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Intelligent patient monitoring for QRS detection

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Abstract: *Today heart disease and complications related to it is one of the major causes of death around the world, so, in medical field it's very important to detect the irregularities in the rhythms of heart. In this paper we present a development platform for portable real-time analysis of ECG signals which can be used as an advanced warning device, using android based mobile phone. This paper also discusses an ECG data acquisition unit, with an emphasis on the software for analyzing the ECG signals, and the algorithm of analyzing and detecting cardiac conditions for "Tachycardia" type – the most common kind of cardiac abnormality.*

***Keywords**: - Android; ECG; patient monitoring; QRS detection; cardiovascular disease*

I. INRODUCTION

Today, main aim of healthcare industry is to provide better healthcare to people anytime and anywhere in the world in a more economic and patient friendly manner. To provide such healthcare to patients we have to improve patient monitoring devices by making them more feasible. When we talk about patient monitoring systems, there are some basic problems which we have to face while dealing with those systems. Care provider should be present near patient and another thing is large amount of wires are required to for monitoring purpose, which make such systems more complicated sometimes. In order to get better results above quoted problems must be solved first. With advancements in technology, it become more feasible to design portable monitoring systems which can record, display and transmit the data at any place. Telemedicine benefits not only the customers who are able to receive health care more efficiently; it also benefits the doctors who can streamline their efforts to assist more patients.

1.1 Tele-Health Care

Use of information technology is done to provide healthcare to distant people. With the advancements in technology, nowadays it is possible to take support in clinical work like surgery from a doctor who is present at far distance from another doctor. In such cases doctor is interested in the patient's previous history so that he can give better diagnosis of disease. For that constant monitoring is needed. These healthcare techniques are extremely beneficial to those people who are living in isolated surroundings and also to the people who are living at remote places where clinical help cannot reach in critical conditions.

1.2 Telemedicine

Using information related to electronics and different technologies under telecommunication for health care, health related education, comes under telemedicine. For faster examination, we can instruct a medical staff which is present at different location using telemedicine. It has been shown to reduce the cost of healthcare and increase efficiency through better management of complex diseases; it provides better staffing for health care, also the travelling time to reach in hospitals and also the stays in hospitals.

1.3Telemonitoring

In such cases, number of monitoring devices is provided near patient at his home and results are transmitted via telecommunication technologies such as mobile phone. The main advantage of this technology is travelling of patient from his home to hospital is avoided. It will be beneficial if patient is in critical condition. Basic information about patient's health is collected using a questionnaire over phone and then it is provided to health care provider to keep in touch. From that a decision is made about patient's health. Telemonitoring also keeps records of chronic diseases such as weight, heart rate blood glucose. Depending upon patient's condition we can check statistics to give treatment accordingly.

II. ARCHITECTURE

With advancements in technology, we can process real time signal with different types of sensors and android technology as operating system. It can process data and monitor all patient related parameters and in case of emergency it can automatically contact the related physicians.

