Methodology of Filtering the Noise and Utilization of STEMI in the Myocardial Infarction

K. Manimekalai, A.Kavitha

Abstract: In order to detect the Myocardial Infarction from ECG records of the patients, the physicians study the electrical motion of the heart. A Myocardial Infarction is an illness condition related to the heart and it is recognized when the pathway to the heart is blocked. These blocks interrupt the regular functioning of the heart; which is spotted through the deviations in the readings of ECG signals. For the sake of detecting Myocardial Infarction, it is essential to detect ST-Elevation followed by the removal of noise in ECG signals with the help of the filtering process. ECG signals are getting affected by various noises with high and low frequencies that will originate the incorrect interpretation. The methodologies for ECG signal filtering using filtering algorithms and for STEMI feature selection from the resultant noise free ECG signals are presented in this paper by employing the MATLAB tool.

Keywords : ECG, Filtering, Feature Selection, Feature Extraction, Heart rate variability, Noise, STEMI.

I. INTRODUCTION

The Electrocardiogram (ECG) is an important bio-electrical signal; it is second-handedly, effectively used by the cardiologist to diagnose different diseases related with the heart and the condition of the cardiac system. ECG is one of the most important tests that measures electrical activity of the heart with the help of electrodes temporarily fixed on the body. The ECG is a graphic recording produced by the myocardium during the cardiac cycle. At the time of diagnosis, a cardiologist verifies the heart rate. The value of heart rate for a normal person should lie between the range of 60 to 100 beats per minute (BPM).

The quality of ECG signal is degraded by unwanted noise. By applying the suitable filtering technique, ECG waveform is better conserved. ST elevation is considered as a continuum of disease. It is one of the entity of Acute coronary syndrome. STEMI produced a result in specific ECG changes. It can help to diagnose the location and stage of the infarct. Copious methods are applied to detect the ECG characteristics points. Computer interpretation is also one of the 12-lead ECG is a widespread technique. Furthermore, the noise removal filtering method and threshold value would have great potential in signal processing.

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II. RELATED STUDY

To avoid artifacts, high pass, low pass and derivative pass filters applied to 12-lead ECG are fundamental part. Sometimes, inappropriate use may lead to misdiagnosis. There are many techniques to remove artefacts from ECG signal. In this paper, several filters are implemented to remove artefacts from ECG signal.

Mahesh S. Chauhan et al worked with elliptic algorithm for real time application. In their work, they reduced artifacts using digital filter. The three filters namely low pass, high pass and band pass filters are well designed and implemented on real time application. Matlab tool is used for designing. They found elliptic filter is better when compared to other filters. [9]

ZHANG Hongjun implemented on low pass filter out of low frequency and high pass filter out of high pass frequency [14].

ST fragment Evaluation and melancholy together with T-wave changes show that the zone of ischaemia is around the applied lead. Along these lines, examination of the ST section is a significant assignment in cardiovascular conclusion. The ST fragment is the piece of the ECG signal between the QRS complex and T wave. Changes in the ST fragment may demonstrate ischaemia brought about by inadequate blood supply to the heart muscle [8].

Jayarani et al used different filters (low pass, high pass and Band stop) are applied on ECG waveform to remove the noises. Matlab is used for the functionality verification on ECG waveforms. [2]

Presence of ST elevation is highly predictive for evolving acute myocardial infarction. Several authors reported that the sensitivity of the ECG for acute myocardial infarction should be as low as 50% [8,12,13].

To detect the myocardial infarction in ECG recordings, many algorithms proposed. Preprocessing and feature extraction is also done. [10, 6, 3, 7]

Sign for ischemia and infarction are numerous. [11]. ST-segment-elevation (STE) is one of the most important detection in myocardial infarction. [5].

From the literature review, many techniques were used to remove artefacts from ECG signal. This paper represents filtering of ECG signal of a patients using filter algorithms like low pass filter, high pass filter and derivative pass filters and then select the features of the resultant noise free ECG signals. Features are well representing the characteristics of the signals.

