domain-specific ontologies.

The core component of S-PSP is the Query Mechanism (QM) as it identifies the questions to include in the public-service dialogue, by traversing the corresponding STO. It takes the appropriate question from the STO and forwards it to the user interface so that the question can be displayed to the citizen. During the traversal of the STO, the public service that the citizen has selected is being personalized according to their answers (Figure 1). This is achieved by resolving the generic service type into the appropriate service version. It is important to note that at each stage of the traversal, the next step option is unique. Upon termination of the traversal, S-PSP portal has collected all the necessary information for identifying the specific public service version that matches the citizen’s profile and for deciding on their eligibility. This information is finally presented to the citizen in a structured and easy to understand form.

S-PSP is deployed in four EU countries (France, Greece, Latvia and Spain) as part of the Rural Inclusion platform (http://vmsgov03.deri.ie:8080/rural-inc/services?pilot=gr&pageLanguage=en).

Figure 1. The S-PSP dialogue

3. References

Acknowledgments. This work has been funded in part by Science Foundation Ireland under Grant No. SFI/08/CE/11380 (Lion-2) and the EU under Grant No. CIP-ICT PSP-2008-2/238900 (Rural Inclusion).
1. Introduction

Specialized domains often use shared vocabularies to agree on terminology and semantics of the models used in the community. However most of the information and knowledge in these domains is usually available as unstructured plain text in form of natural language. Here the vocabularies can be used in a semantically guided information extraction process to automatically create structured content. This is known as Ontology-based information extraction (OBIE) where the ontology is the vocabulary. A crucial problem of these domains is their shallow linguistic, terminological and semantic (STL) modeling which makes it difficult to match them to natural language text objects.

2. Classification with STL Lexicon Objects

To carry out the OBIE task in STL fashion we propose a two way approach. In a first step we generate an STL ontology-lexicon, in the Semantic Web compliant lemon (Lexicon Model for Ontologies) format, from the original domain vocabulary as described in [1], [2] using an extended version of the Lemon Generator. This provides us with a set of rich lexicon objects that represent the S, T and L context of the vocabulary terms. In a second step we then use its STL features to train a classifier for sentence classification [3].

3. Financial Reporting Domain

In this work we focus on vocabularies in the accounting domain, i.e. GAAP (General Accepted Accounting Principles) taxonomies that are used to create and interpret financial reports in the machine processable XBRL (eXtended Business Reporting Language) format. In order to apply STL enrichment we first convert these vocabularies in the Semantic Web RDF ontology format. In particular we are considering the two vocabularies:

<table>
<thead>
<tr>
<th>vocabulary</th>
<th>Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>IFRS (International Finance Reporting Standard)</td>
<td>2768</td>
</tr>
<tr>
<td>xEBR (European Business Registers)</td>
<td>147</td>
</tr>
</tbody>
</table>

A typical IFRS accounting term is:

Decrease Through Classified As Held For Sale Land And Buildings

Applying the STL enrichment adds additional semantic, terminological and linguistic structure in form of annotations to the example term:

<table>
<thead>
<tr>
<th>level</th>
<th>annotation</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1: taxonomic context</td>
<td>S11 ifrs:LandAndBuildings</td>
</tr>
<tr>
<td></td>
<td>S12 is-a dbpedia:Asset</td>
</tr>
<tr>
<td>T1: sub-term</td>
<td>T11 ifrs:LandAndBuildings</td>
</tr>
<tr>
<td></td>
<td>T12 term variation = properties</td>
</tr>
<tr>
<td>L1 tokenization &amp; stemming</td>
<td>L11 decrease/Preposition</td>
</tr>
<tr>
<td></td>
<td>L12 classified/Verb_pastTense</td>
</tr>
<tr>
<td></td>
<td>L13 as/Preposition</td>
</tr>
<tr>
<td></td>
<td>L14 held/Verb_present</td>
</tr>
<tr>
<td>L2: subcat frame</td>
<td>L2 “hold for sale”/Verb_Phrase</td>
</tr>
</tbody>
</table>

Given such an STL enriched representation of the vocabulary term we could then select features to classify the following sentence:

This [decrease] L11 was due to lower gains realized on the sale of foreclosed [assets] S12 [held for sale] L2.

4. Future work

For the future we plan to evaluate this approach on a corpus of financial reports of wind energy companies (UNLP Wind Energy Corpus) which contains concepts from IFRS and xEBR vocabularies. We also plan to extend our approach along the cross-lingual dimension towards Cross-lingual Ontology-based Information Extraction (CLOBIE) facilitating multilingual vocabularies.

References

[1] Wunner, T., Buitelaar, P., O’Riain, S., Semantic, Terminological and Linguistic Interpretation of XBRL. In Proceedings of the Workshop on Reuse and Adaptation of Ontologies and Terminologies at the 17th International Conference on Knowledge Engineering and Knowledge Management (EKAW), Lisbon


1 http://www.monnet-project.eu/lemon
2 http://monnetproject.deri.ie/Lemon-Editor
3 http://www.ifrs.org
Personalized Content Delivery on Mobile Phones
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Abstract
Mobile phones have become one of the largest used media today. They can act as a single source of large amount of information about the user. Also, the current capabilities of the phone in terms of sensors present, applications supported make them very exciting platform for personalized digital content delivery. We are currently researching on the representation of the content, information retrieval for personalizing the content and delivery mechanisms of the content.

1. Introduction
The mobile phones have sophisticated hardware components such as camera, sensors available on them. Also, the users heavily use applications like email, social networks, blogs etc on the phones. Phones also act as unique platform to communicate with other people through calls, messages.

These make the phone a unique source of lot of data about the user of the phone. The data that is explicitly generated by the user using the applications on the phone can be utilized to analyse the characteristics of the user and the preferences he/she has. The data from the sensors can be used to infer about the activities and the environment of the user, the geo location of the user. These data can be combined together to infer about the context of the user at any time. The context of the user thus inferred can be utilized to deliver content that is personalized for the user. The content can be advertisements, friend suggestions, activity suggestions etc. The content can be delivered on various platforms supporting virtual reality, augmented reality etc.

2. Current Research
The current research includes extensive study of data on social networks, sensor data on the phone, information retrieval from these data, representation of the content to be delivered on the phone, the location based services possible based on the information retrieved.

Smart Phones with sophisticated set of sensors enable the user to interact with the real world. The Mobile Augmented Reality, which is an emerging field addresses this issue and requires standardization. It’s a content delivery and interaction mechanism on the mobile phone. We have worked on the representation of the digital content as Linked Data analyzing the advantages and disadvantages of it in [1] and [2]. We have also emphasized the advantages of representing content as Linked Data so that sophisticated queries from the user can be answered.

In [1], we have proposed that using Linked Data principles can be beneficial for personalization of Points of Interests (POIs). We have worked on generating presence information in Linked Data format using the QR codes [3]. This shows the usage of Marker Based Systems for explicit information generation from mobile phones. In this, we have also shown how accurate localization of the mobile phone users can be achieved.

We are currently working on suggesting friends on mobile phones based on the personal preferences set on social networks by the users and the geo-location of the users.

3. References


Empirically Grounded Linked Knowledge

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1. INTRODUCTION

The vast realms of the Web encompass a substantial portion of the human knowledge nowadays. However, the particular pieces of the knowledge are interleaved with a lot of noise and scattered among many information resources of various relevance. Thus it is often difficult or even infeasible to get what one needs to know from the ballast of largely irrelevant content. Our goal is to contribute to giving more meaning to the content on the Web, identifying and interlinking relevant knowledge out there so that machines can help humans to make use of it more efficiently. We are particularly interested in giving a clear empirical grounding to the symbolic meaning being extracted from or asserted on the Web. To do so, we have investigated a generalised extension of the distributional semantics principles (a sub-field of computational linguistics). This is to allow for identification of general, reliable patterns and links among the loosely structured, heterogeneous and noisy (Semantic) Web data, and enable meaningful symbolic reasoning with such relevant content.

2. SOLUTION

Our approach is partly motivated by the recently devised method of universal distributional representation and analysis of natural language corpora [1]. We generalise and extend the tensor-based representation of weighed co-occurrence relations between natural language expressions proposed in [1] to reflect the domain of Linked Data and knowledge on the Semantic Web. Moreover, we provide novel methods of smooth combination of the distributional and symbolic semantic levels in order to allow for automated formal reasoning about the empirically grounded knowledge emerging from the Web.

As of now, we have delivered EUREEKA [2] and CORAAL [3] – two prototypes presenting particular implementations of the general theoretical principles of our approach. EUREEKA is a software library for extraction, representation, integration and processing of emergent knowledge. Currently it focuses mainly on knowledge acquired from natural language texts and existing ontologies. It implements a specific multi-context perspective of the basic corpus data, where uncertain binary relations may further be specified by an arbitrary number of additional context arguments (explicitly attached provenance, time, space, etc.). It deals with a single sub-perspective of entities and their corresponding relationships, employing selective distance-based similarities for the execution of queries, evaluation of inference rules and simple analogical reasoning. The entities are ranked by means of a generalised IR approach and the ranking values serve for a basic implementation of anytime versions of the reasoning and querying algorithms. See [2] for more details.

The EUREEKA library can be downloaded at http://pypi.python.org/pypi/eureeka/0.1.

On the top of EUREEKA, we delivered CORAAL [3], an intelligent publication search engine deployed primarily in the life sciences domain. In a nutshell, CORAAL is able to extract knowledge in the form of argument-link-argument statements associated with a positive or negative certainty value and publication provenance information (i.e., which publications were used for extraction and/or inference of the statements). The extracted knowledge can be automatically integrated with existing domain resources (such as machine-readable life science thesauri) and augmented or refined by means of the EUREEKA reasoning services. The content of the CORAAL knowledge base is served to users via a search interface that allows for complex statement queries in addition to classical full-text capabilities. The search results can be browsed and filtered along multiple facets, which enables the users to quickly pinpoint the knowledge (i.e., statements) that interests them, as well as the publication sources pertinent to it. The CORAAL tool can be accessed at http://coraal.deri.ie.

3. CONCLUSION

We evaluated our approach via the CORAAL search engine. A sample of actual users (experts in the domain of cancer research and clinical care) helped us to assess various quantitative and qualitative aspects of the emergent content processed within our framework. The results of our approach outperformed available base-lines by rather large margins (improvements in the range of 189 – 374%), demonstrating a promising potential of the proposed approach. Note that this short paper is but a very superficial and rather incomplete overview. Readers interested in learning more about our research, its evaluation and about the large volume of related work are invited to have a look at [2].

Acknowledgements: This work has been supported by Science Foundation Ireland under Grant No. SFI/08/CE/I1380.

REFERENCES

A Framework to Describe Localisation Services for Automatic Selection of Optimum Service(s) Facilitating the Dynamic Execution of Workflow

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Abstract

This research is about localisation service description facilitating automatic service selection. This work is motivated by research in localisation supporting Software as a Service (SaaS) concept that integrates Natural Language Processing (NLP) across specialised services to enhance productivity of localisation process [3][5]. Machine translation (MT) services, for example, are evidence of localisation web services.

Localisation is a process that supports a product to be recognised globally. It is a business process that adds value to the products by transforming products with specific requirements of the target market. The Localization Industry Standard Association (LISA) defines localisation as follows: “Localisation is the process of modifying products or services to account for differences in distinct markets”. The classical definition of a typical localisation workflow is found in [1] and Esselink defines the seventeen steps in the process starting from Pre-sales and ending with Project Closure.

The recent evolution and the penetration of digital technologies consequently have led to a growing demand for localisation. Localisation faces increasing volume of digital content, widening markets and various modes of representation of content.

Localisation business processes needs to move towards full automation as currently it requires frequent human intervention. This influences cost, performance and quality of services [2][4].

The description of services for service selection becomes the immediate and essential step. The selection of available services is currently dependant on manual search by skilled professionals to deal with ‘peculiarities’ pertaining for each service [4]. This arises shifting from the development of bespoke services to selecting services in the cloud.

The authors’ experience of integrating MT services on the Web for the translation process in a localisation workflow demonstrates the manually intensive nature of selection and integration of MT services. Moreover available MT services currently do not provide descriptions in a standard manner allowing users to select in order to meet the demand. Process optimisation and automation requires a unified service description which specifies what a service does and how it is provided. Therefore, the specification of service descriptors becomes important as well as methods for filling in the description.

Functional and non-functional requirements capture what the software must do to meet the user needs. The taxonomies in this field provide a theoretical foundation for the categorisation of functional and non-functional attributes of services.

Attributes of current software-based localisation services will be analysed and categorized based on the taxonomy of requirements to form a basis for localisation service description. The service attributes of localisation then forms the descriptors which can be used to select the optimum services.

The question is: is it possible to facilitate automated selection of localisation services through the provision of a descriptor that supports functional and non-functional service attributes?

2. References


Acknowledgments:

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## CIVIL ENGINEERING

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The influence of secondary settlement on foundations supported by stone columns

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Abstract
A finite element/calculation based numerical model will be developed to predict the long-term settlement improvement offered by stone column installation in soft cohesive soils. PLAXIS, a finite element program specific to geotechnical engineering, will be used to model the secondary settlement behaviour associated with stone column-supported foundations. Small-scale model experiments will be conducted in order to support and authenticate the finite element results and to gain a better understanding of the mechanisms of behaviour involved.

1. Introduction
The use of vibro stone columns (VSCs) as a ground improvement technique has gained popularity in recent years. It is now widely accepted that stone columns reduce the settlement and improve the bearing capacity of soft cohesive soils.

However, most of the research that has been carried out to date has been concerned with their effect on primary settlement and very little consideration has been given to how stone columns arrest long-term creep settlements [1]. Secondary settlement (creep) can be significant, if not dominant in normally consolidated cohesive soils. Since stone columns are now being extensively used in such deposits, secondary settlement should be given careful consideration.

2. Numerical Modelling
Preliminary analyses using PLAXIS have focused on a single stone column 0.6m in diameter supporting a circular concrete footing 0.6m thick. The diameter of the footing is the same as that of the column. The soil profile considered for the finite element model is that of the Bothkennar soft clay test site in Scotland. The Bothkennar site has been a popular geotechnical test bed for studying soft soil behaviour for a number of years. The soil profile consists of a 1.5m crust overlying a 13m thick layer of lightly overconsolidated clay. The clay is in turn underlain by a gravel/bedrock layer.

The Hardening Soil Model in PLAXIS is used to simulate the behavior of the crust and the stone column material. The Hardening Soil Model is a hyperbolic elastoplastic model capable of simulating advanced soil behaviour. However, the Hardening Soil Model does not account for viscous effects such as creep and stress relaxation. The Soft Soil Creep Model is used for the clay layers. The Soft Soil Creep Model is a second order model that can be used to model long-term secondary settlement behaviour. It will be used to examine the influence that stone columns have on long term settlement (creep). The column and the concrete footing have been wished in place. The properties of the surrounding soil are thus unaffected by the installation of the stone column. Future work may involve modelling column installation using a cavity expansion technique.

3. Preliminary Analyses
The Soft Soil Creep Model has been used to simulate the settlement reduction offered by column installation over a 10 year period. Preliminary analyses have focused on studying the effect of column installation on the coefficient of secondary compression, $C_{\alpha}$. The initial studies indicate a reduction in $C_{\alpha}$, highlighting the effectiveness of the stone columns.

Preliminary results have indicated that $C_{\alpha}$ decreases as column length increases. This is in comparison with [2] who have carried out a parametric study using PLAXIS 3D Foundation to examine the influence of a number of different factors on the behaviour of small groups of columns supporting rigid footings. The authors have found that increased column lengths resulted in improved settlement performance.

4. Conclusions
Stone Columns effectively reduce primary settlement. However, the long-term secondary settlement reduction offered by column installation needs to be considered. It is hoped that the finite element analyses and small-scale laboratory experiments will lead to the development of a numerical model for predicting the long-term settlement reduction.

5. Acknowledgements
The authors wish to acknowledge the support of the Irish Research Council for Science, Engineering and Technology (IRCSET).

6. References
A Numerical Study on Settlement of Large Pile Groups

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Abstract

The interaction factor method is one of the most widely used approaches in the analyses of pile group settlement for its applicability to almost any pile group configuration. The finite element method is used to investigate the applicability of this method to large pile groups by comparing results of a direct analysis to those obtained by superposition of interaction factors. An investigation is also carried out on the influence of intermediate piles on results obtained by this method.

1. Introduction

It has now been long established that a loaded pile will carry additional loads when located within the displacement field of other loaded piles. One of the most common and tractable approaches in the analysis of pile group interaction settlement has been the use of the concept of interaction factors and the principle of superposition, originally established by Poulos [1]. The successful application of the interaction factor method to small pile groups has been well documented in the literature [2]. The finite element method is used to investigate the applicability of this method to the analysis of large pile groups.

2. Finite Element Study

The soil profile modeled for the finite element study was the Kinnegar test site in Belfast. The soil stratum consists of a layer of made ground which extends to a depth of ~ 1.0–1.5 m and is underlain by 8.5 m of slightly overconsolidated soft estuarine silt (referred to as 'sleech'). The adopted soil parameters which have been well documented in the literature [3] were validated by simulating the pile load test carried out by McCabe and Lehane [3] at the same test site. The advanced elastic-plastic hardening soil model was used in the finite element software package PLAXIS 3-D Foundation. Results of the settlement of a group of 3, 5, 13, 25, 41 and 61 piles were calculated by a direct analysis and compared to those calculated by the interaction factor method.

