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Brain Haemorrhage Detection through SVM Classification of Impedance Measurements

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Abstract— **Machine Learning is becoming increasingly important in interpreting biological signals. In this work, we examine the potential for classification in brain haemorrhage detection. Numerical head and brain models with and without haemorrhagic lesions are designed. Impedance measurements from an electrode array positioned on the exterior of the head are used to train and test linear support vector machine (SVM) classifiers. The results show that this emerging measurement technique may have promise for detection and diagnosis of brain haemorrhage when coupled with such classifiers.**

I. Introduction

The ability to definitively identify the presence or absence of a haemorrhage is of great importance in conditions such as stroke and traumatic brain injury. Impedance measurement is an emerging technique that shows detectable differences between normal brain tissues and haemorrhagic lesions [1], [2]. One imaging modality, electrical impedance tomography (EIT) is based on impedance measurements obtained from an electrode array placed on the exterior of a region of interest, for example the scalp [3]. The objective is to reconstruct an image from these measurements. However, the success of EIT has proven challenging for a variety of reasons, including issues around accurate image reconstruction [4]. In this work, EIT measurement sets from numerical models of the head and brain, with and without haemorrhagic lesions, are used to train and test linear SVM classifiers. The use of classifiers bypasses the need to reconstruct an image, and hence avoids reconstruction issues.

II. Methods

Numerical models of the head and brain were developed with varying head and brain size, electrode location, and size and positioning of lesions. Simulated noise levels were also varied. EIT measurement sets were recorded from a wide variety of test cases and used to train and test linear SVM classifiers. By varying which parameters of the training and test sets were fixed and variable in different experiments, the performance of the classifiers in a range of conditions was assessed. For each experiment, the classifier was first trained and then tested on independent data sets. A bleed was classified as a (+) result, with a normal brain assigned as (-). It was found that the classifier performed well (sensitivity and specificity of 90% +) down to a noise level of approximately 60 dB, was unaffected by lesion location, was robust in detecting lesions down to 10 ml in volume and was unaffected by slight variances (±2 cm) in positioning of the electrodes. However, performance was poor for unseen head and brain combinations indicating a need to train on a wide variety of different anatomies. Overall experiments with ~140 000 training cases and ~14 000 test cases, with all parameters varied, exhibited strong performance as shown in Table I, indicating the classification technique is robust when the training set is sufficiently large.

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TABLE I. SENSTIVITY AND SPECIFITY OF LINEAR SVM CLASSIFIER ON LARGE FINAL TEST SET AT VARIOUS NOISE LEVELS

Noise Level	Sensitivity	Specificity
80 dB	0.921	0.924
60 dB	0.903	0.914
40 dB	0.716	0.721

III. Conclusions

Applying classification to EIT impedance measurements is a promising approach worthy of further investigation. Often in clinical cases, such as stroke and traumatic brain injury, the requirement is to rule in or rule out the presence of a haemorrhagic lesion, and to achieve this outcome an image, the traditional endpoint of EIT, is not necessary. This study demonstrates that a simple classifier, linear SVMs, show great promise when applied to such scenarios, with high sensitivity and specificity to the presence of haemorrhagic lesions. The results however would be expected to deteriorate in clinical practice, based on patient variations in anatomy, noise and drift in the measurement equipment, imperfect electrode contact, and imperfect electrode placement. The long-term challenge will be to maintain the level of clinical performance in the presence of these real-world confounders.

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