III. BASIC TERMINOLOGIES IN ECG

A. *ECG Waveform*

The ECG comprises of P wave, QRS complex and T wave. The depolarization and repolarization of atria and ventricles are produced by these waves. Figure (1) shows the schematic representation of normal ECG.

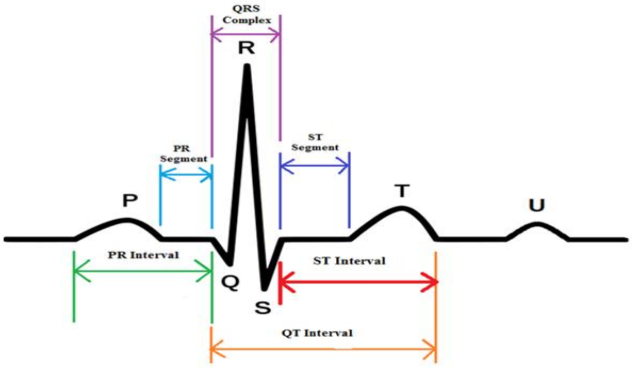


Fig . 1. Schematic representation of normal ECG

The ECG wave form is in the following manner: P wave identifies atria depolarization. QRS complex exhibits ventricular depolarization. T wave infers ventricular repolarization.

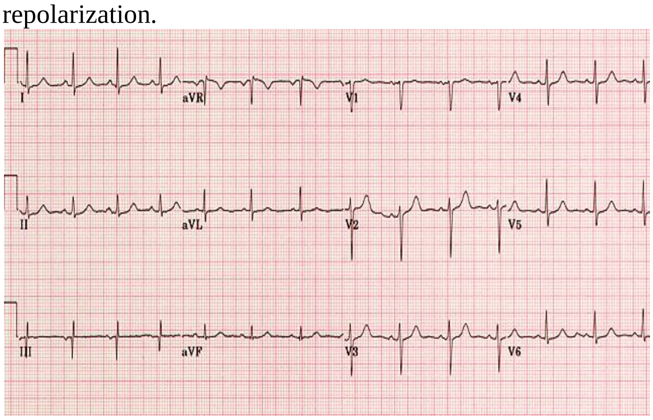
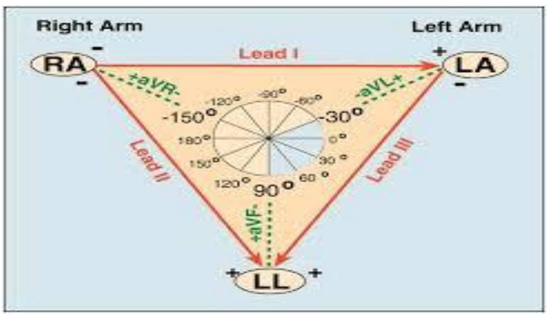


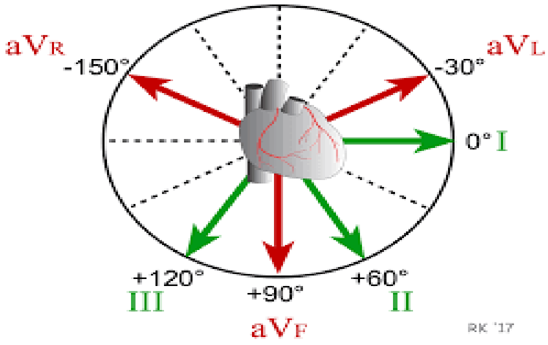
Fig. 2. Normal Electro Cardio Gram Waveform

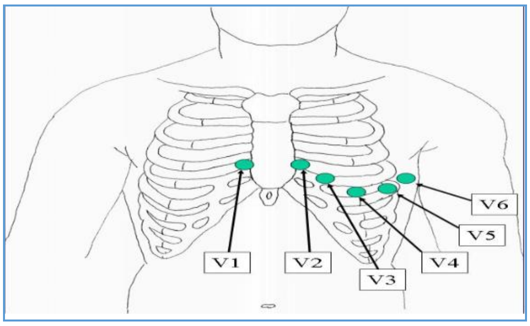
Normal ECG waveform is shown in the below figure 2. The heart beats in a systematic sinus tempo between 60-100 beats per minute (specifically 82bpm). All significant intervals on this recording are within normal ranges.