3. Results

From Figure 1, it is clear that settlement predictions obtained using the interaction factor method are in almost perfect agreement with predictions by the direct analysis. In order to reinforce the findings of Figure 1, an investigation of the effect of intermediate piles on the value of interaction was also considered (Figure 2). It can be seen that the presence of an intermediate pile has an insignificant impact on the interaction factor for a floating pile group.

4. Conclusions

The results from the finite element study confirm the applicability of the interaction factor method to large pile groups. The blocking effect of intermediate piles on the value of interaction factor was also shown to be insignificant for the case of a floating pile group.

5. Acknowledgements

The authors wish to acknowledge the financial support provided by the CoEI Postgraduate Scholarship.

8. References

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

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Abstract
This research primarily focuses on the analysis of shear transfer in void formed flat slab units. It also incorporates the instrumentation of the New Engineering Building (NEB) at NUI Galway and its development as an interactive teaching tool. The project itself is jointly funded by IRCSET and Arup Consulting Engineers.

1. Introduction
Void from flat slab systems are an innovative and novel form of flat slab system. They consist of spherical void-formers, positioned in the middle of the concrete cross section to reduce the overall self weight of the slab, while maintaining the full flexural strength allowing a two-way or bi-axial load transfer. The reduction in self-weight, up to 35%, allows for savings in overall materials and permits longer spans. Void form flat slabs can be constructed by two methods; traditional in-situ or in combination with pre-cast elements. This research focuses on the use of semi-precast elements and how two-way action in the bottom steel is restricted. To ensure that 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. One of the primary aims of this project is to analyse this load transfer.

2. Aims of the Project
The project will also offer an independent investigation into, and contribute an original idea in, the design of void form flat slab systems. At present there are very few publications in relation to this unique slab system and their design is not specifically included within the provision of Eurocode 2. As such the project aims to highlight a set of procedures which could be incorporated within the codes. The extent to which shear transfer is achieved through the use of ‘stitching’ bars in void form flat slabs will be examined and to determine if there is a better and more efficient method of achieving shear transfer. Any design issues in relation to void form flat systems will also need to be clarified along with investigating what areas of the slab are susceptible to failure and the failure mechanisms involved.

3. Methodology
Central to the project will be data gained from the instrumentation of the void form flat slab system used in the NEB. The NEB was the first building to incorporate the use of flat slab systems in Ireland. Over 160 gauges have been installed in the slab element and these are continuously monitoring the temperatures and strains within the slab. This data from site will allow a detailed understanding of exactly how void form flat slabs react during the various stages of a buildings construction and also during its lifetime. The overall research strategy will combine numerical simulation using finite element models and field measurements. The finite element models of the instrumented slab system will be validated by comparison and continual updating of data obtained from measurements on site. Furthermore to augment the data collected on site a range of experiments and testing will be carried out in the laboratory. Aspects which contribute to shear transfer include the adhesion and bonding of concrete, shear friction between the pre-cast and in-situ elements and the dowel action of the reinforcement bars across the precast joints. All aspects will need to be analysed and the manner in which they contribute to the overall shear transfer in the slab system. Time dependant effects of concrete such as creep, shrinkage and temperature effects also need to be taken into account. Each has an effect on the stresses and strains experienced within the slab element and thus have an impact on the data received from site.
Seismic Design of a Self-Centering Brace for Concentrically Braced Frames

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Abstract
Concentrically braced frames (CBF’s) are a popular lateral loading system used in seismic design of steel. The bracing members in the CBF act as the energy dissipative elements while other elements remain elastic. This study focuses on minimizing the residual displacements in the CBF’s after seismic loading. A self centering (SC) brace will be developed to achieve this and will be modeled for a variety of designs used with CBFs. These models can then be used to formulate a displacement based design (DBD) approach for these systems.

1. Introduction
Prior to the 1994 Northridge Earthquake in the US, moment resisting frames (MRF’s) had become a popular arrangement in steel framed buildings. Some laboratory testing had shown that the MRF’s exhibited good ductility under cyclic loading, making them an ideal choice for seismic design, although further testing on these systems showed poor hysteretic behaviour [1]. The connection detail was simple and easy to produce, so this further contributed to its increased popularity among designers. After the 1994 earthquake, many of these MRF’s were noted to have performed poorly under seismic loading, and an investigation [2] afterwards showed that over 130 buildings had experienced failures during the earthquake.

Another mechanism that has become popular since the observations during the Northridge earthquake is the CBF (Figure 1).

![Figure 1: CBF arrangement and mechanism.](image)

Building design codes now tend to require that the beams and columns in the CBF remain elastic during seismic loading to maintain the gravity loading system, and that the diagonal bracing member(s) behave inelastically, acting as the energy dissipative members in the CBF [3].

2. Self-Centering CBF (SC-CBF) Brace
In a recent paper on the DBD of a CBF [4], one of the findings was the inability of analytical models to accurately predict the displacements of the frame, whereas accelerations were. This was due to the residual deformations present in the bracing members after their inelastic behavior during seismic loading.

The principle aim of this project is to develop a SC mechanism for these CBF’s that will minimise these residual drifts that are found in CBF’s. This will be achieved by placing post-tensioned (PT) strands of high strength steel inside the tubular bracing members. This will reduce the residual drifts in the CBF by the elastic restoring forces in the PT strands, while the tubular members will behave inelastically and provide the energy dissipative mechanism in the CBF.

3. Research Outcomes
3.1 Analytical Models
Using this arrangement within the CBF, testing will be carried out and an analytical model will be developed to accurately predict the response of the bracing member under seismic loading. Software such as Ruamoko and OpenSEES will be examined to establish the most suitable modeling software.

3.2 Parametric Study of SC-CBF’s
Once an analytical model has been established to accurately predict the response of this SC bracing member, a number of parametric studies will be conducted. These will expand on the single brace element to single SDOF and MDOF systems, dual systems and vertically irregular systems.

3.3 Direct Displacement-Based Design
Once analytical models for the parametric studies outlined above have been verified, it is envisaged that that a procedure for the DBD of these SC-CBF’s can be developed similar to SDOF CBF’s, as outlined by [4].

4. Conclusions
A SC-CBF brace element will be developed and verified by fitting and analytical model to laboratory results. A parametric study on numerous structure arrangements will be modeled and methods of DBD developed for these SC-CBF’s.

5. Acknowledgements
Irish Research Council for Science, Engineering and Technology (IRCSET).

6. References
Cost-Effective Sustainable Construction Technology.

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Abstract

Through this research project, the development of a novel cost-effective sustainable composite building technology or product for use in a European context will be proven through extensive testing in terms of durability, strength and appearance. In particular, composite materials comprising of locally sourced materials that have low impact on the environment are being developed. One construction technology used in developing countries that has very low impact on the environment is stabilised soil blocks (SSBs). The blocks are low-cost as their main component, the soil, is sourced locally, often directly from the site of construction and the main stabiliser used in their manufacture is cement. Further, these blocks can be produced on site, saving in transportation costs.

This research project is separated into two phases; the first phase investigates alternative binders and stabilisers to Ordinary Portland Cement (OPC), which have pozzolanic properties and are mainly waste materials or by-products of no significant value. The second phase of the project aims at producing innovative composite materials by developing the use of these alternative waste materials as stabilisers in SSBs and investigating the use of these SSBs in a European context.

1. Introduction

Concrete is the most utilised substance in the world after water. Ordinary Portland Cement (OPC), the most common binder used in concrete, is the most expensive and energy intensive ingredient in concrete. Due to the manufacturing process associated with cement production, approximately 900kg of CO\textsubscript{2} is released into the atmosphere for every tonne of cement produced. Therefore, it is imperative that alternative cement replacements are developed. Consequently, the quantity of cement being manufactured would be radically reduced. Wide-spread research has been carried out in the development of cement substitutions. Ground granulated blastfurnace slag (GGBS), and fly ash are commonly used in blended cements or as cement replacements across Europe.

2. Investigation into alternative binders

A full review of various Ordinary Portland Cement (OPC) replacement materials has been investigated. 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 concrete or soil blocks not only reduce their cost and embodied energy, but also improve their structural performance. It is obvious that different substitution materials will have different effects on the properties of concrete due to their chemical and physical characteristics, so it is vital that these characteristics are considered and analysed thoroughly.

3. Concrete Block Testing

Concrete containing both 10% and 20% of the various waste materials was tested in terms of workability, permeability, shrinkage, durability and strength at 3, 7, 1, 28, 56 and 90 days. The various tests were carried out on 100x100mm cubes and 150 dia. x300mm cylinders. Durability tests included the concretes resistance to sulphate attack and chloride ingress. From these test results, the most successful replacement was determined in terms of strength and durability with respect to concrete.

4. 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 is the main concern with SSBs. The ability of the soil in the blocks to resist prevailing rain, wetting and drying cycles, freezing and thawing cycles, and chemical attack are critical issues if there are applicable in a European climate. The testing of the SSBs, incorporating the waste material as a stabilizer, will mainly focus on durability tests. The most common method used in the manufacturing of SSBs is a hand press for compacting the blocks. A more efficient method, which will be considered as part of this project, is to use an electric or diesel powered machine that have high production rates.

5. Conclusions

Through this research project the successful use of SSBs, incorporating a waste material sourced in Ireland as a stabilizer instead of cement, in a European context will be proven.

6. 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.
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 this material is to be put to use in construction. An estimation of the cost of producing such a material will be provided. A successful outcome will result in IBA which would otherwise be land-filled being applied to constructive applications thus improving the nature of waste management in Ireland.

Introduction:
Municipal waste management in Ireland is facing a major change with the arrival of Waste to Energy (WtE) incineration facilities. Our first facility is approaching completion in Meath 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). It is expected that by the end of 2012 the Meath facility alone will produce 50,000 tonnes of IBA per year. Currently it is planned to dispose of this 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 project aims to investigate Irish IBA 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 (Wiles, 1996). 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.

My Project:
I have assembled a statistically representative sample of Irish waste. This will be incinerated at 850°C before testing the quality of the resultant ash. It is also my aim to assess the economic viability of IBA.

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 specific gravity will be assessed in the laboratory. Constructability will be assessed on a trial road foundation constructed from IBA.

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 designed to assess the safety of the material. This includes availability, compliance, column, tank and lysimeter leachate tests.

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 be known on completion of the quality tests.

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.

References:
Modelling Extreme Flood Events due to Tides, Rivers and Storm Surges  
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Abstract  
Flooding in towns and cities is commonplace in Ireland, due to both coastal and river flooding. It is anticipated that in the future this problem will increase due to the effects of climate change. Flooding of coastal hinterlands can be caused by a number of influences: high river flow, high tides, storm surges or a combination of any or all of the above. The dependence between such factors as river flow, tides, and storm surges is a pertinent point of research. It must be known how these factors interact together before flooding can be accurately predicted. To model the effects of such flooding a complete modelling solution is sought, this shall include a 3D ocean model to predict storm surges, a 2D estuary model which uses input from the surge model to model water levels in the harbour, and a floodplain model used to assess water levels within the area concerned, this project will focus on Cork harbour.

1. Introduction  
Coastal flooding is a function of different physical phenomena therefore this research aims to investigate the interactions between tides, river flows and storm surges using extreme value joint probability theory. The main aim of the research is to develop a modelling system that will accurately predict coastal flooding due to the joint probability of these three processes.

Model results will be used in conjunction with statistical theory in two ways. Firstly, based on the independent occurrences of flooding from tide, storm surge and river flow joint probabilities will be derived. Secondly, past extreme events will be modelled using a detailed coastal model in which all three processes are included then combined probability models will be developed for extreme coastal flooding events. The results from both approaches will be critically analysed and compared. Finally, recommendations will be made regarding the most appropriate model to be used. It is also likely that different models may suit different coastal regions; this will be investigated and again recommendations made.

This research consists of two separate work packages:  
1. Investigate the dependence between river flows, tides and storm surges, and thus their joint probabilities of occurrence.  
2. Develop a combined 3D, 2D and 1D model in order to accurately predict water levels in Cork City from a combined combination of storm surges, tides and river flows.

The results of the two work packages will be combined to produce flood risk and extent maps.

2. Joint Probability Analysis  
Joint probability analysis is an important area of research within flood risk studies however it is a subject that has not produced many studies when used on tides, surges and river flows, especially in Ireland. A small number of studies have been carried out in the UK with the development of a best practice approach based on methods used [1]. Research of this nature is very site-specific, there is no general model, and therefore significant work must be carried out in order to obtain results for a particular area.

The joint probabilities method is used to determine the dependence of two or more variables on each other. It determines the likelihood that if one variable is above a certain threshold, then at the same time the other variable will also be over its threshold. The thresholds for each variable are set out initially and represent extreme events.

3. Modelling  
This research proposes to develop a complete modelling system for coastal flood prediction. This will be achieved using a 3D ECOMSED model of the North Atlantic Ocean to produce accurate predictions of storm surges within the relevant coastal area. ECOMSED is a three-dimensional hydrodynamic, wave and sediment model [2]. The coastal area of Cork Harbour will be modelled in 2D using a nested DIVAST model. The numerical model DIVAST (Depth Integrated Velocities and Solute Transport) is a two-dimensional time variant model, developed for estuarine and coastal modelling [3]. These models will be linked with LISFLOOD-FP, this is a two-dimensional hydrodynamic model designed to simulate floodplain inundation over complex topography [4], high resolution topography of Cork city will be represented in the model using 2m resolution LiDAR data.

4. References  
Assessing the contribution of monitoring and modelling data to water quality mapping estimation error

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Abstract

The Water Framework Directive (WFD) (EC 2000) sets the primary objective that all water bodies will achieve a minimum of “good” status by 2015. Limited guidance is available at present for assembly of monitoring programmes for the WFD. Bayesian Maximum Entropy incorporates monitoring data and model data, enabling accurate maps to be generated without the requirement for intensive monitoring campaigns. The author intends to utilise a number of approaches with BME to assist in optimisation of monitoring programmes. Here, an assessment is made of the relative contribution of monitoring and model output to the lowering of mapping estimation error.

1. Introduction

Monitoring programme guidance provided under the Common Implementation Strategy for the WFD lacks a rigorous methodology. Advice relating to WFD monitoring programmes is provided in the areas of monitoring point location and quantity and sampling frequency. Suggestions include grouping of waterbodies with similar natural conditions/anthropogenic pressures, increasing the density of sampling in space & time to counteract high heterogeneity and locating monitoring points at the most sensitive locations. Statistical assistance is limited to approximating the number of monitoring points for a desired confidence level & precision. (Commission 2003)

2. Sparse data and Bayesian Maximum Entropy

Sparse data availability limits the understanding of water quality processes and causations. Normal mapping interpolation of monitoring data via simple/ordinary kriging would result in maps of limited use unless a high number of monitoring points were sampled for mapping, which would prove costly. BME incorporates information such as measured field data and model output to generate grid mean estimates. BME allows the determination of the probability that the variable under examination will be above an environmental quality standard. BME presents an opportunity to improve uncertainty in water quality estimates and assess the efficacy of existing & proposed monitoring programmes, both in terms of cost & sufficiency of estimation uncertainty(Joseph N. LoBuglio 2007). BME involves two main stages: the prior and posterior. The prior stage assembles a general knowledge based pdf \( f_0 \) which describes the likely range of values throughout the domain covered by monitoring/model results. The posterior stage integrates the domain pdf with adjacent data to give a pdf of the estimation points in question (Christakos 2000).

4. Results

Maps were generated using BME with varying numbers monitoring and modelling results for Ammoniacal nitrogen concentrations in Cork harbour. Maps of estimation error were then created. A significant reduction in estimation error is observed with the use of numerical model results. A larger area of low estimation error is observed with the inclusion of uncertain model data. Research will continue into the influence of uncertain model outputs in BME mapping.

5. References


Axial Load Capacity of a Driven Cast-in-Situ Pile in Mixed Ground Conditions

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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 pile in mixed ground conditions at Pontarddulais, Wales. The test results showed that the pile was influenced by residual load due to curing which significantly altered the load distribution 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 ground investigation consisted of 3 no. cone penetration tests (CPT) at the pile test location. Each test was specified to penetrate to a minimum depth of 10 m. The tests revealed mixed ground conditions consisting of 1.5 m of dense fill overlying 3 m of soft clay, followed by 1.5 m of medium dense silty sand. A 1.2 m layer of firm clay was encountered at 6 m, followed by sand of varying density to a depth of 10 m. The water table was located at 2 m below ground level according to borehole reports.

3. DCIS Test Pile
The DCIS test pile was 340 mm in diameter and 8.5 m in length. The pile was instrumented with 16 no. vibrating wire strain gauges in order to obtain the load distribution during testing. Strain readings were taken before and after installation of the reinforcement, and immediately prior to commencing the pile load test. Analysis of the readings revealed that the pile was experiencing significant tensile strains as a result of swelling during curing, which results in the development of residual load [2].

4. Static Load Test
A static load test was conducted approximately 9 days after pile installation. The pile was subjected to three loading/unloading cycles, with failure occurring at a load of 935 kN. The strain gauges enabled the load distribution along the pile at failure to be obtained (Figure 1). The distribution was significantly affected by the residual load which developed during curing, with the base resistance accounting for approximately 31 % of the ultimate load.

Figure 1 - Load distribution in DCIS test pile at failure

6. Conclusions
The concrete curing process for DCIS piles results in the development of residual load which alters the load distribution obtained from a static load test.

