USING PAN TOMPKIN'S METHOD, ECG SIGNAL PROCESSING AND DIGNOSE VARIOUS DISEASES IN MATLAB

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Abstract- Electrocardiogram (ECG) illustrates the electrical activity in the heart, and is the most important physiological parameter that gives the correct assessment regarding the functioning of the heart. ECG is the graphical recording of the electrical activity of the heart used for clinical diagnosis. The project has been devised to find a method for ECG signal analysis which is simple anhas good accuracy and takes less computation time. Electrocardiogram (ECG) is generally used for diagnosis of cardiovascular abnormalities and disorders. Electrocardiogram (ECG) represents electrical activity of human heart. In view of characteristics of the ECG signal is very weak and strong background noise, and treated with hardware before enter the enlargement step to avoid noise signal amplification with the useful signal at the same time; 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.

Index Terms- ECG Signal ,Pan Tompkins Algorithm ,Abnormal ECG, QRS complex ,RR interval.

I. INTRODUCTION

Electrocardiogram (ECG) represents electrical activity of human heart. In view of characteristics of the ECG signal is very weak and strong background noise, and treated with hardware before enter the enlargement step to avoid noise signal amplification with the useful signal at the same time; 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 artifacts'. 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 Pan-Tompkins Algorithm; a widely known technique has been adapted to realize the QRS Complex Classification process. There are eight steps involved namely sampling, normalization, low pass filter, high pass filter (build a band pass filter), derivation, squaring, averaging and lastly is the QRS detection. The simulation results obtained is represented in a Graphical User Interface (GUI) developed using MATLAB

1.1 IMPORTANCE OF ECG

1) It can be used to determine the speed of heart beat.
2) Any abnormality in the rhythm of heart beat such as steadiness, disturbances or irregularities can be detected.
3) The strength and timing of electrical signals can be detected as they pass through each part of the heart. here.

II. PAN TOMPKINS ALGORITHM

The works of Pan Tompkins greatly influence the QRS detection as compared to others. A survey of literatures signifies this approach as one of important algorithm in detecting QRS peak [4].Wherever The accuracy of any Electrocardiogram (ECG) waveform extraction plays a vital role in helping a better diagnosis on any heart related illnesses. Normal ECG should consists of several parts include P wave, QRS complex and T wave.

These waves reflect the heart's activity such as P wave produced by muscle contraction of Atria and its duration indicates the Atrial enlargement. Q wave gives the first negative value and typically supposed to be 25% less than the R wave value.

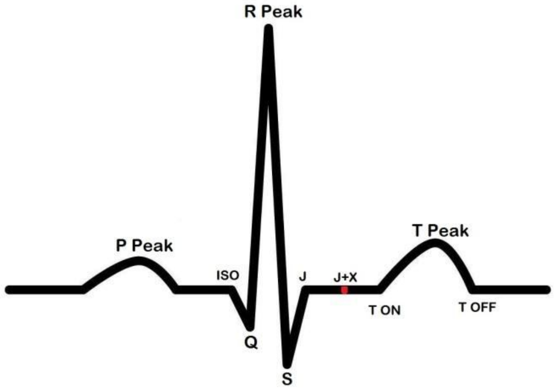


Figure 1

2.1 Normal Values of Amplitude and Duration of ECG

Parameters:

Amplitude-:
• p wave -: 0.25mV
• R wave -: 1.6 mV
• Q wave -:25 percent of R wave
• T wave -:0.1 to 0.5 mV

Duration -:
• P-R Interval -:0.12 to 0.20 sec
• Q-T Interval -:0.35 to0.44 sec
• S-T Interval -:0.05 to0.15 sec
• P wave Interval -:0.11 sec

2.1. INTRODUCTION

The "Pan and Tompkins" QRS detection algorithm identifies the QRS complexes based upon digital analysis of slope, amplitude, and width of the ECG data. The algorithm implements a special digital band pass filter. It can reduce false detection caused by the various types of interference present in the ECG signal. The algorithm automatically adjusts the thresholds and parameters periodically to adapt the changes in QRS morphology and heart rate.

. In summary, it consists of the following processing steps as shown in Figure 2:

· Band-pass filtering.
· Differentiation.
· Squaring.
· Moving window integration.
· Thresholds adjustment.

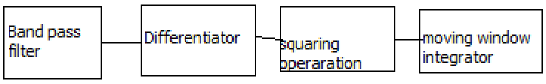


Figure 2.

The processing steps of QRS complex detection. The P wave is a rounded peak occurred before the QRS complex. Therefore, the P wave can be found based on the location of the QRS complex. One of the most popular QRS detection algorithms, included in virtually all biomedical signal processing textbooks, is that introduced by Pan and Tompkins in 1]. An overview of the algorithm follows. Figure 2 shows a graphical representation of the basic steps of the algorithm. The signal passes through filtering, derivation, squaring, and integration phases before thresholds are set and QRS complexes are detected In the first step the algorithm passes the signal through a low pass and a high pass filter in order to reduce the influence of the muscle noise, the power line interference, the baseline wander and the T-wave interference.