B. *Lead Positioning of ECG*

The ECG is one of the most useful investigation for Myocardial Infarction. A record of small voltage changes, as potential difference is transferred into an optical tracing, when electrodes are attached to the chest or limbs. Leads are electrodes which measure the variance in electrical potential between two different points on the body (bipolar leads). ECG Lead positioning in Fig 3.







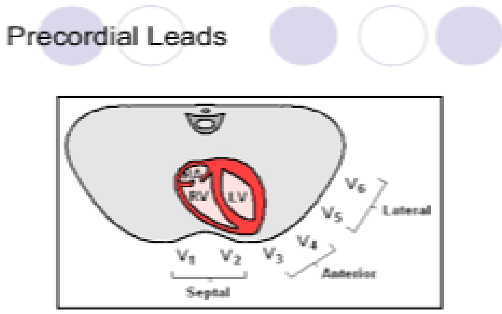


Fig .3. ECG Lead Positioning

The standard ECG usually consists of 12 leads. These Leads are enclosed by 3 standard Limb leads (I, II, III), 3 Augmented Limb leads (aVR, aVL, aVF) and 6 Precordial leads (V1 – V6).

C. *Leads Position In ECG*

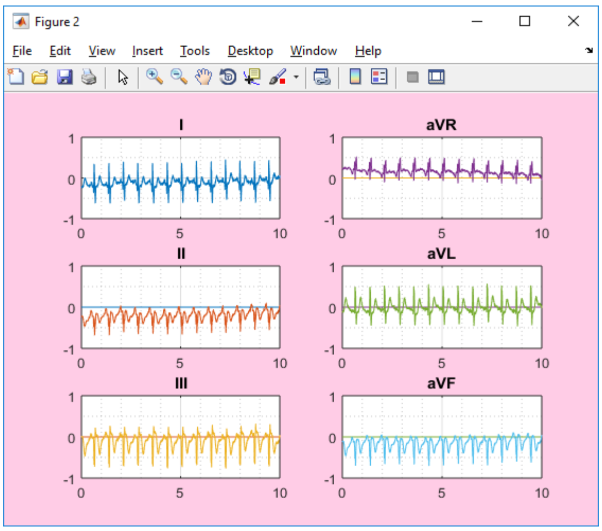


Fig .4. Limb Leads

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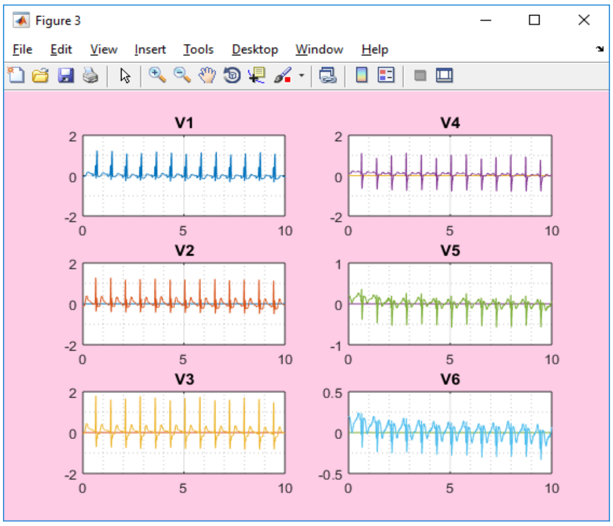