7. Acknowledgements
The authors wish to acknowledge Keller Foundations UK for sponsoring this research project.

8. References
Air Suction Bio-flow Reactor.

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Abstract
The research project involves the development of a new bio-film reactor technology, an Air Suction Bio-flow Reactor (ASB-FR), for the removal of organic carbon, solids, nitrogen, phosphorus, odours and greenhouse gases from municipal, industrial and agricultural wastewaters.

1. Introduction.
Existing wastewater treatment facilities have to improve operating performance and provide effluent of higher quality, conforming to more stringent regulation [1].

A laboratory unit has been setup within the Environmental Engineering Laboratory, at NUI Galway for the treatment of high strength wastewater and is currently in the second phase of testing.

The technology comprises a treatment system of two identical closed cylindrical reactor which can become air-tight when process requires, connected in series through a pipe-connected to a motorised valve. Each tank has an air suction device, plastic bio-film media, influent and effluent pipes with motorised valves, level switches, and is operated and controlled through a programmable logic controller (PLC).

Heterotrophic, autotrophic, anammox and phosphorus accumulating micro-organisms develop on the plastic media to treat the wastewater under suitable aerobic, anoxic and anaerobic conditions by using the PLC to control the movement of wastewater and air in the enclosed tanks. During the aerobic phase the bio-film is passively aerated which removes the need for inefficient mechanical aeration.

The wastewater is moved from one tank to the other by atmospheric pressure and reducing the air pressure in the other tank by the air suction device (ASD). Furthermore, the gases exiting from the tanks through the ASD e.g., N₂O contained in the air from the denitrification process, can be captured and cleaned in scrubbing filters before exhausting to the atmosphere.

3. Results.
During phase 1 of the study, which lasted 166 days, the organic loading rate was 2.84g COD/m² media/day and 0.26g NH₄-N/m² media/day achieved removals of 97% COD, 96% ammonium and 60% phosphorus.

During phase 2, which is ongoing the same organic loading rate was maintained but the wastewater was retained in each reactor for longer periods this reducing the energy costs of operating the vacuum pump by 60%. Removals to date during this phase were 97%, 93% and 78%, filtered COD, ammonium and filtered phosphorus respectively.

A third phase is due to start in the coming weeks.

A pilot scale unit is currently being commissioned at a local landfill site where the treatment of high strength landfill leachate using the ASB-FR treatment unit will be investigated.

4. Conclusion.
Results to date have shown that the treatment unit is capable of complying with both national and international discharge requirements while having a lower operating cost.

The ASB-FR treatment unit is currently undergoing an international patent application.

5. Acknowledgments and References.
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Chemical amendment of dairy cattle slurry to reduce P losses from grasslands

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Abstract

In intensive dairy farming systems, phosphorus (P) inputs can exceed P outputs. Over time, soil test P (STP) levels build up after repeated manure applications, and this can increase the risk of P loss to surface and subsurface waters. There is also the risk of incidental losses when landspreading slurry. Amendments could potentially mitigate P losses in strategic areas. The aim of this study was to identify amendments with the potential to reduce dissolved reactive P (DRP) loss from agricultural grassland in Ireland arising from the land application of dairy cattle slurry.

1. Introduction

In intensive dairy farming systems, phosphorus (P) inputs can exceed P outputs. Over time, soil test P (STP) levels build up after repeated manure applications, and this can increase the risk of P loss to surface and subsurface waters. Amendments could potentially mitigate P losses in strategic areas, while allowing farmers to utilise nitrogen (N) and other nutrients in the slurry. The aim of this study was to identify amendments with the potential to reduce dissolved reactive P (DRP) loss from agricultural grassland in Ireland arising from the land application of dairy cattle slurry.

2. Materials and Methods

An agitator test (Mulqueen et al., 2004), was used to identify the optimal rates of amendment addition to slurry to reduce soluble P and to estimate associated costs. The most effective amendments were as follows: aluminum sulphate (alum) applied at a metal to total P ratio of 1.1:1, poly aluminium chloride (PAC) (0.93:1), ferric chloride (FeCl₂) (2:1), and lime (10:1).

Two runoff boxes 200 cm long by 22.5 cm wide by 5 cm deep with side walls 2.5 cm higher than the soil surface, containing intact soil from a dairy farm treated with dairy slurry and amended slurry were subjected to simulated rainfall with an intensity of 11.5 mm hr⁻¹ (n=3) with each runoff box receiving three successive 1 h rainfall events at time zero (RS1), 1 h (RS2) and 24 h (RS3) with first event being 48 h after land application of slurry. All experiments were conducted in triplicate. All runoff samples were tested for suspended sediment (SS) and DRP.

Proc Mixed of SAS (2004) was used to analyze the data with a covariance structure to account for correlations between the repeated measures.

3. Results

The results of this experiment are shown in Fig. 1. Alum reduced mean flow-weighted concentration of DRP by an average of 83% (p<0.01) over 3 successive rainfall events, compared to 69% for lime (p<0.01), 86% for PAC (p<0.01), and 67% for FeCl₂ (p<0.01).

4. Conclusions

Alum and PAC were best at reducing SS and DRP in surface runoff compared to the control.

5. Acknowledgements

The first author gratefully acknowledges the award of a Walsh Fellowship by Teagasc to support this study.

7. References

Abstract
This project investigates the use of near surface mounted pultruded glass fibre reinforced polymer (GFRP) rods in relation to two applications. Firstly, the performance enhancement of reinforced low-grade glued laminated timber beams is being examined. The production of glued laminated timber beams overcomes many of the natural deficiencies that are found in timber, especially the low-grade timber that is produced in Ireland. Secondly, the use of bonded-in FRP rod materials to repair and strengthen existing structural timber elements is being looked at. Additionally a 3-D non-linear finite element model is to be developed using the finite element package, Ansys. It is envisaged that the use of reinforced glued laminated timber will increase in the construction industry, and with the underutilised timber resources Ireland has it could highlight a potential area for a growth in the production of glulam and reinforced glulam products.

1. Introduction
Timber’s structural weaknesses stem from its nature as a natural anisotropic material. The fact that it is a natural renewable material however is also one of its greatest strengths. The transition is being made to greener, more environmentally friendly, materials not only because it is good for the environment, but because it is becoming more and more cost effective. Ireland has increased its roundwood production by 540% from 1979 to 2003[1]. The majority of this timber fed the Celtic tiger construction industry and now we are left with an underutilised resource that is low grade Sitka spruce. Our climate makes the growth of Sitka spruce quite rapid and as a result we get less dense lower grade timber. The variability of strength in timber is primarily due to deficiencies such as warping, bowing, knots and splits. In the past 100 years, the method of glued laminated timber has developed to reduce and in many cases overcome the shortcomings of timber as a structural material. Glued laminated timber (Glulam) is a combination of individual boards or laminates bonded together with an adhesive to form a stronger grade beam with reduced strength variability and imperfections. In comparison to a similar sized monolithic beam a glulam beam has the advantage of imperfections being contained to single laminates rather than running throughout the beam. This restriction of deficiencies results in a product with a much lower variability in strength and stiffness.

2. Objectives
The objective of this report is to investigate the use of near surface mounted GFRP rods as reinforcement in glued laminated beams made with low grade Irish grown Sitka spruce. Through different reinforcement configurations and methods of reinforcement we hope to develop the most efficient reinforcing arrangement. A finite element analysis will also be undertaken. It is envisaged that the simulated behavior of this model will concur with our experimental data. Testing this model will allow us to carry out parametric analysis and could assist practicing engineers in design scenarios involving laminated timber structures and FRP rod reinforcement. Another objective of this project is to examine the use of near surface mounted FRP rod materials to repair and strengthen existing structural elements. This application is of particular interest considering out of 41,743 timber bridges that are in use across the United States 47% are considered as structurally deficient in the national bridge inventory. The cost to replace all of these beams would not be economically viable but retrofitting and strengthening with FRP rods could offer a potential solution [2].

3. Testing Programme
A beam test programme was undertaken which involved initially testing all glued laminated timber beams in stiffness in their unreinforced state. All beams comprised five laminations of C16 grade spruce bonded together using a phenol resorcinol formaldehyde adhesive. The beams measured 3610mm in length (3420mm span) and 190mm in depth. Unreinforced, artificially fractured, artificially fractured and repaired, single reinforced on the tension face and double reinforcement configurations were examined for flexural stiffness performance, ultimate moment capacity and strain profile distribution. A number of different groove arrangements were examined during the testing.

4. Conclusion
The development of structural timber members with less strength variability and increased load capacity would give an aesthetically pleasing and sustainable alternative to concrete and steel. The method of NSM GFRP retrofitting and repair could extend the service lives of existing timber structures providing an alternative to total bridge replacement.

5. References
Seismic Design of Concentrically Braced Steel Frames and Dual Systems with Vertical Irregularity

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Abstract
Analytical model of concentrically braced steel frames (CBFs) with rectangular hollow section bracings is studied and validated by experimental data (pseudo dynamic cyclic tests for braces and shake table tests for one-story one-bay CBF). Direct displacement based design methodology is being developed for CBFs and dual systems with vertical irregularities with many different configurations and validated by non-linear time history analysis (NLTHA).

1. Introduction
In any seismic area, every structure should be designed to withstand the applied seismic forces in the event of seismic activity to avoid both human and economic losses. These seismic forces result directly from the motion of the ground on which the structure rests. All structures should be designed with an adequate capacity to dissipate energy induced from this ground motion without substantial reduction of its overall resistance against horizontal and vertical loading. The magnitude and distribution of lateral forces and displacements resulting from ground motion is influenced by the characteristics of the ground and the properties of the structure. These lateral loadings induced by the earthquake can be resisted by using lateral resisting frames, walls or dual systems. This research will concentrate in studying and developing a design methodology for concentrically braced frames and dual systems with vertical irregularity.

2. Concentrically braced frames (CBFs)
The study of the performance of CBFs is started by studying the behaviour of the brace element, which is the main element in this system that dissipates energy during seismic actions. The brace element, which is destined to carry reversal axial forces, may yield in tension, buckle in compression or may fracture due to the demand cycles it is expected to endure during seismic actions. A robust numerical model for braces, which are cold-formed square and rectangular structural hollow sections, is developed by calibrating the numerical model for braces with pseudo-dynamic cyclic tests carried out by Goggins [1]. This work has been submitted for publication in [2]. This numerical model for the brace elements is then advanced for a single-story single-bay frame by comparing its performance using shake table tests done by Goggins [1]. Preliminary findings are given in [3]. The validated brace element model is then used to predict the performance of multi-storey structures. Displacement Based Design (DDBD) procedure [4] for CBFs is then developed using the experimental data and non-linear time history analysis.

3. Dual systems with vertical irregularity
Direct displacement based design methodology is developed for dual systems with vertical irregularity. Many configurations are studied, including a dual system with CBF core and irregular steel moment resisting frame that possess a vertical irregularity associated with setbacks up the vertical axis of frame. Another dual system is then investigated by using the same irregular moment resisting frame but with a concrete core. Furthermore, a dual system with a both concrete core and irregular concrete frame is studied.

4. Conclusion
An analytical model for brace members by using pseudo-dynamic cyclic tests is developed [2]. This analytical model is advanced for single-degree-of-freedom CBFs by using shake table tests and NLTHA then developing a DDBD design procedure [5]. DDBD procedure is then developed for multi-degree of freedom system CBFs and validating it using NLTHA. In the second part of this research a DDBD methodology is developed for dual systems with vertical irregularity by using three different configurations- CBF core and vertical irregular steel moment resisting frame, a concrete core and vertical irregular steel moment resisting frame, and a concrete core and vertical irregular concrete moment resisting frame.

Acknowledgement
The first author gratefully acknowledges the fellowship provided by the COEI, NUI Galway.

References
Abstract
A Civil Engineering research team from NUI Galway developed and patented a novel wastewater treatment technology known as the pumped flow biofilm reactor – (PFBR). It is proposed to model the PFBR using the modeling package GPS-X as part of this project.

Wastewater Treatment Plant modelling is a useful tool for performing plant capacity assessments and improving plant operations; therefore, saving energy and chemical costs. Once implemented and calibrated, a model offers many advantages such as:

- Determining Maximum Flow Conditions
- Evaluating Chemical Usage Changes
- Preparing for Upcoming Regulations
- Energy Saving Evaluations
- Pre-Treatment Considerations
- Identifying Bottlenecks
- Predicting Weather Events
- Equipment Evaluations

Devisscher et al., (2006) noted that mathematical modelling can optimise plant efficiencies resulting in cost savings of: (i) aeration energy in the range from 10 to 20% and (ii) chemical dosing up to 30%. The PFBR technology is currently undergoing commercial evaluation; thus a predictive model capable of simulating performance for both municipal and industrial strength wastewaters will add further value to the commercial offering.

1. Introduction
The PFBR is a two-reactor-tank technology that has been extensively tested at laboratory-scale and field-scale for populations ranging from 15 – 400 population equivalents (PE). It is proposed to model the pumped flow biofilm reactor using the modelling package GPS-X. GPS-X is a modular, multi-purpose computer programme for the modelling and simulation of municipal and industrial wastewater treatment plants. GPS-X can be used whether designing a new facility or simulating an existing plant. GPS-X can help significantly improve the design and operating efficiency of wastewater treatment plants (WWTP).

2. Operation of the PFBR
In a typical cycle of the PFBR hydraulic pumps are used to circulate wastewater from one reactor tank to another. These biofilm systems comprise no moving parts or compressors, other than hydraulic pumps or air pumps and motorised valves. Aeration is achieved by alternately exposing the biofilm (attached to plastic media) in each of the two reactor tanks to atmospheric air, thereby eliminating the need for forced aeration. Anoxic/anaerobic conditions can be achieved by keeping the biofilm media immersed in the wastewater. By operating the system in a sequencing batch reactor (SBR) mode to EU and UK design loadings, the following can be achieved: 5-day biochemical oxygen demand (BOD$_5$), chemical oxygen demand (COD) and suspended solids (SS) removal; nitrification; and denitrification – biological phosphorus removal has been achieved at laboratory-scale and will be trialled at field-scale. The PFBR system is operated as a sequencing batch reactor and, as such, requires primary settlement and a balance storage volume up-stream of the reactor tanks.

3. Modelling of PFBR
A model is a representation of a real system. The biggest challenge of model developer is to utilise model concepts and equations to represent the WWTP process dynamics. Due to the novel nature of the technology, it may be necessary to develop specific code and implement it in GPS-X to describe the aeration and hydraulic characteristics of the PFBR. The project methodology will be as follows:

1. Collation of all experimental data relating to both technologies including aeration studies, biofilm measurement data and phase studies.
2. Completion of small aeration trials in the laboratory PFBR reactors to improve understanding of the aeration dynamics.
3. Development of a model that is both physically representative and allows treatment cycle regimes to be described (including pump run times, quiescent times, anoxic, aerobic and anaerobic phases etc).
4. Initial model runs.
5. Sensitivity analysis and parameter estimation.
6. Model calibration and further sensitivity analysis.
7. Final optimisation of the predictive models.

4. Application of PFBR
There are numerous decentralised wastewater treatment plants in Ireland with a population between 15 and 2000. These plants may often not have permanent plant operators. The PFBR is particularly suited to such sites as it can be remotely controlled and operated. The development of a model for this technology will enhance the design and operational efficiencies that can be achieved.

5. Summary
In summary, the proposed development of the new GPS-X model for the PFBR will enhance the understanding of this technology and lead to better designed and more cost-effective wastewater treatment systems.

6. References
## MODELLING, ALGORITHMS & CONTROL

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Abstract
Quantum Walks provide a model for universal computation. Many Quantum algorithms have been shown to have substantial speedup over their most efficient classical counterparts. Some of these (e.g. Grover’s algorithm) make use of Quantum Random walks. However, much of the work concerning Quantum Walks deals with two state walks. In this work we observe the properties of three state walks on a graph.

1. Introduction
Random walks are a statistical tool, used to study patterns in randomness. They can be applied over a finite space (typically a graph) or an infinite continuum.

Quantum (random) walks are the quantum equivalent of classical random walks. They are studied to observe the statistical properties of quantum systems. These results aid in the general design of randomised quantum algorithms, particularly regarding efficiency concerns for those algorithms[1].

Much of the work concerning discrete quantum walks deals with two-state bits, known as qubits. At each time step in a qubit system the particle must move. Our work looks at three-state systems, whose particles are known as qutrits. In a qutrit system the particle is not forced to move at each time step; there is a possibility that it can remain in the same location. This possibility to remain in place gives rise to the name “lazy” quantum walks.

2. Classic Walks
The most approachable application of a discrete classical random walk is a fair coin toss, the result of which moves a particle left or right on an infinite line. After this experiment has been run a number of times, the distance from the origin is recorded. This series of experiments is then run a number of times, and the distance from the origin is recorded each time. When a histogram of these results is plotted, we see that the distribution of distances from the origin is approximately normal. As the particle can only land on an odd numbered space after an even number of steps, over a larger number of steps every second value will be zero.

The lazy classical walk has a normal distribution; the introduction of the lazy step removes the odd/even restriction. Like the standard classical walk, the lazy classical walk converges to equal values on a closed graph.

It is possible to vary the lazy bias of a classical walk. A common bias is to choose a probability per iteration of ½ for the lazy move, ¼ for the clockwise move, and ¼ for the counter-clockwise move. This bias can be modeled as two coin tosses, where one coin signals movement or its absence, the second signals the direction of movement (if the first coin signals movement).

3. Quantum Walks
Two state quantum walks are well studied. We use Marttala’s generalization of a Hadamard coin[2] to study the properties of a three state Quantum Random Walk on a graph.