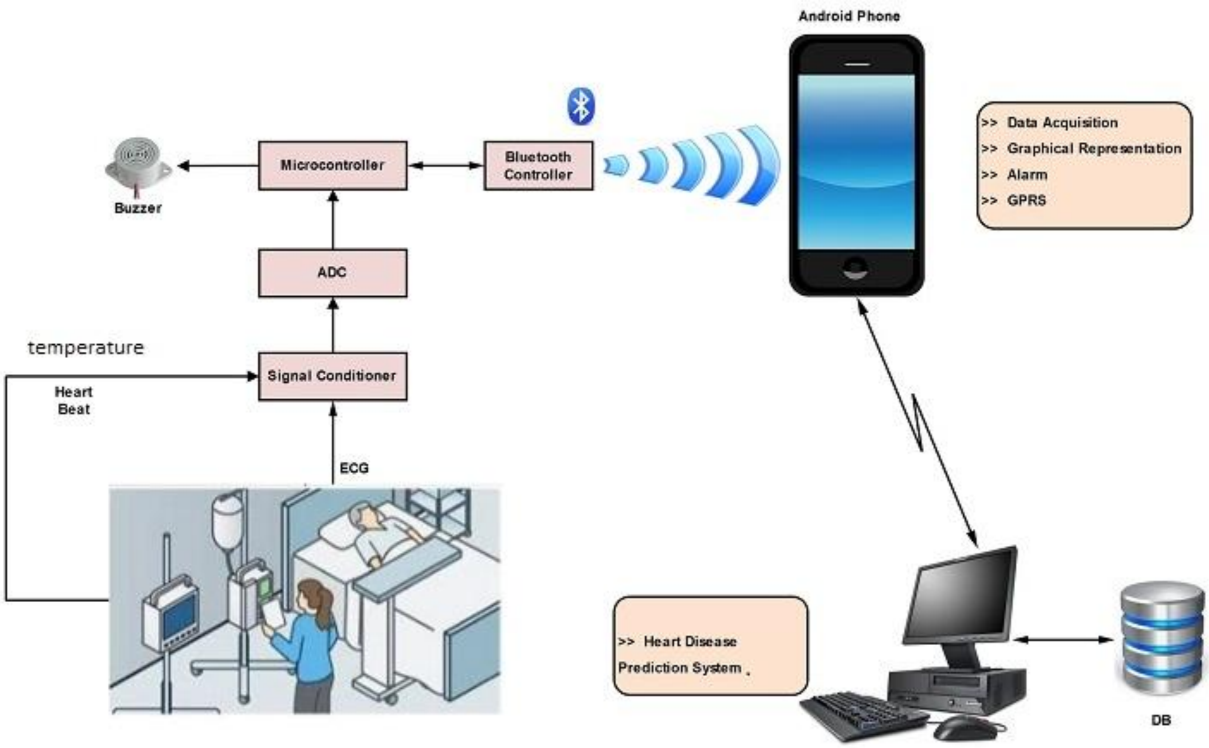

Figure1.general idea of patient monitoring system.

Monitoring system is made up of two components: software and hardware, as shown in above figure main important part in the analysis is software part as process such as amplification, filter process etc. is done using software part. For ECG signal collection we have used three lead probes and gel which is a convention method of recording ECG.

Data from sensors is collected using smart phone and then it is sent to a physician if patient is in critical condition.

We focused on analysis of qrs complex through which we can diagnose the type of heart attacks. In software analysis we detect qrs complex from ECG signals and count the heart beats from R peaks.

Depending on the values of heart beat we can detect the type of heart attack.

III. PATIENT PARAMETERS

3.1 ECG

Electrocardiography is a trans thoracic (across the thorax or chest) interpretation of the electrical activity of the heart over a period of time, as detected by electrodes attached to the surface of the skin and recorded by a device external to the body.

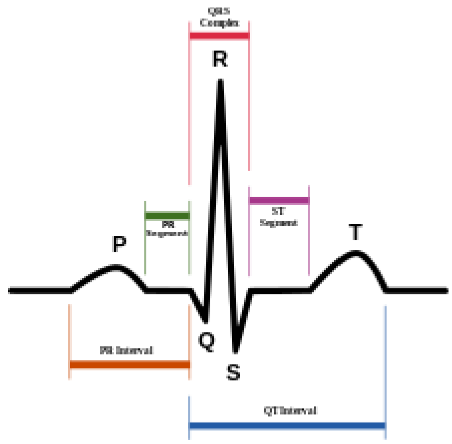

Figure 2.wave description

The recording produced by this non-invasive procedure is termed an electrocardiogram (also ECG or EKG).An ECG is used to measure the rate and regularity of heartbeats, as well as the size and position of the chambers, the presence of any damage to the heart, and the effects of drugs or devices used to regulate the heart, such as a pacemaker. Most ECGs are performed for diagnostic or research purposes on human hearts, but may also be performed on animals, usually for diagnosis of heart abnormalities or research.