2.2.1 Band pass Filtering

The band pass filter for the QRS detection algorithm reduces noise in the ECG signal by matching the spectrum of the average QRS complex. This attenuates noise due to muscle noise, power line interference, baseline wander, T wave interference. The pass band that maximizes the QRS energy is in the 5Hz-35Hz range. The filter implemented in this algorithm is composed of cascaded high pass and low pass Butterworth IIR filters.

2.2.2 Derivative Operator

The next processing step is differentiation, standard technique for finding the high slopes that normally distinguish the QRS complexes from other ECG waves. The derivative procedure suppresses the low frequency components of P and T waves, and provides a large gain to the high-frequency components arising from the high slopes of the QRS Complex.

2.2.3 Squaring

The squaring operation makes the result positive and emphasizes large differences resulting from QRS complexes; the small differences arising from P and T waves are suppressed. The high frequency components in the signal related to the QRS complex are further enhanced. This is a nonlinear transformation that consists of point by point squaring of the signal samples.

2.2.4 Integration

The squared waveform passes through a moving window integrator. This integrator sums the area under the squared waveform over a suitable interval, advances one sample interval, and integrates the new predefined interval window. The half-width of window has been chosen as 27 to include the time duration of extended abnormal QRS complexes, but short enough that it does not overlap both a QRS complex and a T-wave. MA (moving average) filter extracts features in addition to the slope of the R wave. It is implemented with the following difference equation:

$$Y(nT) = 1/N[X(nT-(N-1)T)+\cdots+X(nT)] \quad (1)$$

Where, N=1+2M is the number of samples in the width of the moving window. M is Half-width of moving average filter.

The choice of the duration of the sliding window results in a trade off between false and missed detections.

A large number of QRS detection schemes are described by B.U.Kohler, C.Hennig, and R.Orglmeister (2002). The ability to detect the presence of disorder of concern and percentage of detection peaks that are actually present i.e. sensitivity & efficiency, of Pan-Tompkins algorithm are more than 99%. The computational load is also low.

The low-pass filter is described by the formula:

$y(n)\_= 2y(n-1)- y(n- 2)- x(n)- 2x(n- 6)- x(n-12)$…………(2)

and the high-pass one is given by:

$y(n) = y(n-1) –1/32x(n)-x(n-16)-x(n-17)+1/32x(n-32)$………(3)

After filtering, the signal is differentiated to provide the QRS slope information using the following formula:

$y(n)=1/8[2x(n)+ x n-1)-x(n-3)-2x(n-4)]$………(4)

Then the signal is squared point by point making all data point positive and emphasizing the higher frequencies.

$y(n)= x^2 (n)$ …………………………………(5)

3.Common Diseases of Heart

There are many disease related to heart some of them as fallows-:

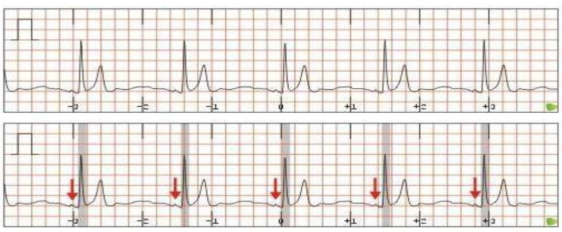
3.1 Common Diseases of Heart

i. Chest pain ,which could be caused by heart attack.
ii. Inflammation of the sac of heart.
iii. Shortness of breathing.
iv. Irregular heart beat(palpitation).

ECG recordings can be used as a diagnostic tool to determine abnormalities in cardiac function or it can be visualize the effects of cardiac tissue damage. Abnormalities in the QRS complex indicate problems in the ventricles or ventricular conduction. In normal ECG, T wave is of positive amplitude but in abnormal ECG, the T wave can be inverted having negative amplitude. There are various abnormal ECG and some ECG we discuss here:

3.1.1 i Sinus Bradycardia.

Bradycardia is a term to describe the heart beating more slowly than normal. Sinus bradycardia can occur in well-conditioned athletes and during sleep relaxation. In the case of athletes, the heart muscle is tremendously strong and efficient at pumping blood, therefore, less contraction needed. During deep relaxation, the body is at rest and requires less oxygen consumption than during normal activity which allows the heart rate to slow. However, sinus bradycardia can also occur as a result of heart disease or as a reaction to medication.

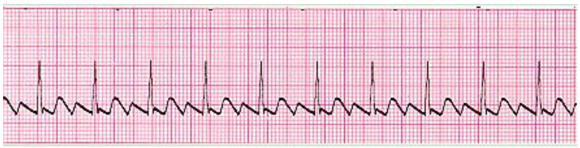


2.1.2 ii Sinus Tachycardia

Excessive heart rate above 100 beats per minute (BPM) which originates from the SA node. Causes include fright, stress, illness and exercise. It is essential to identify one P for each QRS. It may be difficult to differentiate a sinus tachyarrhythmia from an atrial tachyarrhythmia.