4. References
Eigen-based Approach for Leverage Parameter Identification in System Dynamics

Jinjing Huang, Enda Howley and Jim Duggan

Abstract—Eigen-based approaches are useful tools in analyzing dynamic systems. They can be used to identify the leverage points that drive the observed behaviour. The structure under investigation is system parameter. This work distracts from the traditional focus on the eigenvalue to the behaviour mode weight. It is known that not only the behaviour mode (\(e^n\)), but also the weight influences the state behaviour. Further investigation finds the weight can be decomposed into eigenvectors and system initial condition. An analytical methodology to compute the weight elasticity over the parameter is proposed here. An experiment on the labour-inventory model is performed to both validate the methodology and render the implications for policy design.

Index Terms—leverage points identification, parameter analysis, numerical weight analysis

I. INTRODUCTION

System dynamics (SD) is a computer-aided approach to policy analysis and design. The heart of SD lies at exploring the rule of “structure drives behaviour”. SD approaches have a series benefits:

1) grasp counterintuitive behaviors;
2) tell a “system story” about policy outcomes, and highlight the potential leverage points;
3) simplify system archetypes.

Eigen-based approaches including eigenvalues and eigenvector analysis are widely used in the SD research (see [1]). Eigenvector analysis has started to attract more attention recently, [2] first proposed its application in identifying dominant feedback loops. A numerical weight analysis was carried out by [3] to show the leverage structure points.

II. METHODOLOGY OF WEIGHT ANALYSIS

We propose an analytical methodology of weight analysis with respect to the system parameters. It is carried out in the following steps.

1) For an n-order system, the behavior of the state variable \(x_i\) is expressed by Eq. (1).

\[
x_i(t) = e^{\lambda t} \sum_{j=1}^{n} r_{ij} \ell_j X_0 + e^{\lambda t} \sum_{j=1}^{n} r_{ij} \ell_j X_0 + ... + e^{\lambda t} \sum_{j=1}^{n} r_{ij} \ell_j X_0
\]

where \(t\) is time, \(\lambda\) is eigenvalue, \(r\) and \(\ell\) are right and left eigenvectors, and \(X_0\) is system initial conditions. The term under brace is weight.

2) Computing the weight elasticity (\(\varepsilon\)) with respect to a parameter \(p\) in Eq. (2).

\[
\varepsilon_{wi} = \frac{\partial w_{ji}}{w_{ji}} = \frac{\partial \left( r_{ij} \ell_j X_0 \right)}{\partial p} \frac{p}{w_{ji}}
\]

\[
= \left( \frac{\partial r_{ij}}{\partial p} \ell_j + \ell_j \frac{\partial \ell_j}{\partial p} \right) X_0 \frac{p}{w_{ji}} \quad (2)
\]

3) The weight elasticity is decomposed into the calculation of eigenvector sensitivity over the parameter: \(\partial r_{ij}/\partial p\), \(\partial \ell_j/\partial p\), which is solved by [4].

III. EXPERIMENT RESULTS

The labour-inventory model is shown in the diagram below. Part of the analysis results are presented in Table I. It confirms outcomes from both methods match each other.

![Fig. 1. Stock and flow diagram of the labor-inventory model](image)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Inventory</th>
<th>Labor</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAT</td>
<td>-8.7623</td>
<td>-8.6363</td>
</tr>
<tr>
<td>WIPAT</td>
<td>6.2983</td>
<td>6.0653</td>
</tr>
<tr>
<td>MCT</td>
<td>-23.697</td>
<td>-22.034</td>
</tr>
<tr>
<td>SWW</td>
<td>15.13</td>
<td>14.13</td>
</tr>
<tr>
<td>PRO</td>
<td>15.13</td>
<td>14.13</td>
</tr>
<tr>
<td>VAT</td>
<td>2.9025</td>
<td>2.248</td>
</tr>
<tr>
<td>LAT</td>
<td>2.0097</td>
<td>2.0165</td>
</tr>
<tr>
<td>ATTFTV</td>
<td>-4.5658</td>
<td>-5.5783</td>
</tr>
</tbody>
</table>

Part of the analysis results are presented in Table I. It confirms outcomes from both methods match each other.

TABLE I

<table>
<thead>
<tr>
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<th>Labor</th>
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<tbody>
<tr>
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<td>ATTFTV</td>
<td>-4.5658</td>
<td>-5.5783</td>
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</table>

REFERENCES


An analysis of population diversity and multi-chromosome GAs on deceptive problems

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M.Li1@nuigalway.ie  colm.oriordan@nuigalway.ie  seamus.hill@nuigalway.ie

Abstract
This research examined new representations for evolutionary computation and illustrates their performance on a range of problems. The role diversity plays is also examined.

1. Introduction
Much research has shown that population diversity plays a significant role in GAs avoiding being trapped in local optima in deceptive problems [1] and in dealing with dynamic environments [2]. Previous research on how to solve deceptive or dynamic environmental problems has focused on maintaining diversity [3]. This research discusses a new direction in using GAs to solve deceptive fitness landscape by controlling the convergence direction instead of simply increasing the population diversity. Supported by experiments, the deceptive problem's solution space has been analysed.

Based on this analysis, the diversity and convergence of genetic algorithms are discussed. The reasons why a GA can or cannot solve different kinds of deceptive problems is then explained. Experiments show that the canonical genetic algorithms with elitism can solve most deceptive problems, if given enough generations. Two new multi-chromosome genetic algorithms have been designed to accelerate the GA's searching speed in more complicated deceptive problems by looking for a new balance between diversity and convergence. Five different problems have been used in the testing. The results show that the lack of diversity is not the only reason that normal genetic algorithms have difficulty in solving deceptive problems but that convergence direction is also important.

2. Analysis
2.1 Diversity Measurement
Following an analysis of the potential problems associated with the pair-wise diversity measures in binary chromosomes representation, we proposed two new diversity measurements which have the ability to quantitatively measure and analyse, diversity within the population together with the difference between populations. Define: $c_k(\alpha)$ is the number of the gene which has the value $\alpha$ in position $k$.

$$\text{diversity rate} = \frac{\sum_{i=1}^{p} \delta_i}{\frac{p}{2} \cdot \frac{p}{2} \cdot L}$$

where

$$\delta_i = c_i(0) \cdot c_i(1)$$

2.2 New Representations
Through a set of experiments, we analysed the solution space of a range of selected deceptive problems.

Two new genetic algorithms (DGA, TGA) have been introduced to solve deceptive and dynamic environment problems based on multi-chromosome representations. Both DGA and TGA do not have dominance system as they use a fixed dominant chromosome. The recessive chromosome will help the GAs to maintain diversity after the dominant chromosome has converged. A third chromosome has been added in TGA, which is used to search for local minima around the current optima, to check if the current best fitness individual is a local optimum, and reduce the time spent on searching around the local optima.

3. Experiments and Results
Different problems have been used in the testing. The results show that the lack of diversity is not the only reason that normal genetic algorithms have difficulty in solving deceptive problems but that convergence direction is also important. Simulations and empirical analysis demonstrated that the new proposed algorithms are superior to the canonical GA on a range of problems.

<table>
<thead>
<tr>
<th></th>
<th>CGA</th>
<th>DGA</th>
<th>TGA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order 3</td>
<td>99.5%</td>
<td>99.5%</td>
<td>100%</td>
</tr>
<tr>
<td>Mixed Order</td>
<td>27.5%</td>
<td>37.5%</td>
<td>100%</td>
</tr>
<tr>
<td>Rastrigin’s Func.</td>
<td>65.5%</td>
<td>60.5%</td>
<td>90%</td>
</tr>
<tr>
<td>Multi-Level Func.</td>
<td>37.5%</td>
<td>66.5%</td>
<td>88%</td>
</tr>
<tr>
<td>Completely deceptive</td>
<td>NA%</td>
<td>NA%</td>
<td>100%</td>
</tr>
</tbody>
</table>

4. Conclusions and Further work
The analysis of population diversity and deceptive problems shows that the diversity is not the only parameter that may affect the GAs’ performance in solving these kinds of problems. The experiment results show that increasing the diversity can increase the probability that GAs solve deceptive problems, and that the ability to maintain convergence directions affects the efficiency. Maintaining diversity while controlling the convergence direction is much more efficient than only maintaining the diversity.

Future work may include more analysis in the relationships of GAs’ convergence and diversity.

5. References
Abstract
To manage today’s industrial systems, often predictive models are required to weigh options and determine potential changes which provide the best outcome for a purpose. In this research, we investigate genetic programming to develop tangible analytic models of system performance dependent on decision variables to support decision making.

1. Introduction
Management of complex systems, such as in semiconductor manufacturing, requires predictive models. These quantify the impact of decisions on system performance prior to changes. Companies like Seagate, Analog Devices and Intel struggle with being able to predict changes.

In this respect, this research develops approximate models, metamodels, of industrial systems using genetic programming (GP) to facilitate a means to quantify the performance when the trade-off between approximation error and efficiency is appropriate.

2. Predictive Models
The overview of industry and relevant literature has revealed several prominent tools in application and some of their undesired characteristics.

Analytical models are computationally efficient methods, however, they may require restrictive assumptions to make complex systems more tractable for modeling. Spreadsheet simulations are primarily used; but, provide low fidelity models as they do not capture the dynamics of the system. In contrast, discrete-event simulation (DES) can provide higher fidelity models; but are very difficult to develop and maintain and in many cases take too long to execute to support planning (McNally and Heavey, 2004).

In the next, we summarise GP to develop explicit approximate predictive models.

3. Main title
GP is a branch of evolutionary algorithms which emulate the natural evolution of species. It can evolve programs of a domain via symbolic regression. These programs can be interpreted as logic instructions, analytical functions etc. GP develops the models without prior assumptions about the underlying function of the training data. These properties provide a substantial advantage for modelling of complex systems with GP. In the following, we provide the results from the analysis of application of GP in this context.

4. Robustness and Competitiveness
Table 1 - Analysis on different problems

<table>
<thead>
<tr>
<th>Problem</th>
<th>SF1</th>
<th>SF2</th>
<th>SF3</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 station</td>
<td>0.9840</td>
<td>0.9834</td>
<td>0.9856</td>
<td>10m</td>
</tr>
<tr>
<td>9 station</td>
<td>0.9778</td>
<td>0.9811</td>
<td>0.9784</td>
<td>15m</td>
</tr>
<tr>
<td>12 station</td>
<td>0.9856</td>
<td>0.9860</td>
<td>0.9846</td>
<td>15m</td>
</tr>
</tbody>
</table>

We tested accuracy of GP on 3 different production lines, where training data is collected with different space-filling experimental design methods. Results indicate GP is robustness to problem size and data collection (Table 1).

Table 2 - Comparison with ANNs

<table>
<thead>
<tr>
<th>Problem</th>
<th>ANN</th>
<th>GP</th>
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</thead>
<tbody>
<tr>
<td>AMHS</td>
<td>0.79</td>
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<tr>
<td>sS</td>
<td>0.83</td>
<td>0.93</td>
</tr>
<tr>
<td>9 station</td>
<td>0.91</td>
<td>0.99</td>
</tr>
</tbody>
</table>

We compared the performance of GP to artificial neural networks (ANNs) since they are extensively used in metamodeling. GP performed with a better accuracy on un-seen data (Table 2). Furthermore, the explicit functions are delivered which are easy to interpret compared the ANN metamodels.

6. A GP for Dynamic Modelling
Table 3 - Table 4 - Analysis on different problems

<table>
<thead>
<tr>
<th>Problem</th>
<th>SF1</th>
<th>SF2</th>
<th>SF3</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
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<td>0.9955</td>
<td>0.9958</td>
<td>0.9961</td>
<td>2m</td>
</tr>
</tbody>
</table>

We manipulated the standard GP algorithm with new constraints to improve its accuracy and development time of metamodels. Table 3 indicates that GP has obtained significant gains through these changes.

7. Conclusion
In this manuscript, the results from application of genetic programming to metamodeling of industrial systems are summarised. Genetic programming has yield approximate models reaching beyond 98% accuracy efficiently. The results suggest incentive towards developing dynamic models using GP.
Steganography techniques in the AutoCAD environment
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1. Introduction
This thesis will be incorporating several different aspects within the IT domain.
Steganography is defined as the art and science of writing hidden messages in such a way that no one, apart from the sender and intended recipient, suspects the existence of the message, a form of security through obscurity. Research into security keys and methods of encrypting information is also involved in my research. AutoCAD is a CAD (Computer Aided Design or Computer Aided Drafting) software application for 2D and 3D design and drafting. I became familiar with the AutoCAD environment during my studies in Civil Engineering and decided that it would be interesting to research into combining the AutoCAD environment with Steganography.

2. Aim
The aim of this thesis is to investigate different methods of Steganography within the AutoCAD environment using either different tools or features within AutoCAD. The 2010 version of AutoCAD is being used for testing for this thesis. This version contains many improvements over early versions of the application and has a 3D model space which allows for more scope when researching methods of information hiding. It is hoped to develop several methods of message hiding. These methods will each differ in complexity, size of message that can be transmitted, ease of retrieval, etc.

3. Method
The following techniques were used in the development and research into message hiding:

Hatch patterns – AutoCAD has a feature which allows users to create their own custom hatch pattern. The hatch feature is used to fill a certain area within the drawing with a particular pattern. This is done so that materials/areas can be easily identified within a drawing if they are given their own unique pattern. With a custom pattern the user can generate what seems to be just a complex pattern within a drawing but when the intended third party overlays this pattern with their ‘private key’ (custom pattern to decipher the message) then the message is revealed.

Layers – layers within AutoCAD are similar to font types within Microsoft Word. When a line is assigned to a particular layer then it can be manipulated in different ways such as “turning off” that layer would make all objects that were part of the layer disappear. Using the layers feature as a method of message hiding, a drawing is sent which contains an incomplete floor plan of a house. This plan is generated with a public key, the message is then decrypted using the intended party’s private key which places an overlay on the floor plan thus revealing the message.

3D viewpoint – Within the 3D environment, a message is written using an array of points. A message on a piece of paper could be constructed using the X & Y axis. For this method, the Z-axis is also used and pseudo-random values between two limits are used for each point. This means that to a normal observer there would seem to be a clutter of points within the drawing with no real purpose, however, to the intended third party the message can be read by observing the drawing at a certain point within 3d space and viewing the drawing at a particular angle so that the pseudo-random z-axis values do not impact on the message being conveyed.

4. Conclusion
This paper details the design, methodology and advantages of each method of hiding. It also details the development of a small scale automated method of using the 3D viewport of hiding which could be used to assist with copywriting drawings or using the AutoCAD environment as a method of transfer of a simple message between parties.

5. References

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Abstract: Graphical Semantic Wiki for use in the Pre-coding Phase of Discrete Event Simulation

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Abstract
This research concerns the development and application of graphical wiki software to facilitate knowledge management in the pre-coding phase of discrete simulation projects.

1. Description
The objective of this research is to develop a tool to facilitate the collaborative capturing of knowledge for discrete event simulation projects, and while capturing it, put it into a form that will be reused and continue to be developed.

Discrete Event Simulation projects often generate a significant amount of knowledge - at considerable effort - and involve gathering knowledge from many human users in a system. However, this knowledge is often only stored in the simulation itself. A problem with this is that Discrete Event simulations are typically used to solve a specific problem, and then put aside. This means that the only knowledge that is gained in such a project may be the solution to the specific problem being examined. It would be preferable to store the generated knowledge in a manner oriented towards reuse.

The field of knowledge management is concerned with facilitating collaboration between humans, and the sharing and dissemination of knowledge. A lot of literature has been published indicating the need for knowledge management in Discrete Event Simulation. However, far fewer papers have explicitly examined the field of knowledge management and how it can be applied in Discrete Event Simulation projects.

One of the most popular and proven knowledge management tools is the wiki. This facilitates true collaboration and knowledge reuse in a simple and accessible manner. However traditional wikis are limited when it comes to describing systems: They don’t provide support for editing graphical content.

The primary objective of this research is to show how a graphical wiki may be developed and used to facilitate collaborative generation of system descriptions, suitable for use in discrete event simulation projects, and that this description could continue to exist as a useful artifact of knowledge after the DES project has been completed. This wiki would support collaborative editing of diagrams.

The semantic wiki is a wiki which contains a logical definition of its content, and captures the relationship between different parts. This allows the content to be “understood” by machines. It offers such benefits as integration with external software, enhanced querying of the knowledge-base, and automatic verification of consistency in the descriptions. The level of detail that could be captured in a graphical wiki populated with diagrams would be extensive. In a text-based wiki, the main naturally occurring relationship is links between pages; however in a graphical wiki, relationships could be captured for every connection in every diagram. This would increase the potential reuse of the knowledge base. It may also facilitate a level of logical integration between heterogeneous types of diagrams, making knowledge gathering more flexible. Finally, it could feasibly be integrated with software to automatically generate simulations from the descriptions in the wiki.

Therefore a secondary objective of this research is to examine how a semantic layer in a graphical wiki could be used to enhance it as a knowledge management tool.

2. Status
Prototype Graphical Semantic Wiki software has been developed using ASP.NET and Silverlight. Diagrams and diagram elements and connectors may be edited collaboratively by users. Typical wiki features are supported, such as versioning, and accessibility via typical Web browsers.

The software allows ontologies to be defined as the content is generated. Graphical content is associated with semantic objects. When a connector is drawn between two graphical objects, a relationship [associated with the connector type] is created between the associated logical objects. These ontologies are defined in a simple frame-based manner.

