INDIAN INSTITUTE OF INFORMATION TECHNOLOGY

NAGPUR

DIGITAL SIGNAL PROCESSING

Project title-

ANALYSIS OF ECG

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ABSTRACT

Digital signal processing and data analysis are very often used methods in a biomedical engineering research. This paper describes utilization of digital signal filtering on electrocardiogram (ECG). Designed filters are focused on removing supply network 50 Hz frequency and breathing muscle artefacts.

ECG component analysis such as QRS peak detection, heart rate calculation, etc is performed using nonlinear filter technique called first order derivative and moving average filter. The performance of the algorithm is studied in MATLAB environment. The results of this study reveal the potentiality of the DSP system for routine clinical use.

INTRODUCTION

Electrocardiogram (ECG) represents electrical activity of human heart. ECG is composite from 5 waves - P, Q, R, S and T. This signal could be measured by electrodes from human body in typical engagement. Signals from these electrodes are brought to simple electrical circuits with amplifiers and analogue – digital converters. The main problem of digitalized signal is interference with other noisy signals like power supply network 50 Hz frequency and breathing muscle artefacts. These noisy elements have to be removed before the signal is used for next data processing like heart rate frequency detection. Digital filters and signal processing should be designed very effective for next real-time applications in embedded devices. Heart rate frequency is very important health status information. The frequency measurement is used in many medical or sport applications like stress tests or life treating situation prediction. One of possible ways how to get heart rate frequency is compute it from the ECG signal. Heart rate frequency can be detected from ECG signal by many methods and algorithms.

An electrocardiogram (EKG or ECG) is done to:

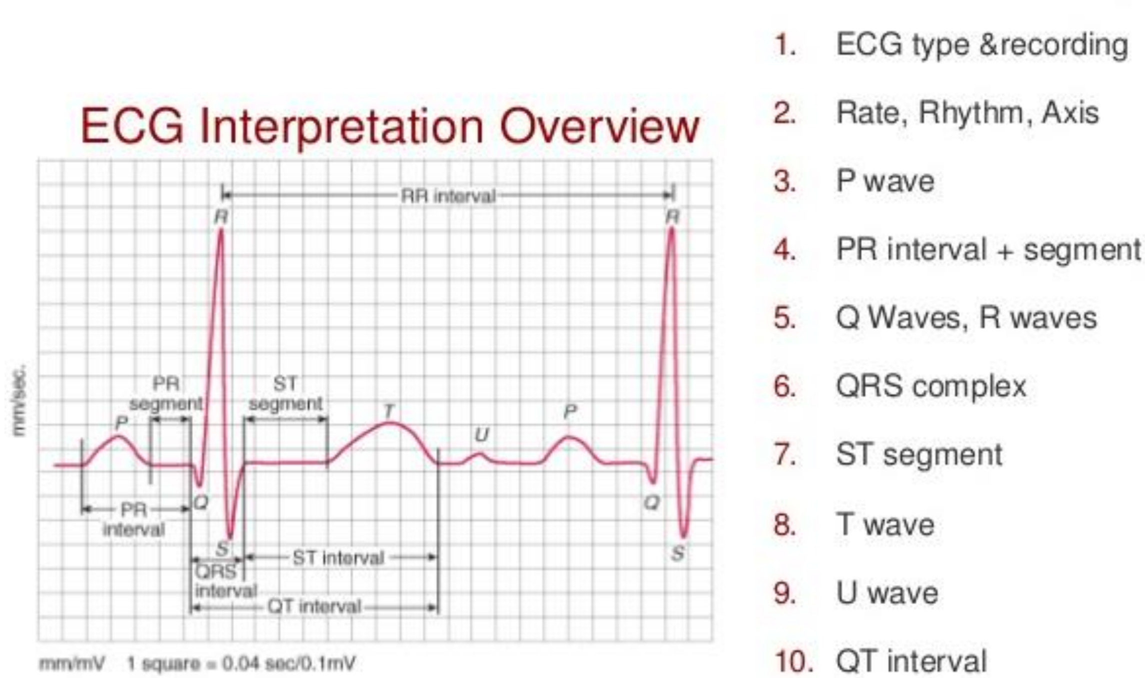
- Check the heart's electrical activity, how fast your heart is beating.
- Find the cause of unexplained chest pain, which could be caused by a heart attack, inflammation of the sac surrounding the heart (pericarditis), or angina.
- Find the cause of symptoms of heart disease, such as shortness of breath, dizziness, fainting, or rapid, irregular heartbeats (palpitations).
- Find out if the walls of the heart chambers are too thick (hypertrophied).
- Check how well medicines are working and whether they are causing side effects that affect the heart.
- Check how well mechanical devices that are implanted in the heart, such as pacemakers, are working to control a normal heartbeat.

