QRS DETECTION ALGORITHM FOR ECG AND LAPLACIAN-ECG MOMENT OF ACTIVATIONS

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Laplacian ECG (LECG) is a new technique for detecting cardiac electrical activity. An algorithm was designed utilizing ECG QRS complexes to determine where cardiac activity was likely in the LECG. The recurrent property of ECG is exploited by this new algorithm for the detection of the QRS complexes by cross (auto) correlation. Further the algorithm calculates the time offset of the LECG signal from the ECG peak. This offset is termed the moment of activation (MoA) and is determined automatically. LECG body surface isochronal maps depict information about cardiac activation patterns. Besio [1] related the ECG QRS complex to the LECG isochrones. We now report on an algorithm to increase the efficiency of this method.

QRS detection is difficult because of the physiological variability of the ECG signal over time. The recurrent (periodic) property of the ECG is exploited by our algorithm for the detection of the QRS complexes. The algorithm uses differentiation and cross (auto) correlation. The correlation between two signals (cross correlation) is a standard approach to feature detection [2]. Our algorithm detects the first peak by differentiation. A window encompassing this peak is then used as a template to detect the remaining QRS complexes by autocorrelation. These ECG QRS complexes are then used to cross correlate the Laplacian ECG to determine MoAs.

The algorithm has been tested for efficiency on two sets of data. The first set is simulated data, using the same QRS complex repeatedly, but varying the amount of noise and the time location of the complexes. The level of white noise was varied from zero percent to seventy-five percent of the full QRS magnitude. The MoAs were recognized correctly 100% of the time with noise levels below ten percent. For a typical offset of 10ms the means for 10, 25, 50, and 75 percent noise levels are 9.979, 10.007, 10.007, and 10.245 and the standard deviations are 0.059, 0.186, 0.263, and 0.498 respectively. The second set of data was recorded from subjects with active pacemakers. The pacemaker caused much artifact that would not normally be discriminated from QRS complexes with common threshold detection methods. For one typical subject of our four, the pattern matching algorithm correctly detected 397 out of 400 QRS complexes in our dataset for a percentage correctness of 99.25.

In conclusion, this pattern matching algorithm is very efficient at detecting QRS complexes and determining the time offsets between them. Further work must be completed on standardized data sets and more subjects.

1. Besio W and Tarjan P, Atrial Activation Pattern from Surface Laplacian Electrocardiograms of Humans, International Journal of Bioelectromagnetism, vol 4, pp. 95-96, 2002.
2. Duda R and Hart P, Pattern classification and scene analysis, New York:Wiley 1973.