Fig. 5. Precordial Leads

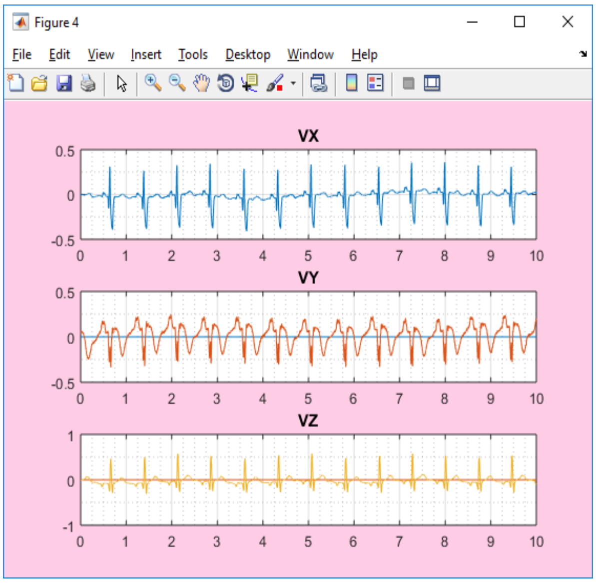

Fig. 6. Frank Leads

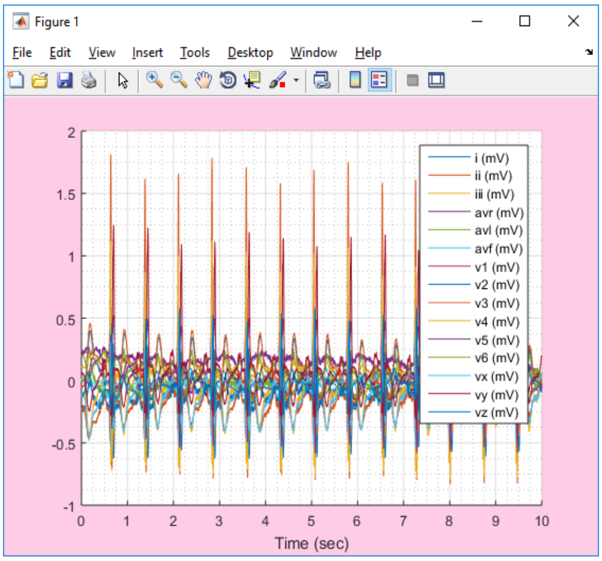

Fig. 7. Entire Leads for one Signal

Fig.4 and Fig.5 represents the Limb Leads, Precordial Leads respectively. Fig.6 shows the arrangement of Frank Leads. Fig.7 shows the entire leads for one signal.

D. ECG Graph Paper

The electrical activity of the heart is recorded on ECG graph paper. The speed of the ECG recorder produces the ECG tracing is standard at 25 mm per second. This image of cardiac electrical activity only reflects the few seconds in time that the strip is being printed. Fig.4 represents the Electrocardiogram paper. The horizontal and vertical axes are represented in this ECG grid with their respective measurement values. In ECG graphs, the small square contains Height 1mm and width 0.04s. Large square contains Height 5mm and width 0.04 x 5=0.2 s.

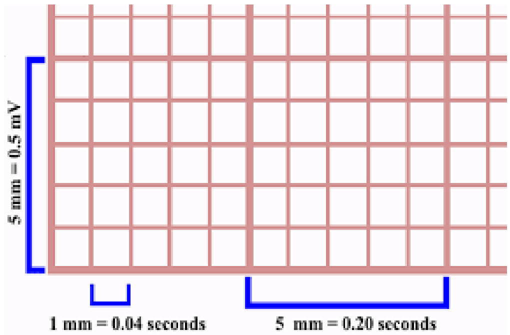

Fig. 8. Electrocardiogram Paper

IV. DATASET USED

The ECG data has taken from physio net database. Table 4 represents the ECG signal from PTB database.

Total of 3,135 normal segments and 13,577 MI segments are used for this study.

TABLE - I. ECG SIGNAL FROM PTB DATABASE

Type of ECG	Number of person	Number of segment
Healthy Controls	52	3,135
MI	148	13,577
Total	200	16,712

V. PRE-PROCESSING

In general, the presence of noise will corrupt the signal. It makes less accuracy in feature selection and classification. In the Preprocessing stage, removal of noise from ECG signal is crucial. This stage contains the following steps:

- ECG data recording: By the use of ECG electrodes, the ECG data is recorded. Generally, 10 electrodes are placed 4 on the human body.
- Filtering of ECG signal: Filtering of the signal is to remove the noise or distortion present in the signal.

In this section, various signal processing methods for removing noise from ECG signal has been described.

