Arrhythmia Analysis in the Community

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Abstract – The Centre for Neural Computing Applications, Department of Design, Brunel University, established a reliable and repeatable approach to the analysis of cardiac arrhythmias using neural networks. The technology was embodied in an easy-to-use portable monitor that detects the patients' electrocardiograph (ECG) and processes the signal in real-time so that analysis can be reported on a beat-by-beat basis. Consideration was given to the issues surrounding the presence of false alarms (false positives) and missed alarms (false negatives), which define the boundary limit of performance in the real world. The results of a year-long trial using the portable monitor are presented in summary form.

Key words – arrhythmia, ECG, neural networks, sensitivity and specificity, false positives, false negatives

I. Introduction

The demographics of the ageing population indicate the need for new techniques in the management of healthcare. Forecasts by the United Nations[1] for 2020 suggest that the percentage of over-65s in the UK population will have risen by 23.6%. Cardiovascular disease (CVD) is the most widespread cause of death, and is likely to present the major burden in healthcare costs in the future. Early diagnosis and treatment of CVD, for example diagnosis and treatment of atrial fibrillation as part of a stroke prevention programme, presents an opportunity to improve the quality of life of individuals and at the same time reduce the demand for stroke treatment.

II. Clinical basis

One of the precursors for the presence of CVD is the appearance of cardiac arrhythmias, and usually these are asymptomatic in the early stages of the disease. As the disease progresses, patient symptoms appear, such as:

- Palpitations;
- Dizzy spells;
- Fainting.

Such symptoms may not be cardiac in origin and it is important that appropriate diagnoses are made in as timely and cost-effectively a way as possible.

III. Technology

Research was carried out at Brunel University into the use of neural networks for the analysis of ECG signals[2]. Research and development[3] continued at Cardionetics Ltd, a start-up founded to commercialise the technology, which has led to the development of an automated arrhythmia monitor that has the potential for widespread adoption in early diagnosis of CVD.

The embodiment of the neural network technology in a self-contained ambulatory device suitable for use in a primary care setting has resulted in an estimated 60,000 tests being performed on patients in the UK since 2000. It is estimated that some 500 to 750 patients are being successfully treated for life-threatening arrhythmias every year as a result.

Figure 1. The Portable Arrhythmia Monitor in use

IV. Trial results

As part of the validation process, a yearlong controlled trial was carried out, as reported in the British Journal of Cardiology[4]. A summary of the results is presented in Table 1 below. The benefit of using intelligent monitoring is a significant reduction in the false positive rate, and a small, but important, improvement in detecting false negatives.

Without Monitoring		**With Monitoring**	
Positives	66.3%	True Pos.	18.4%
		False Pos.	47.9%
Negatives	33.7%	True Neg.	27.4%
		False Neg.	6.3%

Table 1. Trial Results summarised.

V. Screening Issues

In a primary care setting, ECG analysis is carried out in response to patient symptoms; if the application is extended to include general screening, it introduces some issues that need to be addressed.

To illustrate the challenges facing designers of automated sensor and decision-making systems, a generalised model has been developed[5]allowing consideration of the limitations that arise in automated decision-making processes.

The main features of neural network techniques as implemented are described:

- STRENGTHS: Generalisation, robustness, tolerance to noise, graceful degradation and speed of analysis;
- WEAKNESSES: A priori data required, and lots of it, that is “gold standard”, sensitivity to pre-processing changes, and the lack of explicit rules.

VI. Discussion and Conclusions

The decision-making model proposed in this paper helps identify that some conditions will arise that could go undetected. Whether these are important can only be judged on a case-by-case basis. It is possible to measure the levels of false positives and negatives that occur within the constraints set by the detection and decision-making system, but these represent only a sub-set of all events that can occur.

Care must be taken in any automated decision-making process to ensure the causes of false negatives are identified, even though it may not be possible to resolve all these causes within any particular system. For further information contact:

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