Semantic information may be generated from different diagram types [to varying degrees], and heterogeneous diagrams based on the same logical objects may be validated against each other.

Ongoing work includes the development of case studies to further explore the concepts being applied, and to prove them, as well as further examination of how ontologies may be defined.
Particle Swarm Optimisation with Gradually Increasing Directed Neighbourhoods

Hongliang Liu, Enda Howley and Jim Duggan

Abstract—Particle swarm optimisation (PSO) is an intelligent random search algorithm, and the key to success is to effectively balance between exploration and exploitation of the solution space. This paper presents a new dynamic topology called “gradually increasing directed neighbourhoods (GIDN)” that provides an effective way to balance between exploration and exploitation. In our model, each particle begins with a small number of connections and there are many small isolated swarms that improve the exploration ability. At each iteration, we gradually add a number of new connections between particles which improves the ability of exploitation gradually. Furthermore, these connections among particles are created randomly and have directions. We formalise this topology using random graph representations. Experiments are conducted on 31 benchmark test functions to validate our proposed topology. The results show that the PSO with GIDN performs much better than a number of the state of the art algorithms on almost all of the 31 functions.

Index Terms—PSO, Dynamic Topologies.

I. INTRODUCTION

Particle Swarm Optimisation (PSO) was proposed by Eberhart and Kennedy in 1995 [1], [2]. It is inspired by the socially self-organised populations such as bird flocking and fish schooling. The vital property of the PSO is the interactions or connections between particles. These connections are generally known as the “neighbourhood topology” of the algorithm. The neighbourhood topologies of the swarm determine the speed of information flow in the entire population, and furthermore, the speed of information flow could be used to control exploration and exploitation of the search space [3]. This paper presents a dynamic neighborhood topology through gradually increasing the number of connections for each particle in the population. We have formalised this topology using random graph representations. In order to validate our proposed method, we have tested the PSO on 31 benchmark test functions. The results show that the changes in the PSO result on better performance than a number of the state of the art algorithms on almost all of the functions.

II. PSO WITH GRADUALLY INCREASING DIRECTED NEIGHBOURHOODS

In our model, we gradually add connections between particles and these connections between particles are randomly chosen and also have directions. So we choose a random directed graph $G(N, b, \gamma, t)$ to formally define our GIDN. We define the in-neighbourhood set $H^+_t(p_i)$ for any particle ($p_i$) in the $G(N, b, \gamma, t)$ first. The size of $H^+_t(p_i)$ at iteration $t$ is determined by the following equation.

$$|H^+_t(p_i)| = [(\frac{t}{\max_t})^\gamma * N + b] \tag{1}$$

where $[x]$ is the largest integer not greater than $x$ (the floor function), $\max_t$ is the maximum iteration number, $N$ denotes the size of the population, $b$ and $\gamma$ are two parameters. The parameter $b$ is the number of neighbours that each particle begins with. We suggest that $b$ is set to a small number such as 2 or 3 in order to create lots of small swarms in the population. The parameter $\gamma$ controls the neighbourhood size increasing speed and subsequently the information flow speed. Thus, $\gamma$ can be used to control exploration and exploitation. $f(y) = (\frac{t}{\max_t})^\gamma$ is a decreasing function because of $0 < \frac{t}{\max_t} \leq 1$. Our results show that $\gamma = 2$ provides a better balance between exploration and exploitation.

III. SOME EXPERIMENTAL RESULTS

Table I shows a summary of comparisons between our PSO-GIDN and several well-known algorithms including SPSO, GPSO, VPSO, PSO-NO, PSO-RDN, PSO-DMS. There are only a very few cases that the PSO-GIDN performs statistically significant worse than the other PSO algorithms. In contrast, the PSO-GIDN performs statistically significant better on the majority of the functions.

IV. SUMMARY

To conclude, our paper provides an optimistic answer to the challenge of balancing the opposing forces of exploration and exploitation, a key concern in the PSOs.

REFERENCES

Low Coverage Genome Assembly Using Fuzzy Hash Maps

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Abstract  
Despite the high-throughput of sequence reads that characterise second generation sequencing technologies, genome assemblers require a large degree of over-sampling to produce a complete genomic sequence. Using a novel approach to comparative genome assembly, based on the application of fuzzy hash maps, low coverage sequence reads can be rapidly ordered and orientated in an assembly scaffold with a low error rate and a vastly increased N50 length.

1. Introduction  
The advent of second generation sequencing (SGS) technology, capable of rapidly sequencing a massive number of short-length reads, has resulted in a re-appraisal of existing approaches to sequence alignment and genome assembly. The twin characteristics of large read number and short read length has resulted in a move away from assembly strategies based on the traditional overlap graph to more k-mer centric approaches such as de Bruijn graphs and sequence graphs. While the newer k-mer centric genome assemblers are ideal for use with short-length reads, the requirement for a large degree of oversampling, or coverage, renders these approaches unsuitable for assembling genomes of draft coverage or lower. Although comparative assemblers have been developed for assembling draft genomes, the underlying assembly model is invariably based on the traditional overlap graph. We describe how a fuzzy hash-map can be applied to rapidly and accurately assemble a prokaryotic genome, sampled at varying levels of low coverage, against the reference genome of a closely related species.

2. Assembly with Fuzzy Hash Maps  
Hash-tables or maps are dictionary data structures that use a key and a hashing function to provide constant time, O(1), insertion, deletion and retrieval operations. By generating a unique hash code from a given key, hash tables provide a rapid mapping from a domain of unique keys to a range of possible values. Fuzzy Hash Maps (FHM) leverage the power of object-oriented languages to allow a degree of variability in the composition of a hash key. In the Java programming language, a degree of fuzziness can be applied to a hash key by manipulating the contract between the hashCode() and equals() methods in the object used as the hash key. In contrast to traditional hash maps, which seek to avoid collisions, FHMs encourage initial collisions in the map by reducing the size of the key used to compute a hash code. Dynamic programming algorithms can then be implemented in the equals() method to establish whether a full collision is permitted. Using a FHM as the underlying data structure, a de Bruijn graph approach can be used to anchor a set of draft sequence against a reference genome and assemble the draft reads into contiguous sequences [1-2].

3. Results  
The results of assembling the 0.58Mb genome of *M.genitalium* at varying levels of coverage are shown in Table 1. The 0.81Mb genome of *M.pneumoniae* was used as a reference sequence and anchored 65.56% of the *M.genitalium* reads.

<table>
<thead>
<tr>
<th>Coverage</th>
<th>N50 Contig</th>
<th>N50 Scaffold</th>
<th>% Ordering Errors</th>
<th>% Orientation Errors</th>
<th>Time (s)</th>
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<tbody>
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<td>2539</td>
<td>1.38</td>
<td>2.07</td>
<td>4.1</td>
</tr>
</tbody>
</table>

4. Conclusions  
The FHM approach is capable of rapidly and accurately ordering and orientating low coverage sequence reads without sacrificing the execution speed inherent in hash maps.

5. References  
Traffic-Aware Intelligent Access Point (TAIAP)

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Abstract
The overall goal of our research is to investigate the benefits of applying synchronized time to wireless networks. For VoIP, Mouth-to-Ear (M2E) delays over wireless networks can vary significantly due to contention and asymmetries. Real-time applications such as VoIP are very sensitive to delay and Quality of Service (QoS) can be much improved if the M2E delay in a VoIP session is known and can be controlled. We are developing a Traffic-Aware Intelligent Access Point (TAIAP) that will calculate and profile M2E delays in both directions for each active VoIP session in a BSS, in order to prioritize VoIP sessions that are suffering from 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 prioritizes traffic into four categories with Voice traffic being the highest priority followed by Video, Best Effort and Background. Our Access Point (AP) will further prioritize traffic within the voice category, by tuning 802.11e EDCA parameters for individual clients and sessions.

For our experiments, we will implement the Network Time Protocol (NTP) on nodes at both ends of a VoIP session and on the intermediate AP in order to calculate the M2E delay for that session.

2. Experimental setup
Our experiments will involve running multiple VoIP sessions over a wireless network, each connecting to a wired client Fig. 1.

Once the sessions have been initiated, there are a number of different delay values that must be calculated for each session. We must calculate M2E delays in each direction for each individual session. This information can be computed by analyzing RTCP Sender Reports (SR) and Receiver Reports (RR) at the Access Point. These RTCP reports contain system timestamps (TS) in NTP format, which allows accurate computation of delays when all nodes including the AP 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, to generate a real-time picture of delays for all active sessions. This information will then be plugged into an E-Model algorithm to generate R-Values for each session. A further algorithm will prioritize certain VoIP sessions based on their R-Values. This prioritization will be implemented by the issuance of new 802.11e EDCA parameters to all clients via broadcast beacon frames or by sending unicast beacon frames to relevant clients. The life cycle of this process can be seen in Fig.2:

3. Conclusion
This project is being carried out in parallel with the development of an extension module for the NS-2 Network Simulator, and is intended to validate simulation results found in NS-2[2]. We believe that a Traffic Aware intelligent access point would greatly enhance the QoS of multimedia, particularly VoIP, in an office environment, where network administrators could implement this as a dedicated wireless voice communications framework.

4. References
Evolving a Robust Open-Ended Language
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Abstract
Artificial life is the study of life-like characteristics in artificially-created systems, such as robots and computer programs, in order to increase our understanding of how nature works, and to optimize performance of artificial systems. Using word-meaning pairs, simulated agents can evolve an ability to communicate using a shared lexicon. This language will complexify to match increasing complexity in the environment, and can complexify in an open-ended manner even without a corresponding increase in complexity of the environment.

1. Introduction
New computational and problem-solving paradigms can be discovered by the study of natural life systems and complex dynamical systems[1].

Much research has been done on self-complexifying algorithms [2] and evolution of language using genetic algorithms and neural networks [3, 4]. Communication is a key part of any social interaction, and language is a key part of communication. Self-complexifying algorithms become capable of more advanced behavior as they evolve. In order for robots to be able to communicate about new artefacts which they have never encountered before, their language needs to be able to evolve and grow in an open-ended manner. Artefacts in this sense can refer to objects in the environment or events which may come about as a result of social interaction between agents.

Language itself is never static. Human languages are constantly in being adapted and updated, flushing antiquated and unused material and adopting new and more relevant elements.

2. A Shared Lexicon – Words and Meanings
The language is evolved using word-meaning pairs as genes. There are no absolute “right” or “wrong” word-meaning pairings. If two individuals in the population have the same word for the same meaning, then they can communicate this word to each other successfully. If they have different meanings for the same word, the hearer will interpret the message incorrectly. The establishment of a working shared lexicon depends on the pairing of specific words with the same meanings across the population.

Dynamically generating words is trivial; a word is merely a signal. As long as it is shared, it works, whatever it is. Achieving meaningful representations of meanings is more difficult. A pre-defined list of meanings has no room for growth at runtime. Meanings must be represented in a way that allows them to be dynamically created and interpreted by the program.

3. Current Work
Simulations have thus far shown that when selective pressure is placed on both the ability to speak and the equal ability to hear and understand signals, a shared concise lexicon will evolve and propagate through all individuals in the population. We have also shown that a random population seeded by some members using a lexicon will most likely use that seeded solution when final convergence occurs. Thresholds have been observed at which success of the seed is guaranteed. A robust lexicon is unaffected by invasion from randomly created individuals and other established lexica, to an existing point at which creoles (hybrid languages) often start to emerge.

Running the simulations in an n-dimensional grid world allows the language to evolve word-meaning pairs for each dimension, so that they can communicate about the new complexities in the environment. Given enough time the language can complexify indefinitely to match the number of dimensions.

4. Future Work
The next step is to achieve a level of open-ended evolution that is not constrained by the level of complexity of the environment. In this case, the social interactions between the agents in the population become the new artefacts to be added to the language.

5. References
Merging Business Process Models
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Abstract
In this paper, we propose an algorithm that allows for creating a configurable business process model given a set of business process variants.

1. Introduction
One of the most promising mechanisms reusing existing process models in Process Aware Information Systems [1] is the use of configurable process models [2]. A configurable process models is the aggregation of several process variants. The main particularity of such models is that they can be configured in order to create a customized model. Despite their benefits, they have not been widely adopted. This is mainly due to several issues such as the lack of automation support in the creation of configurable models.

In our research, we aim at developing an algorithm that allows for creating such configurable models having as input a set of business process variants.

In the rest of the paper, Section 2 presents the adopted notation; Section 3 describes our algorithm and Section 4 reports on the evaluation of our work and concludes the paper.

2. Notation
In our work we use EPC [3] as a target modeling language. We represent a business process as a directed graph with annotated nodes and edges. A business process graph $G$ is a triple $< WN; RN; E >$ where:
- $WN$ is the set of work nodes: in EPC, work nodes are either function or event nodes. Function nodes are used for representing tasks of the business process. Event nodes are used as preconditions that need to be satisfied to perform a function.
- $RN$ is the set of routing nodes: in EPC, connectors are the routing nodes. They are used for controlling the flow of tasks that need to be performed for achieving the goal of the process.
- $E$ is the set of directed edges which connect nodes from $WN$ and $RN$.

3. Creating configurable process models
3.1. Pre-processing the input models
A start node in EPC must be an event that triggers a first step in a given process. For this, we need to insure that if a start node exists in a particular input model, then it must be a start node in the configurable process model. We examine all the start nodes of all our input models and verify if they are start nodes everywhere (i.e., in all the input models). If a node appears as a start node in some models and not a start node in others, then it is considered as a conflict and has to be resolved. The resolution consists of changing the identifier of a confliction node by a randomly selected new identifier. We proceed similarly to resolve conflicts that may be related to end nodes as well.

3.2. Merging the input models
The merging phase consists of a simple set union operation between all the process graphs. The merged process graph $(MG) = < WN_{MG}; RN_{MG}; E_{MG} >$ such that ($k$ represents the number of the initial process graphs):

$$WN_{MG} = \bigcup_{i=1}^{k} WN_i; \ RN_{MG} = \bigcup_{i=1}^{k} RN_i \text{ and } E_{MG} = \bigcup_{i=1}^{k} E_i$$

3.3. Post-processing the configurable model
After merging the business process graphs, we expect obviously that some EPC requirements are violated and this step allows for resolving this issue. Such requirements are: each work node must have at most one input and one output.

3.4. Reducing the configurable model
During the post-processing step, several routing nodes will be inserted which may lead to the appearance of several connector chains. The reduction step of our algorithm allows for reducing these chains.

4. Conclusion and future work
Our algorithm has been implemented as a java program and tested on several real world business process variants. The result of our work has shown that in few milliseconds it is easy to merge business process models with less risk to make errors. Our algorithm allows for merging models with identical labels for nodes, as a future work we plan to allow for approximate matching.

5. Acknowledgement
This work is founded by the Lion II project supported by Science Foundation Ireland under grant number 08/CE/11380.

6. References
Abstract
Concordance analysis supports users in studying how terms are used in a document vs. another by investigating their usage contexts. This type of analysis is useful in many domains, from literary study to market analysis. However, as current approaches usually present a large set of contexts in their full text form or as a large frequency-based word cloud, they still require a lot of effort from users to make sense of the underlying complex and dynamic semantic dimensions of contexts. To address this limitation, we propose Context Stamp as a visual representation of the gist of a term's usage contexts. To abstract away the textual details and yet retain the core facets of a term's contexts for visualization, we blend a statistical topic modeling method with a combination of the treemaps and Seesoft visual metaphors. This paper provides a high level description of the text analysis method and outlines the visual design of Context Stamps.

1. Introduction
Apart from the needs to search for and navigate to relevant information, many knowledge workers also need to compare different usages of a word in one document vs. another, or at one point in time vs. another. This comparison can be achieved by looking into the usage contexts of the word. In literature analysis, a concordance is commonly used, which includes an index of the terms in question, their frequencies and the surrounding contexts. Concordance analysis “is intended for understanding properties of language or for analyzing the structure and content of a document for its own sake, rather than search” [2]. It helps users investigate word frequencies, study how terms are used, or which words tend to go well together. Outside of the literature domain, concordance analysis can also be used for other purposes. For instance, in market analysis, it can be used to track how customers' responses to a product evolve over time.

2. Research Goal
The inherent categorical nature of text and its very high dimensionality makes it very challenging to display the contexts graphically [2]. Our goal is to propose a novel approach to make it easy for users to quickly compare the sets of contexts within which a term is used in one document vs another.

Here we consider:
• Instead of presenting a term’s set of contexts in their original textual form, can the details be abstracted away and only their gist retained to let users make contextual sense of the term?
• Which visualization elements can be used together to convey both the distribution of a term and its contexts at different levels of detail?

3. Text Analysis and Visual Design
As with other visual analytic solutions, our focus is not to propose a new visual metaphor, but to identify a good automated algorithm for the analysis task, and then integrate the results with appropriate visualization and interaction techniques.

To abstract away textual details of a set of contexts and yet retain facets of rich information about them, we rely on statistical topic models to obtain the relationship between the mental representation of language (meaning) and its manifestation in written form. Instead of treating documents as bags of words, a topic model treats documents as mixtures of latent topics, and each topic is a probability distribution over words. A word can be assigned to various topics with different probabilities, depending on its levels of association with various strands of meaning. With a topic model, we have the inferred distributions of topics within documents, and the distributions of words over the topics. The key outcomes are the compositions of the inferred topics, which are coherent clusters of thematically related words. While the inferred model is imperfect as finding the optimal model parameters for a dataset is non-trivial, these topic-word distributions can be employed to abstract away textual details of a term's set of contexts in a document.

