

DELINEATION OF ECG SIGNAL USING SPATIAL VELOCITY FUNCTION (SVF)

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ABSTRACT: The diagnostic tool that is often used to assess the electrical and muscular functions of the heart is termed as electrocardiogram (ECG). The electrical activity of the heart generates time- varying bio-electric potentials is recorded in electrocardiogram and is used to measure the functional performance of the heart. The information obtained from an electrocardiogram can be used to discover different types of heart disease. The process of Delineation of ECG signal involves determination of QRS complex and to identify characteristics of various waveforms (P, T and U waveform) associated with the ECG signal. Spatial Velocity Function (SVF) is used for delineation of ECG signal. In work QRS complex of ECG signal is delineated using spatial Velocity Function.

Keywords: Electrocardiogram, Spatial Velocity Function, Delineation, Segments, Intervals, QRS complex.

I. INTRODUCTION

ECG signal depicts the Status and Functionality of Heart. ECG signal is biomedical Signal consisting of various segments and intervals which can be delineated using Spatial Velocity Function (SVF) .

1.1: Spatial Velocity Function (SVF)

An ECG waveform is comprised of various segments, intervals, complexes and wave forms like P, T and U wave [1-4]. In delineation of ECG signal various portion of ECG signal are identified. R peak can be most easily identified in an ECG signals [5,6] though it is having the maximum amplitude. Thereafter other waveforms can be identified on the basis of R peak.

ECG recordings are generally available in 2-Lead or 12 – Lead format. However to completely diagnose a patient all these leads should be examined. Therefore, a combined QRS segment should be detected by taking all the leads simultaneously. For finding QRS detection for all the leads a function called Spatial Velocity Function (SVF) [7, 8] that gives a combined QRS starting and ending point for all the leads. This function differentiates the areas associated with the QRS complexes.

The detection function $d(i)$ can be written as :

$$d(i) = \sum_{k=1}^N |T(X_k(i))| \quad (1.1)$$

with T is a transformation of $X_k(i)$ and N is the Maximum number of leads

Formula for computing the derivative is the two sided first derivative so

$$T = |X_k(i+1) - X_k(i)|^2 \quad (1.2)$$

where,

T: Spatial Velocity Function value

$X_k(i)$: Data point in ECG signal for lead k at time i

II. METHODOLOGY AND RESULTS

2.1 Source of ECG Signal

The ECG signal used in this work is a two lead ECG data taken from the MIT-BIH Arrhythmia Database [9]. Single patient record has been used which is digitized at 360 samples per second per channel with 11 bit resolution over 10 mV range.

2.2 Detection of QRS complexes ECG Signal

QRS complex has the most informative portion of an ECG waveform. It is the basis to find other waveforms. To determine the quality of reconstructed signal the QRS complex of original and reconstructed signal is detected using Spatial Velocity Function (SVF) as explained in section 1.1. Spatial Velocity Function suppresses the other wave forms and enhances QRS regions for all the leads simultaneously in a single wave form as shown in figure 1. This figure shows combined QRS region for Lead I and Lead II of patient 101.

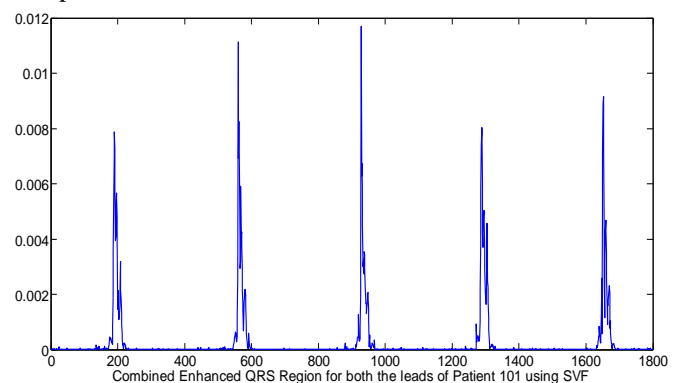


Figure 1: Combined Enhanced QRS Region for both the leads of Patient 101 using SVF

Following section shows the marked QRS regions for ECG signals for various patients.

2.3 Delineation of ECG signals

In this section original and reconstructed signal of Lead I and Lead II of four patients from MITBIH Arrhythmia data base are shown with their QRS complexes. These reconstructed signals were obtained after filtration. The QRS complex is marked using Spatial Velocity Function (SVF).