These methods are very simple to implement, and also yet effective. It is done by using Matlab.

A. ECG Signal Filtering

Filters applied to ECG are fundamental to avoid artefacts, but inappropriate use may lead to misdiagnosis.

B. Low-Pass Filters

High frequency noise ECG signals are removed by using Low-pass filters. Using Equ (1) and (2), the low pass filter is obtained. The transfer function of the second order low pass filter is given by,

$$H(z) = \frac{(1-z^{-6})^2}{(1-z^{-1})^2} \quad (1)$$

$$y(nT) = 2y(nT-T) - y(nT-2T) + x(nT) - 2x(nT-6T) + x(nT-12T) \quad (2)$$

The noisy signal holds the smoothed ECG signal along with high frequency noise. Using low pass filter, the signal is filtered. The Original Signal and Low-pass filter signal is shown in fig.9.

C. High-Pass Filter

Low frequency noise ECG signals are removed by using High-pass filters. The low-pass filter is an integer-coefficient filter with the transfer function

$$H(z) = \frac{(-1+32z^{-16}+z^{-32})}{1+z^{-1}} \quad (3)$$

and the difference equation

$$y(nT) = y(nT-T) + x(nT) - x(nT-32T) \quad (4)$$

$$H_{hp}(z) = \frac{P(z)}{X(z)} = z^{-16} - \frac{H_{lp}(z)}{32} \quad (5)$$

The difference equation for this filter is

$$p(nT) = x(nT-16T) - \frac{1}{32}[y(nT-T) + x(nT) - x(nT-32T)] \quad (6)$$

Total Delay = z^{-16}

D. Derivative Base Filters

$$H(z) = (1/8T)(-z^{-2} - 2z^{-1} + 2z^{1} + z^{2}) \quad (7)$$

This derivative is implemented with the following equation

$$y(nT) = \frac{2x(nT)+x(nT-T)-x(nT-3T)-2x(nT-4T)]}{8} \quad (8)$$

High pass filter and Derivative pass filter is shown in fig. 9.