FEATURES	DISCRIPTION	DURATION
RR Interval	The interval between an R wave and the next R wave: Normal resting heart rate is between60 and 100 bpm.	0.6 to 1.2s
P wave	During normal atrial depolarization, the main electrical vector is directed from the SA node towards the AV node, and spreads from the right atrium to the left atrium. This turns into the P wave on the ECG.	80 ms
PR Interval	The PR interval is measured from the beginning of the P wave to the beginning of the QRS complex. The PR interval reflects the time the electrical impulse takes to travel from the sinus node through the AV node and entering the ventricles. The PR interval is, therefore, a good estimate of AV node function.	120 to 200 Ms
PR segment	The PR segment connects the P wave and the QRS complex. The impulse vector is from the AV node to the bundle of His to the bundle branches and then to the Purkinje fibers. This electrical activity does not produce a contraction directly and is merely traveling down towards the ventricles, and this shows up flat on the ECG. The PR interval is more clinically relevant.	50 to 120 ms
QRS complex	The QRS complex reflects the rapid depolarization of the right and left ventricles. They have a large muscle mass compared to the atria, so the QRS complex usually has much larger amplitude than the P-wave.	80 to 120 ms
J-point	The point at which the QRS complex finishes and the ST segment begins, it is used to measure the degree of ST elevation or depression present.	N/A
ST segment	The ST segment connects the QRS complex and the T wave. The ST segment represents the period when the ventricles are depolarized. It is isoelectric.	80 to 120 ms
T wave	The T wave represents the repolarization (or recovery) of the ventricles. The interval from the beginning of the QRS complex to the apex of the T wave is referred to as the absolute refractory period. The last half of the T wave is referred to as the relative refractory period (or vulnerable period).	160 ms
ST interval	The ST interval is measured from the J point to the end of the T wave.	320 ms
QT interval	The QT interval is measured from the beginning of the QRS complex to the end of the T wave. A prolonged QT interval is a risk factor for ventricular tachyarrhythmias and sudden death. It varies with heart rate and for clinical relevance requires a correction for this, giving the QTc.	Up to 420 ms in heart rate of 60 bpm
U wave	The U wave is hypothesized to be caused by the repolarization of the interventricular septum. They normally have a low amplitude, and even more often completely absent. They always follow the T wave and also follow the same direction in amplitude. If they are too prominent, suspect hypokalemia, hypercalcemia or hyperthyroidism usually.	

J wave	The J wave elevated J-point or Osborn wave appears as a late delta wave following the QRS or as a small secondary R wave. It is considered pathognomonic of hypothermia or hypocalcaemia.	

Table1.ECG parameters

The following table mentions some pathological patterns that can be seen on electrocardiography, followed by possible causes.

Shortened QT interval	Hyperkalaemia, some drugs, certain genetic abnormalities, hyperkalaemia
Prolonged QT interval	Hypocalcaemia, some drugs, certain genetic abnormalities
Flattened or inverted T waves	Coronary ischemia, hypokalaemia, left ventricular hypertrophy, digoxin effect, some drugs
Hyper acute T waves	Possibly the first manifestation of acute myocardial infarction, where T waves become more prominent, symmetrical, and pointed
Peaked T wave, QRS wide, prolonged PR, QT short	Hyperkalemia, treat with calcium chloride, glucose and insulin or dialysis
Prominent U waves	Hypokalemia

Table2.pathological variations in ECG

3.2 Heart Rate

Normal range for heart rate of a person is 60 to 100 bpm. Generally, it is considered that if heart beat is lower, heart is in good condition. Bradychardia is considered under heart beat range of 60 bpm. Normally 50-60 bpm is considered as normal rate for common people and they do not require special attention. For Tachycardia heart rate is considered above 100 bpm. Hence normal resting rate is considered from 50-100 bpm. If the heart rate of a person is above or below that range, then this type of people need extra attention.

3.3 Pulse Rate

Pulse rate is actually the count of heart palpation, from that we can know the overall heart health and its fitness. Conventional way is to check pulse rate with trained hands.

3.4 Temperature

It is ability of human body to generate and get rid of heat whenever required, oral measurements are always considered as higher than any other body temperature measurement. Body itself maintains its temperature within normal below or above the average range. Depend upon the places, body temperature changes. Commonly average body temperature accepted is 37.0°C that is 98.6°F.