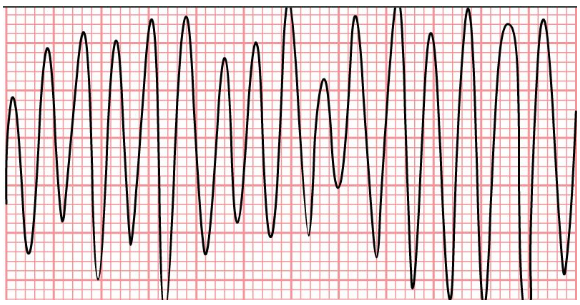
2.1.3 iii Atrial Flutter

Atrial flutter is a condition where there are multiple atrial contractions for every ventricular contraction. It is caused by a single large electrical signal that propagates around the atria. The rate of atrial contraction can be between 200 and 350 beats per minutes. The amount of blood being pumped by the atria can be very small as a result of one side of the atria being contracted while the other being relaxed. The electrical signals enter the AV node at a rate that is too rapid to create a ventricular contraction for every atrial contraction. As a result, there are multiples P-waves in the ECG for every QRS-T complex.



2.1.4 iv. Ventricular Flutter

In this cardiac arrhythmia, the verticals can be paced at more than 200 beats per second. This can be triggered by an extrasystole or ectopic pacemaker that occurs in the ventricles. The pumping of blood becomes extremely inefficient. There is no visible P wave in the ECG recording and the QRS complex and T wave are merged in regularly occurring waves with a frequency between 180 to 250 beats per minute



3.2 Common Diseases of Heart

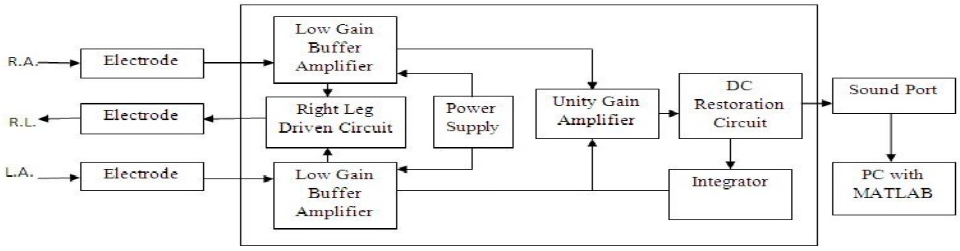
- Chest pain ,which could be caused by heart attack.
- Inflammation of the sac of heart.
- Shortness of breathing.

Irregular heart beat(palpitation).

A. 3.2.1.These are the steps followed for real time ECG signal processing

1) Acquisition of ECG signal using DAQ (data acquisition
2) Filtering of the acquired signal using band pass filter set to the frequency range 2 to 40 Hz.
3) Differentiation of the filtered signal.
4) Squaring of the differentiated signal.
5) Integration of the squared signal.
6) Determination of the frequency of the integrated signal.
7) Time period calculation using the determined frequency which gives the R_R interval.
8) Time period = 1/ frequency.
9) calculation of the heart rate by using the R_R interval
10) Heart rate = 60/ (R_R interval (m sec)
11)If the heart rate exceeds 90 tachycardia
12) If the heart rate is less than 40 Bradycardia

3.2.2.Output Display Unit:



The output of the acquisition circuit is connected to the sound port of the interface unit (PC) and the signal displayed using the MATLAB software. Sound port of PC provides the interface between the PC and mobile phone. It makes the system cost effective and convenient, as there is no need of data acquisition card for the interfacing between circuit and PC. Using a MATLAB program code, the PC can recognize and display the ECG signal received at the sound port. The command "winsound" in MATLAB is used to acquire the signal from the sound port and display on the screen. To minimize the noise content from the real time acquired signal, FIR digital filter and band pass filter with pass band 0.05-150 Hz can be used. The subject was asked to sit comfortably on chair. The raw ECG signal was then acquired at normal position. The signals received are then filtered using digital filters used in MATLAB program.

III. RESULTS

Interval r	Reason for Wave generation	Amplitude	Time Interval	characteristics
p wave	Represents Atrial Depolarization	Normal amplitude is 1-1.5 mm	<0.12 sec	Small, rounded and upright
QRS complex	Represents Atrial Depolarization	Normal amplitude of R-wave is 8-12 mm	<0.04 to 0.10sec (QRS Interval	The first negative wave in the complex is the Q wave, the first positive wave in the complex is the R-wave and the first negative wave following the R-wave is the S-wave
T Wave	Represents ventricular repolarization	Normal amplitude is 2 – 5 mm	<0.04 to 0.10sec (QRS Interval	Same polarity as QRS complex usually correlates with polarity of Rwave
U Wave	Purkinje fiber repolarization	Not measured (low voltage)	<0.01sec	Usually of low voltage and same polarity as T wave when present

IV. CONCLUSIONS AND FUTURE WORK

In this paper we propose Matlab software for the Pan and Tompkins QRS detection algorithm for detection of diseases related to heart, implementation every stage processes the entire sample and then can the next stage begin. However, the samples that have already been processed by a stage may be processed by the next without waiting all the samples to be processed by the first.

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