DETECTING ATRIAL FIBRILLATION FROM WEARABLE SENSOR SIGNALS

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SUMMARY
Atrial fibrillation (AF) is one of the most common heart arrhythmias, and increases the risk of adverse events such as strokes. AF causes the heart rhythm to be highly irregular, making it possible to detect it from signals such as the electrocardiogram (ECG) which measure the timing of heart beats. However, in practice it is often not detected until an adverse event because it does not necessarily produce symptoms. The increasing use of smart wearables provides a new opportunity to detect AF in daily life. Smart wearables such as fitness bands measure the photoplethysmogram (PPG) signal, from which individual heart beats can be detected, and therefore the heart rhythm can be assessed. The aim of this project is to assess the performance of signal processing techniques for detecting AF from the PPG using a large scale clinical database, and to develop them to make them suitable for widespread use in smart wearables.

1. INTRODUCTION
One of the most promising uses of smart wearables for health monitoring is for automated detection of atrial fibrillation (AF). AF is one of the most common arrhythmias, and is a major cause of stroke. However, it can be difficult to identify as it may not produce symptoms. Currently there is no widespread screening for AF. Screening for AF is indicated if patients report symptoms of AF, such as heart palpitations. Screening is performed through measurement of the electrocardiogram (ECG) signal, which is indicative of the heart’s electrical activity. However, this process is expensive and is reliant on symptoms being present. An alternative approach is to identify AF from smart wearables.

Smart wearables measure the photoplethysmogram (PPG) signal for heart rate (HR) monitoring. This signal exhibits a pulse wave for each heart beat. It is possible to detect AF from beat-to-beat timings derived from the PPG, since AF causes irregular beat-to-beat intervals, as shown in Fig. 1. Techniques are being developed to detect AF from the PPG [1], although these need to be made sufficiently robust to reduce the frequency of false alerts. This is of particular concern if the algorithms are used for widespread, continuous and unsupervised AF detection. In this project previously proposed techniques for detecting AF from the PPG will be implemented, their performance will be assessed, and the techniques will be improved with the aim of making them sufficiently robust for automated AF detection using smart wearables.

Fig. 1. Detecting atrial fibrillation (AF): The variability in inter-beat intervals (IBIs, bottom) is increased in AF (left) when compared to sinus rhythm (right). Consequently, AF can be detected from the PPG (middle) in a similar manner to that used for the ECG (top). Adapted from [2], CC BY 4.0.

2. METHODS
The MIMIC database will be used for this project. It contains photoplethysmography signals alongside reference heart rhythm labels for thousands of critically-ill patients. Since these patients were critically-ill, many experienced different heart rhythms, including normal sinus rhythm (NSR, i.e regular rhythm) and AF. Data will be extracted for subjects in NSR and subjects in AF, which will be used to assess the performance of algorithms for detecting AF. The algorithms will initially be based upon those which have been previously reported in the literature. The algorithms will be implemented in Matlab®, and the heart rhythm labels provided by the algorithms will be compared to those extracted from the patient notes. The performance of the algorithms will be assessed using statistical techniques. The student may also wish to include other heart rhythms in the dataset, to increase the level of difficulty presented to the algorithms, and to make their own improvements to the algorithms.
3. OUTCOMES

In addition to the core outcomes of the Summer Research Module, this project provides opportunity to create a publicly available repository of AF detection algorithms, providing the student with experience in making research resources publicly available. It is hoped that the student will submit a paper on their work to the 6th International Conference on Sensors and Applications, providing valuable experience in disseminating research to the wider scientific community.

4. RECOMMENDED READING

The following publications are recommended reading, and should form the basis of the literature review:

- The clinical importance of AF: [3, 4]
- Techniques for identifying AF from the ECG: [5, 6]
- Techniques for identifying AF from the PPG: [7, 8, 9, 10, 11]
- The PPG signal: [12, 13]
- The role of wearable sensors: [2, 14]

5. REFERENCES