IV. REAL TIME QRS DETECTION

QRS complex is the most important factor in ECG waveform. We have to detect the r-peaks of QRS complex. The accurate detection of the R-peak of the QRS complex is the prerequisite for the reliable function of ECG-analyzers [4].The recognition of almost all ECG parameters is based on a fixed point identifiable at each cycle.
The time and amplitude measurements are done when R peak is detected from ECG wave.
There is a large number of recognition algorithms used in ECG-analyzers and, in many cases, the principles of operation vary. Some are based on different types of amplitude triggering, while others examine the signal in the frequency domain [5, 6]. The adaptive properties of algorithms to the changing signal may differ and some algorithms use statistical methods for identification. We have implemented the Pan- Tompkins real time QRS detection algorithm [1]. As shown in fig. 2 this algorithm uses filtering, differentiation, signal squaring and time averaging to detect the complex

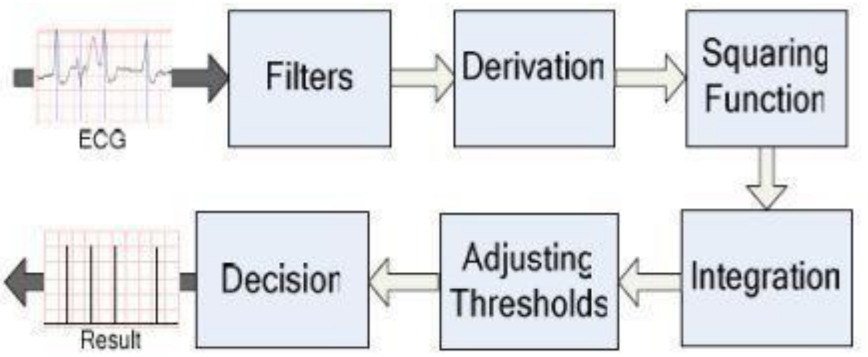

Figure3.Pan-Tompkin real time QRS detection algorithm.

4.1 Filtering

The ECG signals which are collected from electrode can have noise and other different interferences. So we have to process the signal to avoid misinterpretation.
Cascading of 2nd order low pass filter and high pass filter is done to form a band pass filter.

4.1.1 Low-pass Filter

The transfer function for 2nd order low pass filter is given by: $H(z) = (1 - z{-}6)^2/(1 - z{-}1)^2$
y[n] = 2 y[n-1] - y[n-2] + x[n] - 2 x[n-6] + x[n 12]
Where the cutoff frequency is about 11 Hz and the gain is 36.

4.1.2High-pass Filter

The transfer function for the high pass filter is:

H (z) = Y (z)/X (z) = (1 +32 z-16 + z-32) / (1 + z-1)

The gain for this filter is 32.

4.2 Differentiator

Third step is to differentiate the signal. We used a five point derivative with transfer function:
H (z) = 0.1 (2 + z-1 - z-3 - 2 z-4)

4.3 Squaring function

Point by point squaring is done after differentiation. The equation of this operation is
y[n] = (x[n])2
This makes all data points positive and does nonlinear amplification of the output of the derivative emphasizing the higher frequencies.

4.4 Moving-Window Integration

The purpose of moving window integration is to obtain waveform feature information in addition to the slope of R wave.
It is calculated from
y[n] = (x[n - (N-1)] + x[n - (N-2)] + … + x[n]) / N
N is number of samples in the width of an integration window.

4.5 Computation of Heart Rate

After R peak detection in QRS complexes the heart rate is computed in terms of BPM (bits per minute) from no of R peaks detected per minute.