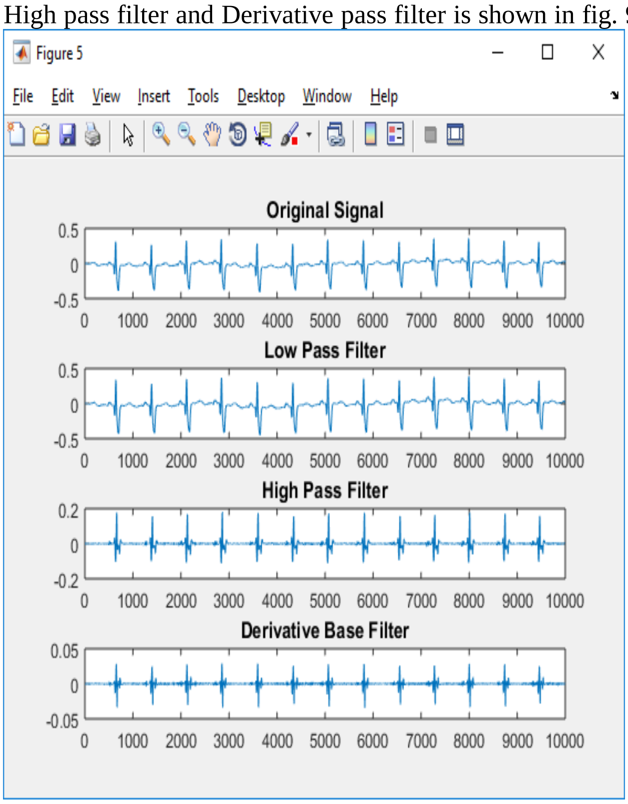

Fig .9. Filter Signals

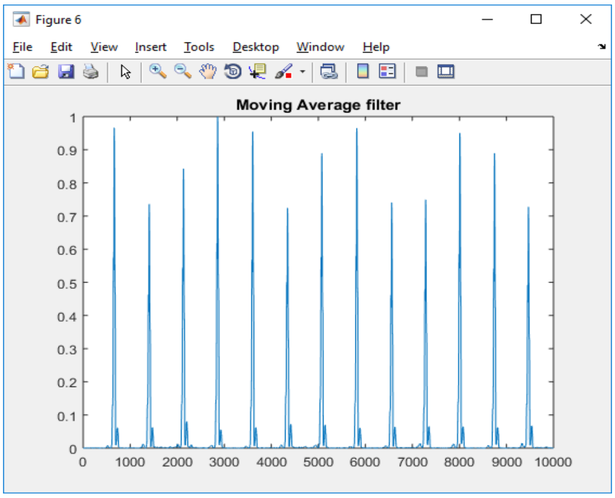

Fig.10. Moving Average Filter

E. Performance Analysis

To determine the Signal to Noise Ratio, the following formula is used.

$$SNR_{dB} = 10log_{10}\frac{\sum_{i=1}^{n}[s(i)]^2}{\sum_{i=1}^{n}[s(i)-x(i)]^2} \quad (9)$$

In the above equation, the variable, ‘s(i)’ is denoted as the recorded or noisy signal and the variable, ‘x(i)’ is denoted as the denoised counterpart. The length of the signal is denoted by using ‘n’. The signal is considered one lead signal at a time. After the base line wandering is added, power line interference of 50 Hz is added to the signal. The contaminated signal is then filtered.

VI. FEATURE SELECTION

ECG signal contains numerous ECG beats and each ECG beat consists P wave, QRS complex and T wave. Each segments such as PR and ST, intervals such as ‘PR’,’RR’, ‘QRS’, ‘ST’ and ‘QT’ and peaks such as P, Q, R, S and T of ECG signals have their regular amplitude or duration values. These segments, intervals and peaks are denoted as ECG features[4].

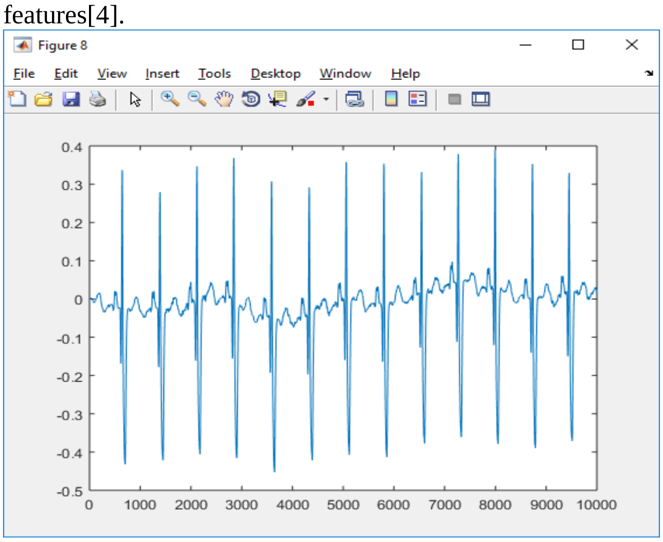

Fig. 11. PQRST Elevation

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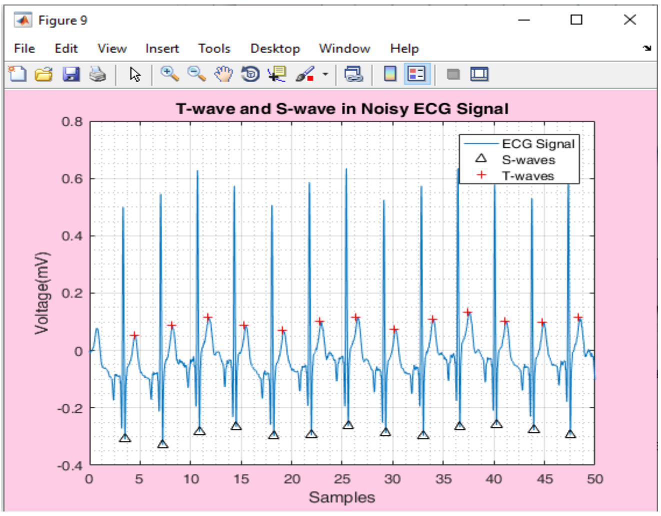

Fig .12. T-wave and S-wave in Noisy Signal

Fig 11 shows the PQRST elevation, and Fig 12 shows T-wave and S-wave in Noisy Signal.