- Check the health of the heart when other diseases or conditions are present, such as high blood pressure, high cholesterol, cigarette smoking, diabetes, or a family history of early heart disease.

THE WAVES AND INTERVALS OF ECG

A typical ECG tracing of the cardiac cycle (heartbeat) consists of a P wave, a QRS complex, a T wave, and a U wave, which is normally invisible in 50 to 75% of ECGs because it is hidden by the T wave and upcoming new P wave. The baseline of the electrocardiogram (the flat horizontal segments) is measured as the portion of the tracing following the T wave and preceding the next P wave and the segment between the P wave and the following QRS complex (PR segment) . In a normal healthy heart, the baseline is equivalent to the isoelectric line (0 mV) and represents the periods in the cardiac cycle when there are no currents towards either the positive or negative ends of the ECG leads. However, in a diseased heart, the baseline may be depressed (e.g., cardiac ischaemia) or elevated (e.g., myocardial infarction) relative to the isoelectric line due to injury currents during the TP and PR intervals when the ventricles are at rest. The ST segment typically remains close to the isoelectric line as this is the period when the ventricles are fully depolarized and thus no currents can be in the ECG leads. Since most ECG recordings do not indicate where the 0 mV line is, baseline depression often gives the appearance of an elevation of the ST segment and conversely baseline elevation gives the appearance of depression of the ST segment. The electrocardiographic deflections are termed P, QRS complex, T and U.

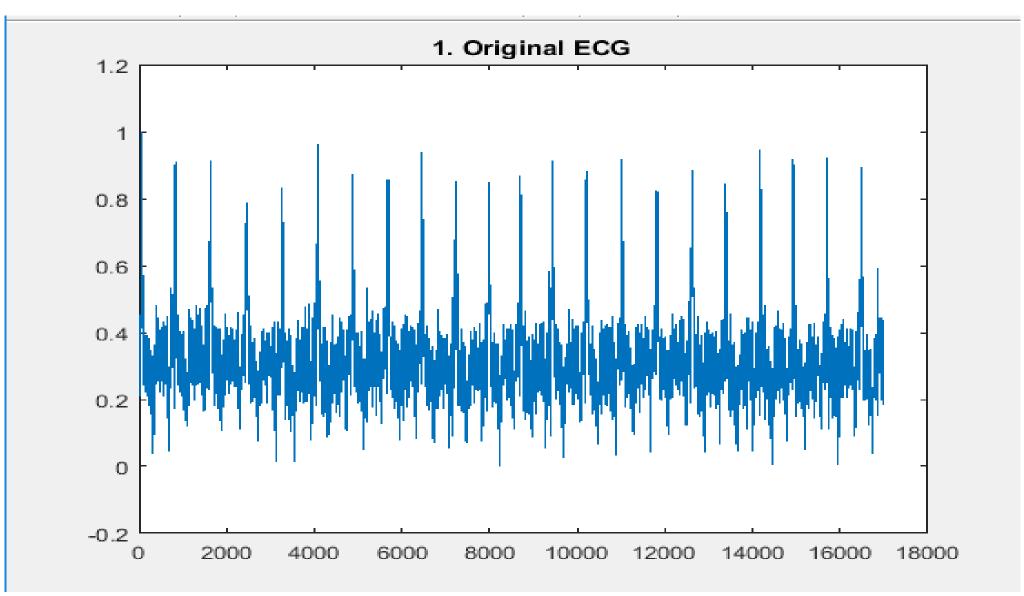
- The P wave represents Atria activation (Contractions).
- QRS complex represents ventricular activation or depolarization.
- The T wave represents ventricular recovery or re-polarization.
- S-T segment, the T wave and the U wave together represent the total duration of ventricular recovery



SIGNAL ACQUISITION

ECG signal for digital signal processing and heart rate calculation was acquired by measurement card with sampling frequency fs = 1000 Hz. The first ECG lead was measured.

This signal was used as input signal for the digital filters and the heart rate detection algorithms designing and testing.



