Declaration

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Abstract

Biosignals are physiological signals that are recorded from various parts of the body. Some of the major biosignals are electromyograms (EMG), electroencephalograms (EEG) and electrocardiograms (ECG). These signals are of great clinical and diagnostic importance, and are analysed to understand their behaviour and to extract maximum information from them. However, they tend to be random and unpredictable in nature (non-linear). Conventional linear methods of analysis are insufficient. Hence, analysis using non-linear and dynamical system theory, chaos theory and fractal dimensions, is proving to be very beneficial.

In this project, ECG signals are of interest. Changes in the normal rhythm of a human heart may result in different cardiac arrhythmias, which may be fatal or cause irreparable damage to the heart when sustained over long periods of time. Hence the ability to identify arrhythmias from ECG recordings is of importance for clinical diagnosis and treatment and also for understanding the electrophysiological mechanism of arrhythmias.

To achieve this aim, algorithms were developed with the help of MATLAB® software. The classical logic of correlation was used in the development of algorithms to place signals into the various categories of cardiac arrhythmias. A sample set of 35 known ECG signals were obtained from the Physionet website for testing purposes. Later, 5 unknown ECG signals were used to determine the efficiency of the algorithms.

A peak detection algorithm was written to detect the QRS complex. This complex is the most prominent waveform within an ECG signal and its shape, duration and time of occurrence provides valuable information about the current state of the heart. The peak detection algorithm gave excellent results with very good accuracy for all the downloaded ECG signals, and was developed using classical linear techniques. Later, a peak detection algorithm using the discrete wavelet transform (DWT) was implemented. This code was developed using non-linear techniques and was amenable for implementation. Also, the time required for execution was reduced, making this code ideal for real-time processing.

Finally, algorithms were developed to calculate the Kolmogorov complexity and Lyapunov exponent, which are non-linear descriptors and enable the randomness and chaotic nature of ECG signals to be estimated. These measures of randomness and chaotic nature enable us to apply correct interrogative methods to the signal to extract maximum information. The codes developed gave fair results. It was possible to differentiate between normal ECGs and ECGs with ventricular fibrillation. The results show that the Kolmogorov complexity measure increases with an increase in pathology, approximately 12.90 for normal ECGs and increasing to 13.87 to 14.39 for ECGs with ventricular fibrillation and ventricular tachycardia. Similar results were obtained for Lyapunov exponent measures with a notable difference between normal ECG (0 – 0.0095) and ECG with ventricular fibrillation (0.1114 – 0.1799). However, it was difficult to differentiate between different types of arrhythmias.

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