3.6 Results

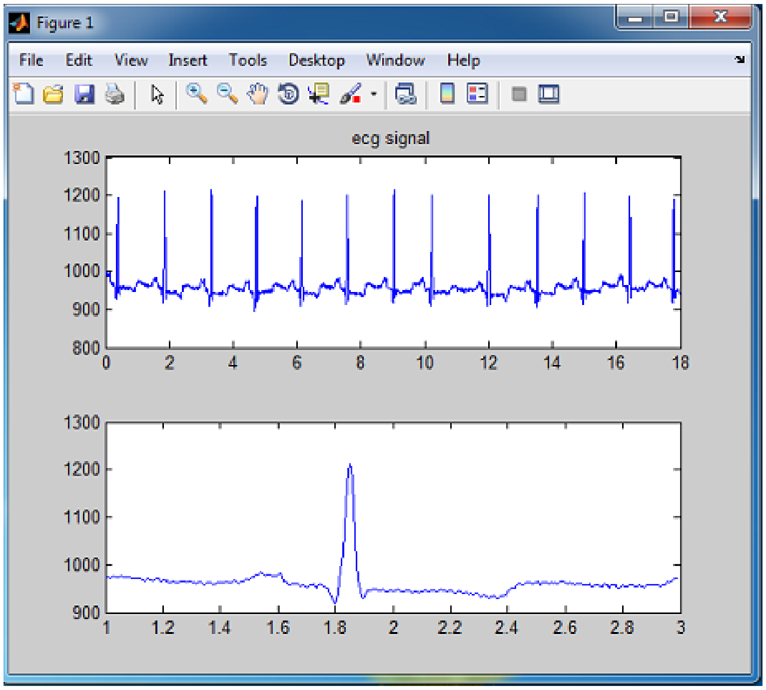

Figure 3. Original signal

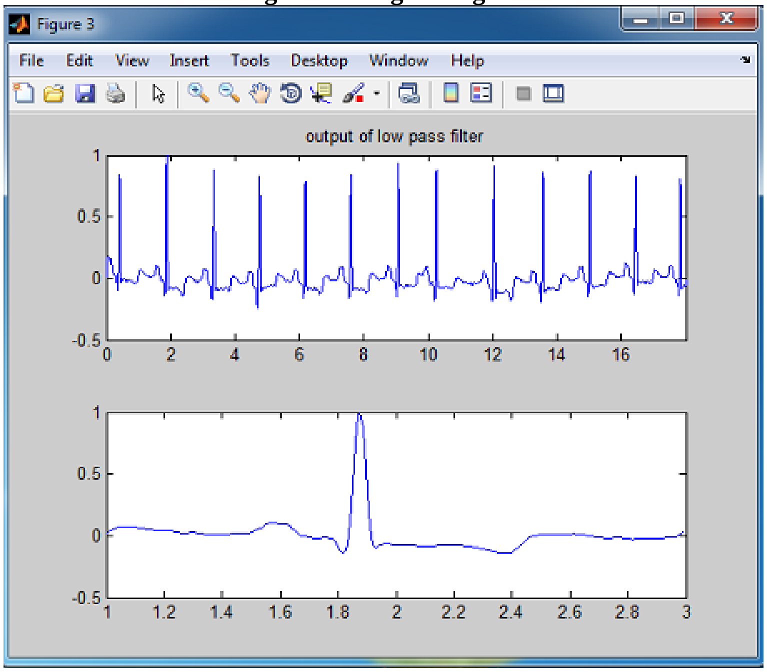

Figure 4. Output of low pass filter

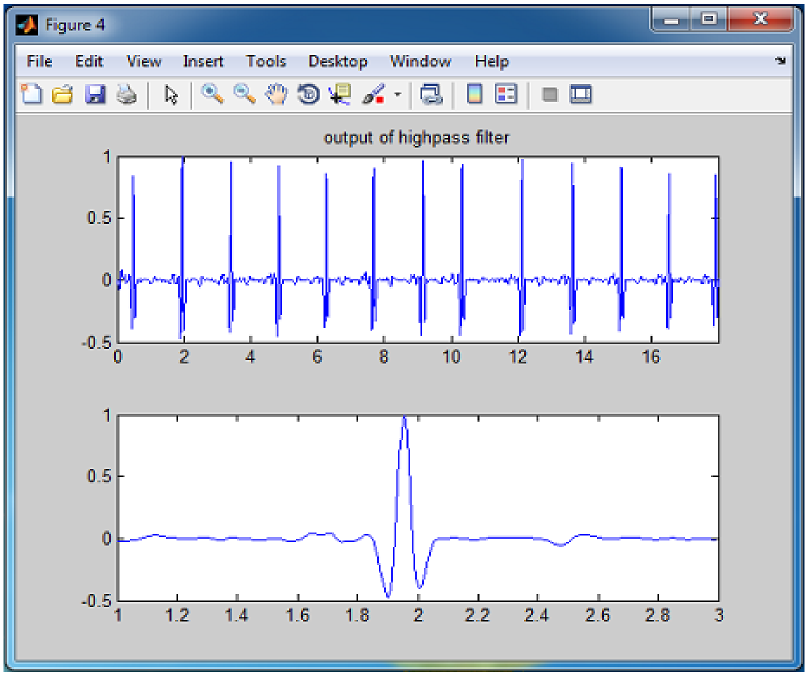