To show both the distributions of a term and the compositions of the core elements of its contexts, we propose a visualization that is an innovative combination of the treemaps metaphor [3] and the Seesoft-based visualization [1].

Further details are available in [4].

4. References
Abstract
Although services are delivered across dispersed complex service eco-systems, monitoring performance becomes a difficult task. This research explores the development of service performance analytics within the discipline of service science and explains how actor network theory (ANT) and social network analysis (SNA) can be introduced as the core theories to examine service operations and performance.

1. Introduction
The emerging discipline of ‘service science’ sets out to explore the socio-technical and socio-economic factors which contribute towards service delivery [1]. While the literature often investigates services from aspects of people, computer hardware and software, business, and information systems [2], few efforts encapsulate all of these factors to understand the intertwining trajectories of service networks. Services are complex socio-technical entities which result in intertwining human and non-human factors. Thus, viewing services through an actor network theory (ANT) lens allows us to develop an understanding of the complexity of service environments as they operate across heterogeneous networks.

2. Research Approach
This research adopts ANT to explore the implications of technology on relational structures (links within a network) and their affects on service performance across a service network. In addition, we examine how service actors impact on change and we visualise this through a technique called social network analysis (SNA). SNA is an approach and set of techniques which studies the exchange of resources (for example, information) among actors.

SNA focuses on patterns of relations among nodes (figure 1) and demonstrates the value of ties and relationships between each node by providing a visual and mathematical representation of interaction and exchanges which influence behaviour.

3. Service Operations and Performance
There have been minimal research efforts to explore service networks from both a service management and a service computing perspective. This has significant consequences on manager’s ability to understand the implications of implementing and managing technology to support service operations. Service network performance analytics (SNPA) is an area which we develop as it is becoming a crucial topic within service environments to allow managers gain greater insights on service operations, i.e. what works well, what needs improvement, and what needs to be removed. Performance is often influence by external entities causing structural variability across a service eco-system. We explore this from a service management and service computing perspective which attempts to unite the two disciplines for two main reasons:

1. To enhance service management decision-making tasks (service management),
2. To feed performance information into service requirements engineering (service computing).

Figure 2 illustrates the service anatomy in which we focus on service process and key performance indicators (KPI) to model service performance – SNPA. The focus on service network relational structures acknowledges the fundamental role that relational structures play on the generation of value through the sustainability of service network relationships, interaction, exchange of resources and competencies to enhance service performance.

4. References
DSP-Based Control of Multi-Rail DC-DC Converter Systems with Non-Integer Switching Frequency Ratios

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Abstract
In this work, a modification to a standard Digital Signal Processor (DSP) is proposed that enables it to control multi-rail DC-DC converter systems with non-integer switching frequency ratios. The modified DSP overcomes the drawbacks of conventional DSPs, which are attributable to large variations in the delay from when the ADC samples the output voltage to when the duty cycle is updated. By incorporating modified interrupt control logic in the DSP, the effects of a variable delay are minimized by significantly reducing the worst case sampling to duty-cycle-updating delay.

1. Introduction
Multiple Point-of-Load (POL) converters are frequently found in computing and telecommunications devices, where they are applied to loads with a variety of specifications at different voltage levels. A single DSP can be time-multiplexed to execute multiple control algorithms for these multi-rail POL converter systems. A problem with using conventional DSPs is that the switching frequencies of the individual power converters being controlled are normally restricted to being identical or integer multiples of each other. This restriction is imposed due to variations in the delay between ADC-sampling and duty-cycle-updating, which are caused by simultaneously occurring interrupts if the switching frequencies have a non-integer ratio. Constraining the switching frequencies to integer multiples of each other can negatively impact the efficiency or performance of the DC-DC converters because the power supply designer is forced into selecting non-optimal switching frequencies.

2. Modified interrupt controller
To avoid the problems associated with a variable delay between ADC-sampling and duty-cycle-updating, the delay can be fixed at its maximum possible value, $T_{\text{DMAX}}$, for each iteration of each control algorithm to be executed. However, a problem with using the maximum fixed delay is that it is excessive and therefore degrades the performance of the voltage regulator due to a slower response to load transients. Improved performance can be obtained by reducing this delay [1].

A modified interrupt controller for DSPs is therefore proposed here that reduces $T_{\text{DMAX}}$ to an acceptable value. By postponing the pre-calculation sections of the control algorithms until all duty-cycle-updating has been completed, the total ADC-sample to duty-cycle-update delay, $T_{\text{DMAX}}$, is reduced. This is achieved by automatically re-enabling all interrupts after the duty cycle has been calculated and the Digital Pulse Width Modulator (DPWM) has been updated. This therefore allows interruption of one control algorithm by another control algorithm during the pre-calculation stage.

3. Multi-rail DC-DC converter application
In order to evaluate the performance of the proposed interrupt controller, it has been compared with the standard interrupt control method. The comparison is based on the application of both interrupt control methods to a power converter system consisting of three independent DC-DC converters. The proposed interrupt controller was incorporated into an FPGA-based dual-MAC DSP for power control applications [2], as illustrated in Fig. 1. A third order linear compensator was implemented for execution on the DSP to regulate the output voltage of each of the power converters.

The restriction of the long $T_{\text{DMAX}}$ delay for the standard method results in a slow response in the output voltage when a load current step is applied at the output of the DC-DC converters. The modified interrupt method with the shorter $T_{\text{DMAX}}$ delay provides better performance and thus also facilitates the use of a wider bandwidth compensator. This enables a faster output voltage response to the same load step to be obtained.

![Figure 1. Modified interrupt controller applied to multi-rail DC-DC converter test system](image)

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Topographical Cues - Controlling Cellular Behavior
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Abstract

The widespread interest in employing tissue-engineered scaffolds as therapies is based on their capability to mimic native extra cellular matrix (ECM) architectures. These scaffolds should support cellular attachment, proliferation and directional growth in order to promote functional neotissue formation [1]. Electrospinning has been recently introduced as a simple and versatile polymer processing method to produce sub-micron fibrous constructs with biophysical properties comparable to native ECM assemblies [2].

1. Introduction

Herein, we fabricated electro-spun mats with different topographies (non-aligned, aligned and porous) and evaluated the influence of topography on cell attachment, alignment and proliferation. Our data indicate that the different topographies did not affect cell viability (p>0.05), micro-machining resulted in decreased cell attachment and only aligned fibres facilitated directional cell migration.

2. Materials and Methods

Non-aligned and aligned electro-spun polymeric mats were fabricated as has been described previously [3]. The fibres were collected either on a static drum (non-aligned mats – Figure 1a) or on a rotating drum (aligned mats – Figure 2a). Non-aligned and aligned mats were further processed to create porosity (1c and 2c respectively). Following that, all scaffolds were seeded with SAOS-2 for 14 days. Immunofluorescence images of the nuclei on the scaffold were used to quantify the effect of the topography on the scaffold.

3. Results

In this study, the influence of nano-topography on cellular behaviour was evaluated. Figure 1 shows scanning electron micrographs of (a) solvent casted films; (b) non-aligned electro-spun nano-fibrous mats; and (c) aligned electro-spun nano-fibrous mats. (d), (e) and (f) represent laser lithography treated (a), (b) and (c) samples respectively.

However, only aligned electro-spun nano-fibrous mats (c) facilitated cell alignment in the direction of the nano-fibrous substrate (a to f as Figure 1). Similarly to aligned electro-spun nano-fibrous mats, nano-imprinted scaffolds facilitated cell attachment and alignment.

4. Conclusions

Aligned electro-spun mats and nano-imprinted films provide a conducive environment for cell attachment and orientation, whilst decreasing metabolic activity. Studies are underway to understand the effect of nano-topography at the molecular level to decipher the effect on gene expression.

5. Acknowledgements

This work was supported by Enterprise Ireland, (Competence Centre for Applied Nanotechnology, Project No. CCIRP-2007-CCAN-0509) and by the Irish Government under the National Development Plan 2007-2013.

6. References

On the microscale deformation of an austenitic stainless steel at ambient and elevated temperatures

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Abstract
In this study, three dimensional crystal plasticity based finite element models are presented to examine the multiscale deformation behaviour of austenitic stainless steels at ambient and elevated temperatures 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. As an application, the macroscopic stress-strain response, the microscopic lattice strain evolution and the texture development during uniaxial tension for austenitic stainless steels are simulated with validation through the in-situ neutron diffraction measurements. Overall, the predicted lattice strains are in very good agreement with these measured in both longitudinal and transverse directions (parallel and perpendicular to tensile loading axis, respectively). Furthermore, apparent effects associated with the latent hardening of multiple slip systems are also identified as a result of altered work hardening at the microscale.

1. Introduction
The macroscopic response of materials is controlled to a large extent by deformation and damage mechanisms operating at the microscale—for polycrystalline engineering alloys the relevant length scale is the grain (crystallite) size. Thus, simulations and experiments conducted at the microscale can provide important insight into the macroscale integrity of engineering materials or components.

Micromechanical finite-element (FE) method has been applied to examine the mechanical response of engineering alloys [1, 2]. The present study will focus on the microscale deformation of austenitic stainless steels especially on the strain hardening effect at finite strains.

2. Method
Three dimensional Voronoi constructions are created to explicitly represent the realistic microstructure of the polycrystalline materials. The mechanical response of individual grains is simulated by the crystal plasticity model on the basis of thermally activated kinematics of dislocation slip to be able to account for texture evolution and anisotropic latent hardening. As an application of the presented models, finite element based micromechanics analysis of representative volume element (RVE) is carried out in conjunction with in-situ neutron diffraction (ND) measurement to investigate the microscale deformation in austenitic stainless steels under uniaxial monotonic tension.

3. Results

Fig.1 Comparison of lattice strain evolution in longitudinal direction (parallel to the loading axis) between in-situ neutron diffraction measurements and predictions of three dimensional columnar (3DC) and equiaxed (3DE) finite element models (FEM).

4. Conclusion
Predictions from finite element modelling study show very good agreement with the ND measurements, particularly providing a precise prediction on the nonlinear lattice strain response as material deforms plastically. In addition, apparent latent hardening effects of multiple slip systems are identified to alter lattice strain evolution through the modification of work hardening at the microscale.

5. References
Creep Relaxation and Crack Growth Predictions in 316H Austenitic Steel under Combined Primary and Secondary Loading

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Abstract

Compact tension 316H specimens, extracted from an as-received ex-service pressure vessel header, have been pre-compressed to different load levels in order to introduce a tensile residual stress (RS) field in the specimens. Finite element (FE) analysis has been carried out to predict the required loading level. Residual stress profiles along the crack path are also compared with those measured using neutron diffraction (ND) facilities. The creep relaxation behaviour has been studied numerically and the results have been compared with the earlier studies.

1. Introduction

Studies of creep behaviour of crucial structures such as power generation plant are always important in the category of structural integrity assessment. Type 316H-austenitic steel is a typical material used in the steam headers, working at the elevated temperature (550°C). Several procedures regarding the structural integrity assessment have been standardized [1,2] and successfully used to evaluate the effect of defects on creep behaviour. The effect of tensile RS in 316H compact tension, C(T), specimens (25mm thickness) subjected to pre-compression, has been studied in [3]. In this work, however, the combined stress effects on creep crack growth and relaxation are studied under different residual stress.

2. Method

Four C(T) specimens (Fig. 1) were extracted from a 316H header, subjected to pre-compression (53 and 65 kN) and then pre-cracked using electro-discharge machining (EDM). Neutron diffraction measurements have been carried out at E3, Helmholtz-Zentrum Berlin (HZB) to obtain the RS profile ahead of the notch. Finite element analysis has been carried out and the results have been compared to the ND data (Fig. 2).

3. Results

Figure 2. Comparison of residual stress values from the FE analysis and ND for 53 kN pre-compressed C(T)s

4. Conclusion

The measured data from ND for two C(T) specimens are in very good agreement and confirms the tests repeatability. Residual stress profiles measured using ND, provide a good agreement with the plane stress results from the FE analysis. The surface and smearing effects due to the gauge volume size may cause the disparities near the notch tip that is seen in both free edges of the specimens. It is seen that the kinematic hardening material model may improve the agreements close to the notch root by predicting a lower stress level. Though not shown here, creep relaxation behaviour was also studied numerically and compared with the earlier studies.

5. References

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-CAL⁰. 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.

References

Finite Element Modelling of Failure Behaviour in Intercalated Epoxy-Clay Nanocomposites

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Abstract
Failure behaviour in an intercalated epoxy-clay nanocomposite is analyzed with a 2D finite element (FE) model using the representative volume element (RVE) concept. The intercalated morphology of the nanocomposite is modelled with clay tactoids, randomly distributed and oriented within the epoxy matrix. Cohesive zone elements are used to model the gallery failure within each tactoid. Effects of cohesive law parameters (fracture energy), tactoid aspect ratio and clay volume fractions \( f_p \) on the macroscopic behavior of the nanocomposite are investigated. The analysis shows that the reduction of the nanocomposite strength and strain to failure is associated with the gallery failure.

1. Introduction
Available experimental results show that intercalated clay particles dispersed in a pure epoxy matrix can reduce the strength of epoxy-clay nanocomposites. It has been suggested that microcracks initiating within tactoids (in so called galleries) can be the main failure mechanism [1], leading to the strength reduction of the nanocomposite. Hence, the main objective of this work is to investigate that hypothesis using FE modelling.

2. Numerical model
Intercalated morphology of an epoxy-clay nanocomposite is represented by clay tactoids, randomly distributed and oriented in a 2D (plane strain) RVE. Those clay tactoids are modelled as stacks of clay platelets intercalated by galleries. The epoxy matrix and clay platelets are discretized by continuum elements, while cohesive elements are used to mesh the galleries. Clay platelets are assumed to be elastic and isotropic [2]. The epoxy matrix is modelled as a nonlinear Ramberg-Osgood material. Linear traction-separation laws are used to define the behaviour of the galleries. Periodic boundary conditions (PBCs) are imposed on the RVE, and the numerical homogenization is used to determine the nanocomposite response [2].

3. Results and discussion
Fig. 1 shows simulated stress-strain curves for the nanocomposites with different clay volume fractions \( f_p \) and fracture energies associated with the gallery resistance to failure, \( G_{IC} \). The stress-strain curves show that the nanocomposite strength (defined as peak stress) and strain to failure are reduced due to gallery failure. The analysis shows that the gallery failure occurs earlier for higher volume fractions of clay particles. The latter is connected with enhanced interactions between tactoids, and hence leads to the increase of stresses in the galleries. It is worth noting that the increasing clay loading suppresses plastic deformation in the matrix, on the account of higher stresses in the galleries. Also, the results predict that weaker galleries (i.e. galleries with lower values of \( G_{IC} \)) fail earlier, and lead to a significant reduction of nanocomposite peak stresses and strains to failure. Those results suggest that failure of the galleries is a mechanism responsible for the reduction of the nanocomposite strength and strain to failure. The amount of energy dissipated due to the gallery failure (defined as the difference between areas under stress-strain curves for models including gallery failure, and those for which failure was not considered, ‘NO FAIL’ curves in Fig. 1) increases with increasing volume fraction of clay particles and with decreasing \( G_{IC} \).

4. Conclusions
FE-modelling of failure behaviour in an intercalated epoxy-clay nanocomposite shows that the gallery failure is the main mechanism for strength reduction in the nanocomposite.

5. References
Fatigue Life of GFRP Tidal Turbine Blades
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Abstract
A fatigue life prediction methodology for ocean energy structures is presented. Starting with a tidal velocity model, the maximum strains in a tidal turbine blade are predicted. This is then compared to fatigue test results via a fatigue model, to give a blade life prediction. The effect of R ratio and matrix material is investigated and both are found to have significant effects on the predicted fatigue life.

Introduction
Glass-fibre reinforced polymers (GFRP) are candidate low cost materials for use in ocean energy structures. Quasi-isotropic (QI) laminates are useful where (i) the loads are not very well understood, or (ii) the loads are complex and multi-directional in nature. The fatigue of QI laminates is investigated as part of research investigating the fatigue behaviour of GFRP laminates while immersed in seawater.

Methodology
The flowchart shown in Figure 1 depicts the methodology proposed here to estimate the fatigue life of a tidal turbine blade.

Fig 1. Flowchart of fatigue life methodology

The tidal velocity is approximated by a combination of two sinusoids one that accounts for the twice daily tides and a second that models the 14 day spring-neap cycle[1].

\[ v_t = \cos(\omega_d t) [v_{ave} + v_{alt} \cos(\omega_m t)] \]

A hydrodynamic model (stream tube momentum) then converts that tidal velocity into loads on the tidal turbine blade and recommends chord lengths and angles of twist for the blade. A finite element model (e.g. Fig. 2) of a 5m blade is constructed in the ABAQUS software program using these design recommendations.

Fig. 2 Deflected shape of blade at maximum load

Following practice in the wind turbine blade industry[2] a box section spar with thick laminates is used as the main structure of the blade with lighter laminates used for the nose and tail fairings. Loads corresponding to the maximum expected tidal velocity are applied to the FE model of the blade and representative strains are extracted.
A series of fatigue tests has established a Strain/Life curve for both Vinyl Ester/E-Glass and Epoxy/E-glass quasi-isotropic laminates. This information is used in the fatigue model to estimate the life of the turbine blade under the assumed load regime. The 7 day repeating pattern in the tides is relatively short and allows explicit modelling of each rotation of the tidal turbine as a fatigue cycle. Tower "shadow" is assumed to cause unloading of the blade on each cycle. Both the case where it becomes completely unloaded (R = 0.1) and where it is 50% unloaded (R = 0.5) are considered.