VII. CONCLUSION AND FUTURE WORK

Electrical and electromechanical interferences are very much common in the field of medical signaling. Input to the proposed system is the output of an electromechanical device; hence impurities are removed by choosing suitable filters at the preprocessing stage itself. Further, signals without artifacts are thresholded and ST elevation is detected. From this, the essential features are brought out. These features are well representing the characteristics of the signals. As the continuation of this work, in the future, the signals can be classified with the application of deep learning algorithms since the data is vast.

REFERENCES

1. C. Hsu, C. Chang and C. Lin, "A practical guide to support vector classification", Technical report, National Taiwan University, Taiwan, 2003, pp 1-16
2. D. Jayarani, T. Jaya Singh, "Analysis of Noise Reduction Techniques on QRS in ECG Waveform by applying Different Filters", 2010, IEEE.
3. H. Lee, J. Park, J. Choi, A. Rabbi, and R. Fazel Rezai, "Automatic detection of electro cardiogram in ST segment: Application in ischemic disease diagnosis", International Journal of Advanced Computer Science and Applications, Volume: 4, Issue: 2, 2013, pp 150-155.
4. H. Tun, "Analysis of Computer Aided Identification System for ECG Characteristic Points", International Journal of Biomedical Science and Engineering Volume 3, Issue 4, August 2015, 2015.pp. 49-61
5. K. Thygesen, J. S. Alpert, A. S. Jaffe, M. L. Simoons, B. R. Chaitman, and H. D. White, "Third universal definition for myocardial infarctions," Global Heart – Elsevier Journal, Volume: 7, Issue:4, pp: 275–295, 2012.
6. M. Arif, I. A. Malagore, and F. A. Afsar, "Detection and localization of myocardial infarctions using k- nearest neighbour classifier," Journal of medical systems, vol. 36, no. 1, pp. 279–289, 2012.
7. N. Safdarian, N. J. Dabanloo, and G. Attarodi, "A new pattern recognition method for detection and localization of myocardial infarctions using t-wave integral and total integral as extracted features from one cycle of ECG signals," Journal of Biomedical Science and Engineering, Volume:7, Issue:10, 2014, pp : 818 - 822.
8. R. F. Rude, K. W. Poole, J. E. Muller, "Electro cardiographic and clinical criteria for recognition of acute myocardial infarction based on analysis of 3,697 patients. American Journal of Cardiology, Volume: 52, 1983, pp. 936-942.
9. S Mahesh, A Agrawala, D. Uplane, "Digital Elliptic Filter Applications for noise Reduction in ECG Signal" 4th WSEAS International Conference on Electronics, Signal Processing and Controls, 2005, pp : 58-63.
10. S. Li, K. Yang, L. Sun, "ECG analysis using multiple instance learning for myocardial infarctions detection," IEEE transactions on biomedical engineering, Volume: 59, 2012, Issue: 12, Page. No: 3348–3356.
11. S. Tewelde, A. Mattu, and W. Brady, "Pitfalls in Electro cardio graphic Diagnosis of Acute Coronary Syndrome in Low-Risk Chest Pain," Western Journal of Emergency Medicine, Volume: 18, Issue: 4, 2017, pp :601–606.
12. T. H. Lee, G. W. Rouan, M. C. Weisberg, "Sensitivity of routine clinical criteria for diagnosing myocardial infarctions within 24 hours of hospitalization". Annals of Internal Medicine, Volume: 106, 1987, pp: 181-186.
13. W. Gibler, G.Young, J. Hedges, "Acute myocardial infarction in chest pain patients with Non-Diagnostic ECGs", Annals of Emergency Medicine, Volume: 21,1992, pp : 504-512.
14. Z. Hongjun "Research on ECG Diagnosis system Based on Suport Vector Machine, " Journal of Convergence Information Technology, 2011, Volume : 6, Issue : 3.

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