DIGITAL SIGNAL PROCESSING WITH DIGITAL FILTERS

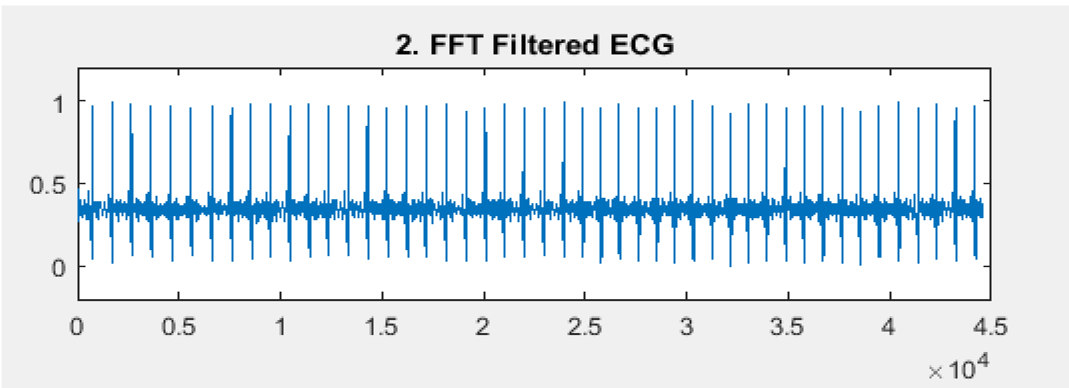
In this part there is described noise elements filtering and baseline wander elimination with digital filters. The main noise elements are power supply network 50 Hz frequency and breathing muscle movements. These artefacts have to be removed before the signal is used for next data processing like heart rate frequency determination.

After the basic filtering, the R-peaks are detected from ECG signal. R-peaks filtering are necessary for next heart rate detection.

Steps for detection-

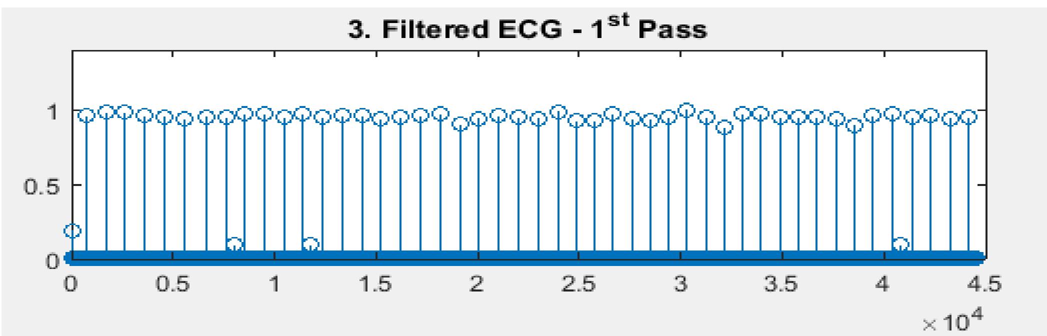
Step 1 -Remove lower frequency components