Results
The combination of relatively flat ε-N curve for the material and the cyclic load spectrum modelled here leads to a high degree of sensitivity of predicted fatigue life to predicted strain level. Just 13% (epoxy) or 16% (vinyl ester) increase in strain levels will decrease life from 20 to 5 years. A detrimental effect of decreasing R-ratio is established from the fatigue test programme and associated combined structural-hydrodynamic, tidal turbine analyses. Furthermore, the fatigue "strength" of the vinyl ester matrix laminates is shown to be 25% lower than that of the epoxy laminates.

Future work
Testing to establish the effect of long term water immersion on the fatigue life of these materials is ongoing. The methodology presented here will be used to assess the impact these effects will have on the fatigue life of tidal turbine blades.

References
Influence of Fluorine and Nitrogen on the IR Transmission of Glasses

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Abstract
The influence of glass chemistry and firing conditions on the thermomechanical properties and IR transmission of aluminosilicate, sialon, fluorinated aluminosilicate and fluorinated sialon glasses has been examined. Improvements in the thermomechanical properties were achieved with increasing nitrogen content while a concomitant improvement in IR transmission was achieved under specific firing conditions.

Introduction
Glass is commonly used as a medium to transmit infrared (IR) radiation in applications. Glasses, however, normally contain water impurities in their atomic structure which are efficient absorbers of IR radiation leading to energy loss and heat generation in the glass. Commercial producers of IR glasses overcome this by employing expensive processes and ultra pure materials. The incorporation of nitrogen into rare-earth aluminosilicate glasses has previously been shown to enhance infrared transmission due to the reduction in the formation of silanols in the glass network [1]. However, the production cost of rare-earth sialon glasses, fired under reducing conditions, is not commercially viable. In this study the feasibility of using nitrogen-based glasses to reduce the occurrence of ‘water’ impurities in alkali-earth sialon glasses has been examined.

Materials and Methods

Glass compositions
Glass compositions (Figure 1) were prepared using high purity (99.9 %) reagents which were melted for 1 hr at 1500 - 1600°C under nitrogen at a pressure of 0.1 MPa. The glass melts were annealed in a muffle furnace at Tg - 30°C for 1 hr.

![Figure 1: Vertical triangular plane of the Janecke triangular prism for Ca-sialon glasses examined](image)

Materials characterisation
Powder X-ray diffraction (XRD) was performed between 10 to 70 degrees 2θ with a CuKα radiation source at 35mA, 40kV (λ = 1.540566) (Phillips X’Pert diffractometer) to confirm that the samples were amorphous. FTIR spectra (Perkin Elmer Spectrum 100) of the glass slices (thickness = 1.06 ± 0.1 mm; polished to 1μm) were collected between 4000 – 450 cm\(^{-1}\) (resolution = 1 cm\(^{-1}\), number of scans = 50).

Results
Sialons and fluorinated sialons, with different modifier cations (Mg, Ca, Sr and Ba) have been produced that show improved thermomechanical properties, compared with their oxide/oxyfluoride counterparts, and improved infrared transmission in the 2.5 – 5 μm range compared to a boro-aluminosilicate standard (Figure 2).

![Figure 2: Comparison of the FTIR transmission of F_N glasses (High purity) and the boro-aluminosilicate standard (Glass slices 1.06 ± 0.1 mm thickness)](image)

Discussion
For the Ca-oxyfluoronitrdes examined there was an increased incidence of transparent glasses produced when the Al content = 20 eq.%. Transparency may therefore be related to the number of bridging oxygens per tetrahedra (BO/T) as no transparent glasses were obtained when the BO/T > 3.33 for the base oxide. This may be related to a shift in Si from Q\(^3\) to Q\(^4\) following the addition of nitrogen and is currently being examined by Raman spectroscopy.

References
A Long-term Study of the Setting Reaction of Glass Ionomer Cements by IR

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Abstract
Changes in the positions and intensities of carboxylate stretching modes during the setting reaction of dental restorative experimental glass ionomer cements (GICs) have been monitored by FTIR.

Introduction
Numerous approaches have attempted to characterise the changes that occur in the cement matrix of GICs during setting including FTIR \cite{1}, Raman \cite{2} and MAS-NMR (\textsuperscript{13}C NMR \cite{3} and \textsuperscript{27}Al MAS-NMR \cite{4, 5}). This has resulted in alternative hypotheses having been proposed to account for the long-term changes observed in the mechanical properties but the mechanism of these changes is not fully understood \cite{4}. In this study, changes in the carboxylate stretching modes during the setting reaction have been monitored by FTIR.

Materials and Methods
Glass compositions
The frits of the glass compositions (Table 1) were attrition milled to produce powders with a $d_{50}$ of approximately 5 µm.

Table 1: Pre-firing constituent molar ratios of the experimental glasses

<table>
<thead>
<tr>
<th>Glass</th>
<th>SiO$_2$</th>
<th>Al$_2$O$_3$</th>
<th>P$_2$O$_5$</th>
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</tr>
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<td>LG26Sr</td>
<td>4.5</td>
<td>3</td>
<td>1.5</td>
<td>-</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>ART10</td>
<td>4.5</td>
<td>3</td>
<td>0.75</td>
<td>-</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Cement Design
The cements were mixed at powder (glass + poly(acrylic acid) (PAA\textsubscript{200}) (Mw = 210,300; Mn = 111,300):water ratio of 3:1. The glass:PAA ratio was varied so that the charge g$^{-}$ of the glass in the cements was constant. At various times after mixing the samples were immersed in nitrogen (l), frozen (-20 °C, >24 hrs), freeze-dried (-60 °C, > 1 atm, 3 days), gyromilled and sieved < 45 µm.

FTIR measurements
ATR-FTIR spectra (Perkin Elmer Spectrum 100; zinc selenide crystal) of the cements (< 45 µm) were collected between 4000 – 600 cm$^{-1}$ (resolution = 1 cm$^{-1}$, number of scans = 50). Background spectra were subtracted from the sample spectra, which were normalised using 1800 cm$^{-1}$ as the zero point. Deconvolution of the spectra was performed using a Gaussian model (Peak Fit (Version 4)).

Results
It is suggested that the setting reaction of the LG125 and LG26Sr cements are essentially the same, while the ART10 cements display an extended secondary hardening phase (Figure 1). The extended time frame of the secondary hardening phase in the ART10 cements may be due to the low phosphate content of the ART10 glass which renders the glass more susceptible to dissolution and ion release. This view is supported by the observed changes in the glass peak positions and intensities in the ART10 cements while no significant difference in this peak is observed between the 28 day and 12 month spectra of the LG125 and LG26Sr cements.

Deconvolution of the spectra was performed using a Gaussian model (Peak Fit (Version 4)).

Table 1: Pre-firing constituent molar ratios of the experimental glasses

<table>
<thead>
<tr>
<th>Glass</th>
<th>SiO$_2$</th>
<th>Al$_2$O$_3$</th>
<th>P$_2$O$_5$</th>
<th>CaF$_2$</th>
<th>SrO</th>
<th>SrF$_2$</th>
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<td>LG125</td>
<td>4.5</td>
<td>3</td>
<td>1.5</td>
<td>2</td>
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<tr>
<td>LG26Sr</td>
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<tr>
<td>ART10</td>
<td>4.5</td>
<td>3</td>
<td>0.75</td>
<td>-</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 1: Change in the degree of crosslinking (DCL) of the ART10-PAA\textsubscript{200} cements over 12 months. Values of DCL were determined by the peak areas of the $\nu$C-O COO(Al) (1450 cm$^{-1}$), $\nu$C-O COO(Ca,Sr) (1407 cm$^{-1}$) and $\nu$C=O of the COOH (1700 cm$^{-1}$) from the ATR-FTIR

References
Phase Decompositions of Bioceramic Composites

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Abstract
The effects of increasing zirconia (ZrO$_2$) content on the phase stability of microwave sintered Hydroxyapatite (HA) were examined. An increase in the amount of zirconia content led to a substantial increase in the decomposition of HA to Tricalcium Phosphate (TCP). The decomposition was also found to be temperature dependant, with greater temperatures leading to increases in the amount of decomposition.

1. Introduction
Calcium phosphate based ceramics, in particular hydroxyapatite [Ca$_{10}$(PO$_4$)$_6$(OH)$_2$, HA], have generated a significant amount of attention as replacements for hard tissue due to their biocompatibility, bioactivity, osteoconductivity and direct bonding to bone tissue [1]. However, HA is generally limited to non-load bearing applications and metal implant surface coatings due to its limited mechanical properties [2]. This has led to attempts at using ZrO$_2$ as a reinforcing phase. In particular, Yttria doped tetragonal zirconia polycrystals (Y-TZP) tend to be the most widely used zirconia ceramic for biomedical applications due to the retention of the “metastable” tetragonal phase, thus maximising the toughening mechanism [3]. Studies on the formation of HA-ZrO$_2$ composites suggest that ZrO$_2$ can lead to decomposition of HA using conventional sintering techniques [4]. This study examines the effect of a microwave sintering technique on the phase compositions of HA-ZrO$_2$ composites.

2. Materials and methods
Laboratory synthesized HA and composites containing 0, 5 and 10 wt% ZrO$_2$ (3Y-TZP, Tosoh, Japan) were milled and uni-axially pressed to form pellets ~ 2mm thick and 20 mm in diameter. Pellets were sintered using a hybrid microwave furnace at temperatures of 1000-1300°C. X-ray diffraction (XRD, Philips X’Pert) was performed on the sintered pellets. The XRD patterns were then matched to patterns in the JCPDS database, using the X’Pert software, to determine the phases present. Quantitative analysis was performed using Rietveld analysis.

3. Results & Discussion
In terms of phase stability it was found that the decomposition of HA to $\alpha$ and/or $\beta$-TCP increased with increasing temperature and was found to increase in microwave sintered samples at 1300°C, Figure 1.

![Figure 1. Phase composition of composites containing 5 wt % ZrO$_2$](image)

It was also found that CaO released through the decomposition of HA reacted with the ZrO$_2$ reinforcing phase to form either a c-ZrO$_2$ solid solution and/or CaZrO$_3$ above temperatures of 1100°C.

4. Conclusion
Microwave sintering of HA-ZrO$_2$ compositions resulted in the decomposition of HA to TCP. The amount of degradation was found to be dependent on both the quantity of ZrO$_2$ present and the sintering temperature, with increases in either leading to increased decomposition.

5. References
Abstract

Laboratory synthesized hydroxyapatite (HA) and commercial nano-sized zirconia (ZrO$_2$) were comparatively sintered using conventional and microwave methods at temperatures of 700, 1000, and 1200°C. The microwave sintered (MS) samples show less decomposition than their conventionally sintered (CS) counterparts. Stabilisation of the ZrO$_2$ phase occurs in small amounts in both the CS and MS samples at 1200°C. Increasing sintering temperature increases density, with no discernable difference between regimes at 1200°C. The change in relative density is determined as the main controlling factor over the mechanical properties. The nano-sized ZrO$_2$ has no strengthening effects. Instead it works to hinder densification.

1. Introduction

Due to its resemblance to the mineral phase of bone, hydroxyapatite (HA) [$\text{Ca}_10(\text{PO}_4)_3(\text{OH})_2$] is used in an increasing number of medical applications. HA has been shown to be both bio-compatible and osteo-conductive [1], allowing it to promote new bone growth in-vivo without eliciting an immune response. The inherent low mechanical strength and brittleness of HA have excluded its employment as a load bearing implant. Sintering at high temperatures can result in the formation of calcium phosphate based decomposition products that, in certain instances, have been reported to adversely affect biological response [2]. Zirconia (ZrO$_2$) has a high fracture toughness and is relatively bio-inert, and as such provides an ideal toughening material for implant applications. However, high sintering temperatures are required to fully densify ZrO$_2$. In this work HA-ZrO$_2$ composites have been fabricated from nano-sized powders to reduce the activation energies necessary to cause densification. In addition, microwave sintering is used to reduce sintering temperatures.

2. Materials & Methods

Laboratory synthesized HA, which was evaluated for quality, was ball-milled with 0, 1, 2, 3, 4 and 5wt% commercial nano-sized ZrO$_2$ powder to ensure homogeneity and to break up any soft agglomerates. Cylindrical green bodies ~3mm thick & ~19mm Ø were uniaxially pressed (5000 Kg, 20 seconds). Comparative microwave and conventional sintering regimes were done on the samples. The physical and mechanical properties were then determined.

3. Results & Discussion

Increasing sintering temperature increases relative density over all compositions. Relative density is the major controlling factor over BFS, Figure 1.

![Figure 1: Average BFS vs. relative density.](image1)

Hardness shows very similar trends to relative density over the sintering range of 700-1200°C. Grain size has no effect on the mechanical properties. Increasing ZrO$_2$ content does not increase BFS or hardness; instead it reduces these properties. It is hypothesized that the ZrO$_2$ particles impede densification by segregating at the grain boundaries, hence increasing porosity.

Figure 2: Fracture surface SEM of HA (grey) with 5wt% ZrO$_2$ (white) CS at 1200°C.

4. Conclusion

Microwave sintering has no advantage over conventional sintering in HA-ZrO$_2$ composites. Nano-sized ZrO$_2$ impedes densification, reducing the mechanical properties.

8. References


High Resolution Microscopical Analysis of Metallurgical Grade Nanoporous Silicon Particles

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Abstract
Porous silicon finds numerous applications in the areas of bio-technology, drug delivery & energetic materials. This work studies the structural morphology of chemically etched porous silicon particles using high resolution electron microscopy techniques combined with porisometry type measurements. The surface pore structure is examined in detail using Scanning Electron Microscopy and Transmission Electron Microscopy while the internal pore structure is explored using Focused Ion Beam milling and Ultramicrotomed cross-sections.

1. Introduction
Porous Silicon (PS) is a sponge like structure that is formed when bulk Silicon (Si) is etched either chemically or electrochemically in hydrofluoric acid based solutions [1-4]. Since Canham made the discovery of its room temperature photoluminescence [1-3], subsequent research followed focusing on developing possible PS applications in such areas as microelectronics, chemical and biological sensors [4]. Mesoporous and nanoporous Si is also currently being investigated for drug delivery, bioactive and energetic materials applications [5, 6, 7]. The possible applications of PS would now seem abundant and therefore microscopical analysis of the material is critical to aiding in the development of new PS applications. Vesta Sciences have recently developed PS nanosponge particles from metallurgical grade Si through their own patented chemical etching process (Irish patent no. IE20060360). The work presented here, studies the structural morphology of these PS nanosponge particles using high resolution microscopy techniques to fully characterise the material. The related surface pore structure is examined in detail and the internal pore structure is explored using a combination of sample-prep methods and FIB milling, SEM, TEM & Helium Ion Microscopy.

2. Results/Discussion
The results of the etched material indicate a disordered pore structure with pore diameters ranging from 10-15nm on particles ranging from 4-6µm. When particles were viewed in the [100] and [111] crystallographic directions, the pore size appeared to be the same for both directions but are however, larger on thinner Si structures. Internal pore data indicated pore depths of up to 500nm on some particles with smaller Si particles appearing more porous internally compared to the larger Si particles. All microscopy results were compared with porisometry type measurements.

3. References
A Novel Bioreactor for Biodegradable Alloy Assessment in Physiologically Realistic Environments

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Abstract
To date, in vitro studies on biodegradable alloys failed to reproduce results from in vivo tests. Therefore, in order to obtain more reliable corrosion rates, a more realistic representation of the in vivo interface is required. This is addressed in this study by the design of a new bioreactor to reproduce an environment closer to the in vivo one.

1. Introduction
Stents are commonly used to treat atherosclerosis by providing mechanical support to the artery vessels, preventing early recoil. Since remodeling of arterial vessels is expected, the role of the stent should be temporary. However current stent technology is based on permanent implants which can eventually lead to long term complications. Stents that will gradually dissolve in the body, or biodegradable stents, have the potential to provide initial scaffolding and avoid long term clinical problems.

Disparities between magnesium absorbable stent (MAS) behavior in vivo and in vitro have been reported in literature which suggests that in vitro test may not fully capture transport conditions in the body [1]. Moreover MAS are subject in vivo to fluid flow and covered by a layer of neointima within a few weeks of deployment. Therefore the aim of the present work is the development of a new bioreactor allowing the evaluation of realistic corrosion rates of biodegradable alloys.

2. Methods
The bioreactor developed in this study (Fig. 1) consists of a parallel plate flow chamber where fluid flows over alloy samples. A uniform and constant shear ($\tau_w$) stress is applied to the alloy samples for a given flow rate ($Q$) according to:

$$\tau_w = \frac{6\mu Q}{wh^2}$$ (1)

CFD Analysis has been performed in order to verify that flow in the channel is laminar and that the shear stress is uniform and falls in the physiological range [2].

Preliminary studies on the effect of proteins on degradation behavior of a biodegradable alloy were performed in static solutions of Hanks’ salts and endothelial cell growth medium.

Studies of cell viability on biodegradable alloy samples in static environment have also been performed.

3. Results
Lower corrosion rates were observed in the protein containing media, shown in Fig. 2. A lower cell viability was noted on the biodegradable alloys compared to the control of tissue culture treated plastic.

4. Discussion
Protein containing medium slows down the alloy corrosion rate. This shows closer agreement with the in vivo results [1] than immersion in simple saline based solutions and is also preferable for stent applications. The lower cell viability observed may be accounted through the introduction of dynamic flow conditions in the bioreactor developed in the study.