2.3.1 Procedure to obtained QRS complex in Lead I

The combined enhanced QRS region shown in figure 1 is obtained after applying SVF on the both the leads simultaneously. Thereafter in this QRS regions the starting consecutive 8 points in the ascending order with a set threshold are saved as starting point of QRS complexes and their corresponding points in lead I are marked as left points. The width of the QRS region varies between 21 to 36 points. Therefore highest value between each left point and next consecutive 50 points from this left point in lead I is marked as R wave. Thereafter the minimum value between this R point and left is marked as Q wave. The minimum value between this R wave point and next consecutive 30 points is marked as S wave. This process is applied for the complete original and reconstructed signals of Lead I .Marked QRS complex in original and reconstructed signal of Lead I is shown in figure 2.

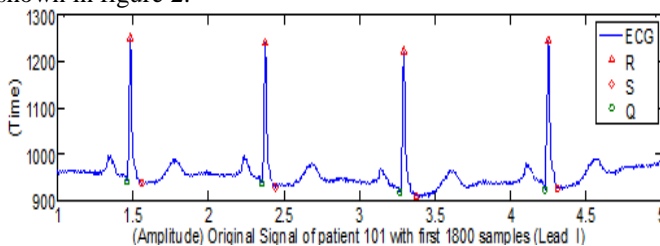


Figure 2: ECG signal of Patient 101 with first 1800 samples (Lead I)

2.3.2 Procedure to obtained QRS complex in Lead II

The QRS complex of Lead II comprises of r, s and R' wave forms. To obtain this QRS complex the left points in lead II are identified in the same way as it has been done in lead I. Thereafter the minimum value between this left point and next consecutive 50 points is marked as s wave. The largest value between left point and s wave is marked as r wave .To find R' the highest value between s point and next 30 consecutive points is identified and marked as R'. This marked r,s and R' wave forms in the ECG signal in lead II of patient 101 are shown in figure 3.

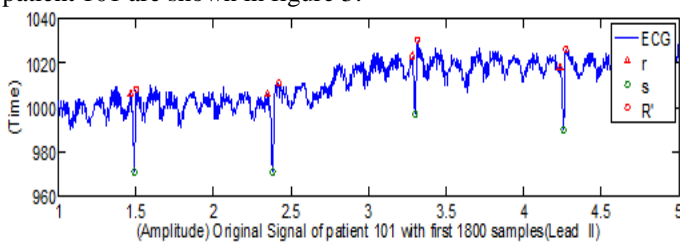


Figure 3: Original and Reconstructed signal of Patient 101 with first 1800 samples (Lead II)

Figure 4 and 5 shows marked QRS complex in Lead I and Lead II of patient 121.

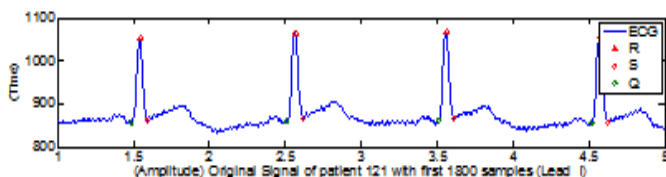


Figure 4: ECG signal of Patient 121 with first 1800 samples (Lead I)

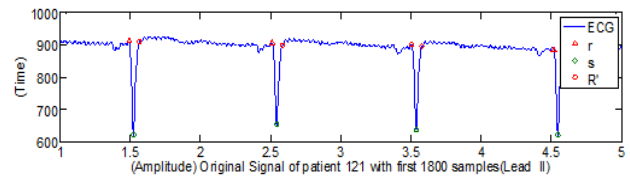


Figure 5: ECG signal of Patient 121 with first 1800 samples (Lead II)

It can be seen from these figures that the QRS complex is clearly visible in both the leads and there is also even no shift in QRS complex. It can also be observed these figures that the Q, R and S waves and r, s, and R' wave for Lead I and Lead II can be marked using SVF.

III. III.CONCLUSION

The same experiment is done with both the leads of 19 patients of MITBIH Arrhythmia database and exact reconstruction is achieved for all patients. QRS complexes has been successfully delineated in the ECG using SVF function. The QRS complex has been delineated successfully for all the patients.

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