1. Change to frequency domain using fft
2. Remove low frequency components
3. Back to time domain using ifft

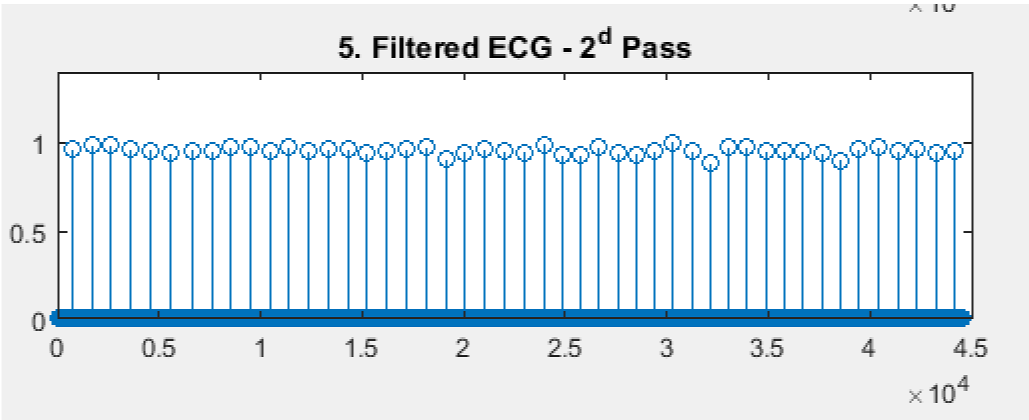


Step-2 Find local maxima using windowed filter

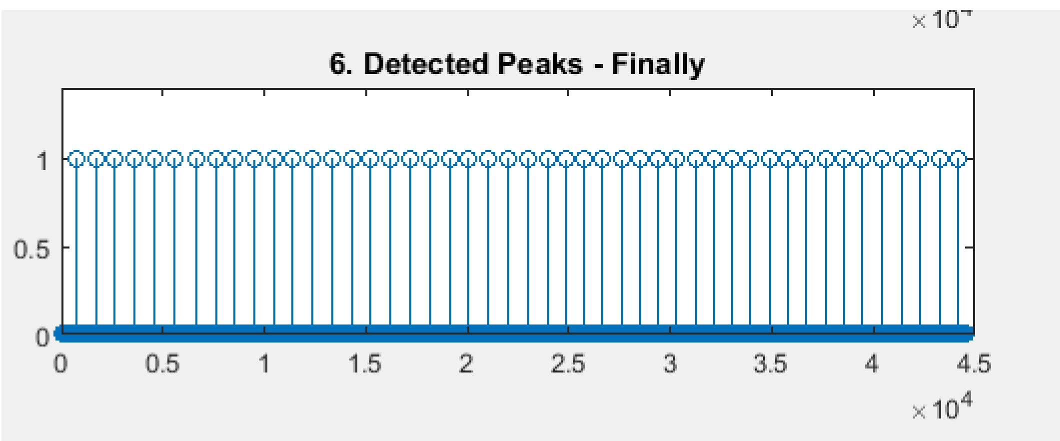
Step-3 Remove small values, store significant ones



Step-4 Adjust filter size and repeat steps 2 and 3.

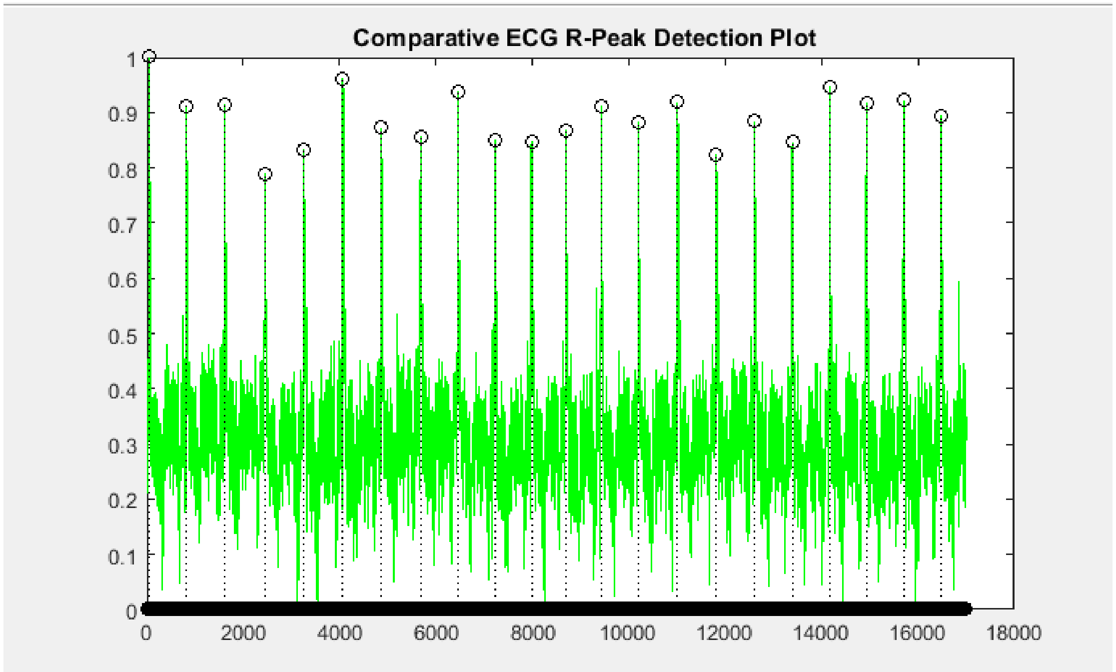


Step-5 detect r-peaks



Step-6 Heart rate calculation by distance between r-peaks

Average Heart Rate = 60 * (Sampling Rate/average Distance between Peaks)



CONCLUSION-

In this project filtering techniques for ECG signal is presented; windowing techniques are used.

It can be concluded, quantitatively as well as by visual inspection that ECG waveform shows significant improvement in quality with the use of high attenuation low pass filter. This can extract the ECG signal from noise, thus enabling cardiac experts for reliable and dependable clinical diagnosis.