References
An Experimental and Numerical Analysis of the Dieless Drawing of Nickel Titanium Alloy
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Abstract
The considerable die wear that occurs at the tool-die interface during production of wire using a conventional drawing method of a die to reduce its diameter, coupled with the additional lubrication and pre-cleaning costs, add considerably to the overall cost of the process, [1]. A process known as dieless drawing has the potential to reduce the costs of production and improve the properties of the finished product, [2]. An experimental rig for dieless drawing was previously designed, built and successfully operated at the University of Limerick [3]. The next step in the development of this process is to develop 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. Good agreement has been shown between experimental and numerical results.

1. Introduction
The process of dieless drawing is an innovative method for the production of wire without the use of reduction dies, which is best suited to material forms that currently have high production costs and are difficult to produce using the conventional method. The shape memory material, Nitinol presents such difficulties during production due to its high toughness and work-hardenability[4]. Nitinol is widely used in wire and tube form in the biomedical industry as guidewires for deploying stents, angioplastic balloons and filters, and as self-expanding stents which are precision laser-cut from thin walled tubing[5, 6].

2. Experimental Method
An initial test of ten NiTi rods of 5mm diameter was carried out on the dieless drawing machine. Successful rod drawing tests were carried out at temperatures of 800°C. An initial drawing velocity of 3mm/min and heater/cooler assembly velocity of 12mm/min was applied to the rod, giving a process ratio of 0.25. 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.

3. Results and Discussion
The percentage reduction per pass was measured over the steady state length of drawn rod to be 51.8% to a diameter of 3.47mm for a rod drawn with a drawing velocity of 5mm/min and a heating/cooling velocity of 12mm/min. The final rod length was extended by 143mm. A smooth, even, oxidized surface resulted from the single pass dieless draw.

The finite element model developed has accurately predicted 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.

The experimental results have shown the possibility to reduce the number of passes and subsequent heat treatments required in fabricating Nitinol wire.

4. Conclusion
The cross-section of 5mm diameter NiTi rods were successfully reduced using the dieless drawing method at temperatures of 800°C.

Further work is required to define the material behavior under load at elevated temperature. A more accurate definition of the interaction between the rod and the heating/cooling environment of the machine is also required.

5. 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

Thermomechanical characterisation of P91 power plant components

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Abstract

A time-dependent, elastic-plastic-creep, thermomechanical methodology has been developed to characterize P91 power plant components subjected to realistic loading conditions.

1. Introduction

9-12%Cr ferritic steels are commonly used in fossil fuel power plant. 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]. Concomitantly, changes in the operational schedule of current plant from ‘base load’ operation to ‘load-following’ (in order to facilitate electricity supply due to the unpredictable output of wind and other such renewable energy sources) exposes plant to an increased frequency of thermal and pressure cycles, thus increasing the risk of thermal fatigue.

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 process is based on published experimental material data from [2-4]. This material model encompasses cyclic isotropic hardening/softening effects, non-linear kinematic hardening effects, strain rate (viscous) effects, as shown in Figure 1 (a to d).

Figure 1 Isothermal hysteresis loops for P91 material at different temperatures: softening effects shown in a - c and strain rate sensitivity effect in d.

3. Methodology

A methodology was then developed to incorporate the cyclic viscoplasticity model into time-dependent, thermo-mechanical analysis of P91 power plant components, as depicted in Figure 2.

3.1 Power plant operating cycle

Figure 3 shows measured steam temperature and pressure, and outside surface temperature histories of a power plant pipe steam header. This history represents a routine start-up of plant from ambient conditions, attaining an intermediate fluctuating temperature, associated with attemperation, before temperature and pressure increase to fully operational conditions of 500 °C and 17 MPa, for a period before cooling to ambient conditions (the process is repeated for three consecutive cycles). The measured data of Figure 3 was used as input to the thermomechanical analysis.

3.2 Thermal model

The thermal model employed for the plant cycle incorporates: (i) forced steam convection on pipe inside surface, based on measured time-dependent steam temperature data, e.g. Figure 3, (ii) transient conduction through pipe wall (with temperature-dependent properties [4]) and (iii) natural convection on pipe outside surface.

4. Results and Conclusion

A cyclic viscoplasticity material model has been developed for multiaxial thermomechanical analysis of P91 material. A transient thermo-mechanical analysis methodology has been developed for P91 power plant components, incorporating a transient thermal model and a multiaxial viscoplasticity model. Figure 3 (inset) shows typical predicted thermomechanical loops for power plant pipes. Stress ranges of more than 300 MPa with tensile mean stresses were predicted, with significant cyclic inelastic strains of at least 0.2 %.

5. References

Investigations into Multi-Stable Laminates
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Abstract
The cured shapes of multi-stable composite laminates are investigated. In certain cases, composite laminates featuring an unsymmetrical lay-up sequence have been observed to differ in shape from the predictions of Classical Laminate Theory (CLT). Continuing from existing theory, a mathematical model has been developed to predict the cured shape of unsymmetrical laminates. Current research aims to characterize viscoelastic and environmental effects, using numerical analyses and experimental techniques, such as Dynamic Mechanical Analysis (DMA), Differential Scanning Calorimetry (DSC), Finite Element (FE) modelling, and MATLAB. Digital Image Correlation (DIC) will be used to record the cured shape of laminates to compare experimental results with theory.

1. Introduction
Carbon Fibre Reinforced Plastic (CFRP) is a composite material that has a polymer (typically epoxy) and a fibre (carbon) as its two base constituents. The material can offer an excellent strength-to-weight ratio, an increase in fatigue life, a reduction in corrosion issues, and an increase in stiffness when compared to many metals. Use of this material in high performance applications has increased steadily, with the latest generation of airliners (such as the Boeing 787) now using CFRP for 50% of its primary structure. One of the most popular methods of manufacturing composite parts involves using pre-preg plies (sheets of carbon fibres already impregnated in a polymer). Stacking these sheets (i.e. ‘laying up’) in a particular order allows engineers to tailor the properties of the structure to suit the loading it will experience. Once stacked, the laminate is cured in an autoclave at an elevated temperature and pressure. Multi-stable laminates are a family of unsymmetrical laminates, which, once cured, can display two or more stable shapes. The shapes can be ‘snapped’ from one shape to the other by a manual force application. No force is required to hold a laminate in a particular shape. This property is considered to offer several novel engineering applications; from simple access panels and shut-off valves, to morphing (i.e. adaptable) aircraft wings. As force is only required to snap the laminate from one shape to another, multi-stable composites can reduce the requirements of actuating mechanisms and thus reduce the weight and complexity of the system.

2. Manufacture of multi-stable laminates
Multi-stable composite laminates are manufactured by exploiting a property that, in normal applications, is negated by the symmetry of the lay-up – this is, the difference in Coefficient of Thermal Expansion (CTE) between the longitudinal and transverse direction of a CFRP ply. The laminate is initially flat, at the elevated temperature in the autoclave. During cool-down from the curing temperature, the miss-match in CTE produces residual stresses within the laminate. Due to the unsymmetrical lay-up sequence of the laminate, the residual stresses are unbalanced about the mid-plane and thus cause the laminate to warp. Classical Laminate Theory (CLT) can be used to predict the room temperature shapes of such laminates. For a cross-ply laminate (e.g. a [0\(_2\)/90\(_2\)] lay-up), CLT predicts a ‘saddle’ shape, with curvatures about the x and y axes. However, when manufactured with certain characteristics (i.e. length-to-thickness ratio, temperature change), the laminates exhibit multi-stable behaviour. The two shapes are cylindrical, with their generators lying on two mutually perpendicular axes and opposite curvature. CLT does not predict this behaviour.

3. Current research
Several techniques are being used to study this behaviour – these include (1) mathematical modelling to predict the shapes; (2) Finite Element Analysis (FEA) to validate the experiments; (3) Digital Image Correlation (DIC) to record the shapes of the manufactured panels; and (4) Dynamic Mechanical Analysis (DMA) and Differential Scanning Calorimetry (DSC) to investigate polymer properties. A mathematical MATLAB model that uses the Rayleigh-Ritz method and the minimization of potential energy has been developed, based on existing theory. The theory differs from CLT as a geometric non-linearity is introduced, and can predict the shapes of a cured laminate, as well as the bifurcation point. Future work (which is poorly addressed in the literature) will explore other factors that affect the residual stresses within the laminate (e.g. moisture and viscoelasticity). DMA and DSC will be used in conjunction with FEA (ABAQUS) to characterise the changes in residual stress state caused by these factors. The results of this work will be introduced into the MATLAB model to predict the shapes of multi-stable laminates over time. To compare experimental work against theory, DIC will be used as a non-contact method of measuring and recording the shape of laminates. Additionally, the effect of externally applied stresses on the residual stress state, and the resulting changes in stable shapes will be investigated. This is required to determine the behaviour of such laminates when used as part of a structural component.
A multiaxial damage mechanics methodology for fretting fatigue prediction

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Abstract

A multiaxial damage mechanics methodology is developed to predict fretting crack nucleation. Material degradation and wear behaviour are predicted incrementally during each fretting cycle using an energy-based wear simulation method. A combined wear-fatigue methodology is implemented in a finite element (FE) adaptive mesh framework. Predictions are validated against published data.

1. Introduction

Fretting occurs when two contacting bodies experience small amplitude oscillatory motion. Fretting in different layers of flexible marine risers is one application of the present work. The aim is to develop a continuum damage mechanics (CDM) methodology for fretting fatigue prediction. Two specific contact arrangements -- round-on-flat (RF) and rounded punch-on-flat (RPF) are compared in terms of the prediction of evolution of wear, plasticity, fatigue damage and the contact geometry across a range of fretting variables. An incremental wear simulation method based on the energy approach of Fouvry et al [2] and previous work [1] is implemented within an adaptive mesh user subroutine. A non-linear kinematic hardening plasticity formulation is employed along with a critical-plane, Smith-Watson-Topper approach to predict multiaxial fretting crack nucleation. Wear evolution and crack nucleation predictions are validated against existing published data for Ti-6Al-4V [1]. CDM (user subroutine) implementations of the uniaxial Basquin equation and multiaxial Lemaitre and Chaboche [3] cumulative fatigue damage model are developed. To apply this fretting methodology to flexible riser pressure armour layer material, a tribology test programme is proposed.

2. Method

Fig 1 shows FE models of the RF and RPF contact geometries for fretting wear simulation. Hertzian theory was used to validate the initial (no-wear) stress and contact pressure distributions. Non-linear kinematic hardening plasticity is employed to capture a cyclic plasticity ratchetting phenomenon.

For both the gross slip (no stick) and partial slip (central stick region) fretting regimes, a user subroutine UMESHMOTION was used to incrementally simulate wear damage, based on the energy wear approach proposed by Fouvry et al [2]. A multiaxial implementation of the Lemaitre and Chaboche non-linear-continuous-damage (NLCD) model [3] is adopted to predict the evolution of fretting-induced fatigue damage via a UMAT user subroutine. The evolution of multiaxial damage is given by:

\[
dD = \left[ \frac{A_{II}}{M_e(1-3\beta_2}\sigma_{H,mean}) (1-D) \right]^\beta dN
\]

where \( A_{II} \) is the amplitude of octahedral shear stress and \( \sigma_{H,mean} \) is the mean hydrostatic stress. The material is softened by the damage as follows:

\[
E = E_0(1-D)
\]

3. Results and conclusion

A validated fretting wear-fatigue methodology has been developed for Ti-6Al-4V. The key role of slip regime for crack nucleation is highlighted. Wear is predicted to have a significantly more profound effect on fatigue crack nucleation life for the RF case, reducing life in the partial slip regime and increasing it in the gross slip regime. The predicted (with wear) life for the RPF geometry under nominally identical load conditions, is significantly larger than for the RF case at low displacements but similar at high displacements. Fig 2 shows the predicted evolution of fatigue damage.

4. References

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Synthesis and characterisation of strontium sialon (Sr-Si-Al-O-N(F)) glasses
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Abstract
Sr-Si-Al-O-N-F glasses have been synthesised and their thermo-mechanical properties examined. The density, Young’s modulus, microhardness and glass transition temperature of the glasses increased with increasing nitrogen content. The addition of fluorine had little effect on the physical properties of the glasses but caused a reduction in the thermal properties. Nitrogen and fluorine are shown to cause independent changes in the glass structure.

1. Introduction
SiAlON glasses are of interest as they possess superior thermomechanical properties compared with other glasses [1]. The structures of SiAlON glasses are comparable to those of aluminosilicates but in SiAlONs some of the oxygen atoms are replaced by nitrogen. Oxygen substitution by nitrogen in the glass network increases the crosslink density (CLD) and results in an increase in thermomechanical properties compared to those of the pure oxide glass [2]. The incorporation of fluorine into Ca-SiAlONs has been shown to reduce the glass transition temperature (Tg) without significantly influencing the mechanical properties [3]. In this study the influence of strontium on the thermomechanical properties of SiAlON(F) has been examined.

2. Experimental
2.1. Glass synthesis and heat treatment
Glass compositions (in eq.%) 56Si:16Al:28Sr:(100-(x+y))O:xN:yF (where x = 0 – 40 eq.% and y = 0 or 1 eq.%) were prepared using high purity (99.9 %) reagents which were melted for 1 hr at 1650°C under nitrogen at a pressure of 0.1 MPa. The glass melts were cast into blocks in pre-heated graphite moulds and annealed in a muffle furnace at 780°C for 1 hr.

2.2: Materials characterisation
Powder X-ray diffraction (XRD) was performed between 10 to 70 degrees 2θ with a CuKα radiation source at 35mA, 40kV (λ = 1.540566) (Phillips X’Pert diffractometer). Simultaneous thermogravimetric and differential thermal analyses (TG/DTA) was performed (SDT Q600 (TA Instruments)) between 20 to 1400 °C at a heating rate of 10 °C min−1 in an oxygen-free nitrogen atmosphere. The bulk density of the glasses was measured by the Archimedes displacement technique (ASTM C373-88), Young’s modulus (E) was measured at room temperature using the ultrasonic pulse-echo-overlap technique (ASTM E494-92) and the microhardness (Hv) was measured (LECO (M400 G1) Microhardness Tester) in accordance with ASTM E 384-89.

3. Results and Discussion
All samples were verified as being amorphous by XRD. The change in the Hv and Tg with nitrogen content are indicated in Figure 1 and Table 1. Hv and Tg increase with increasing nitrogen content but a the addition of 1 eq.% fluorine results in a decrease in Tg. This confirms the decrease in Tg with fluorine content without an influence on the network forming ability of nitrogen.

4. Conclusion
Up to 30 eq.% N can be achieved in the Sr-Si-Al-O-N(F) system. Density, Young’s Modulus, and Microhardness increase with nitrogen incorporation into the glass. The glass transition temperature also increases with N content but it is counterbalanced by the addition of F.

5. References
The effect of citrate ester plasticizers on the thermal and dynamic mechanical properties of Poly (DL lactide) for use as medical implants

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Abstract
Poly (D,L lactide) (PDLLA) was blended with three different citrate ester plasticizers and the resultant blends were analyzed using differential scanning calorimetry (DSC) and dynamic mechanical thermal analysis (DMTA). Each plasticizer was miscible with the polymer for all compositions and with increasing plasticizer content a decrease in \( T_g \) was obtained.

1. Introduction
Developing degradable polymers as medical implants is of great research interest. Polylactide (PLA) is a thermoplastic polymer with hydrolytically labile aliphatic ester linkages in its backbone. It is considered safe, non-toxic and biocompatible for use as an implantable biomaterial. However, PLA devices tend to be susceptible to fracture when subjected to tension or load bearing stresses during use. [1]
In order to modify its properties, PDLLA has been blended with citrate esters plasticizers, which are non-toxic and approved for use in medical plastics.

2. Methods
Poly (D,L lactide) (PDLLA) was blended with three different citrate esters; triethyl citrate (TEC), tributyl citrate (TBC) and acetyl tributyl citrate (ATBC) and the resultant thermal and mechanical properties were analyzed. DSC was preformed using a Perkin-Elmer Pyris 1 DSC, while DMTA scans were carried out using a Rheometric scientific mark 3.

3. Results
3.1. DSC
Each plasticizer was miscible with the polymer for all compositions as only one \( T_g \) was noted. By increasing plasticizer content a decrease in \( T_g \) occurs which is true for all three plasticizers analyzed. The smaller molecules of TEC are more effective at enhancing chain mobility and this effectiveness is reduced with the increasing molecular size of the plasticizer.

3.2. DMTA
With increasing plasticizer content a decrease in \( T_g \) is also obtained, but \( T_g \) values are higher then those obtained by DSC. At temperatures above the \( T_g \), the storage modulus of each sample drops dramatically due to the softening of the polymer specimens. Below \( T_g \), the storage modulus values are highest. With increasing plasticizer content there is a decrease in storage modulus values as the plasticizer increases the mobility of the polymer chains.

Figure 1: \( T_g \) as a function of plasticizer content obtained by DSC for PDLLA samples plasticized with different citrate esters

Figure 2: Storage modulus curves obtained by DMTA for PDLLA and PDLLA samples plasticized with TBC

4. Conclusion
Each citrate ester was a suitable plasticizer for PDLLA. With increasing plasticizer content a decrease in \( T_g \) is obtained. The \( T_g \) values obtained by different experimental techniques lead to different \( T_g \) values due to the frequency of the analysis method.

8. References