Figure 5. Output of high pass filter

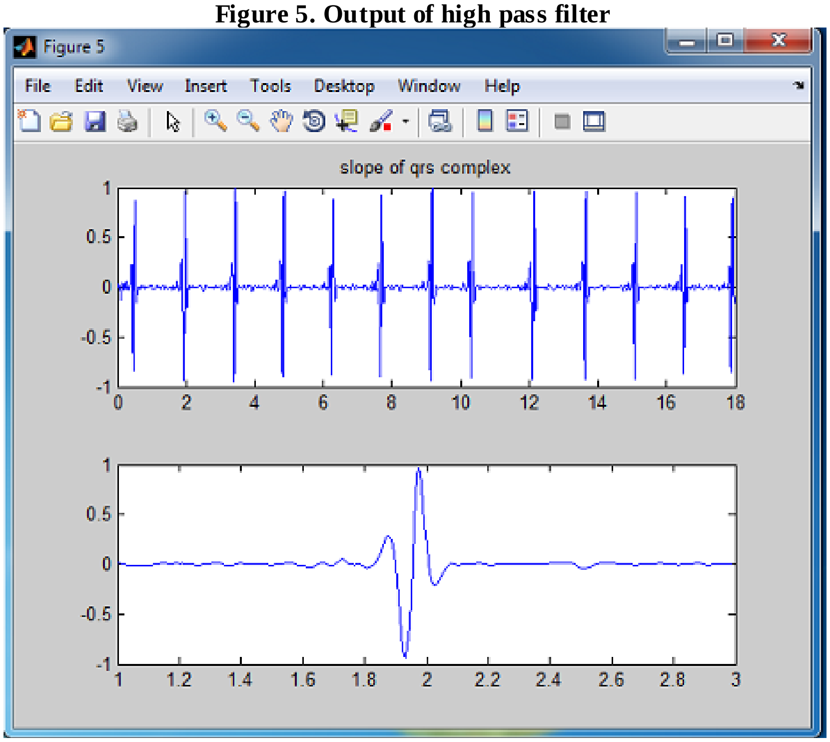

Figure 5. Slope of qrs complex

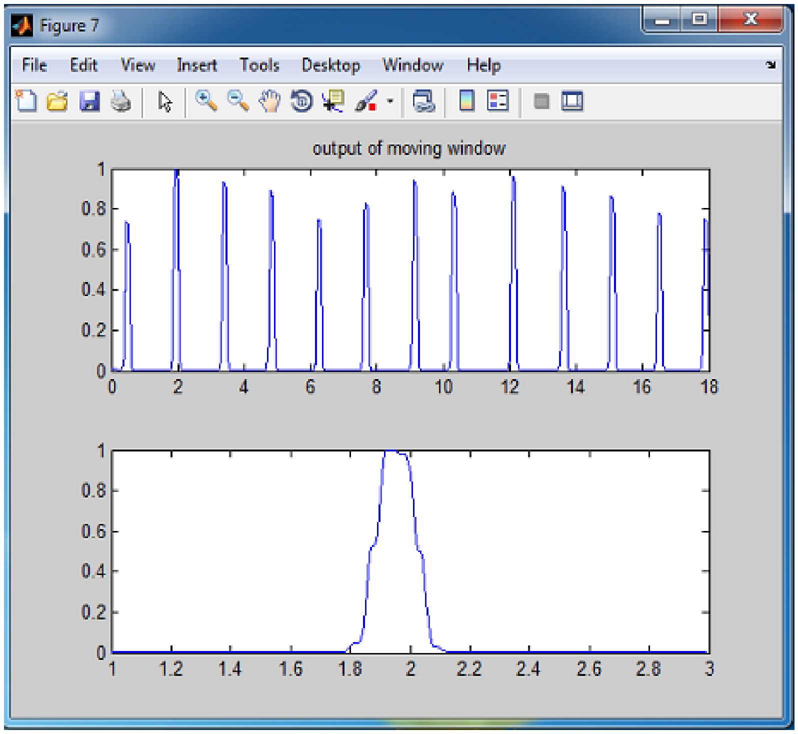

Figure 6. Output of moving window

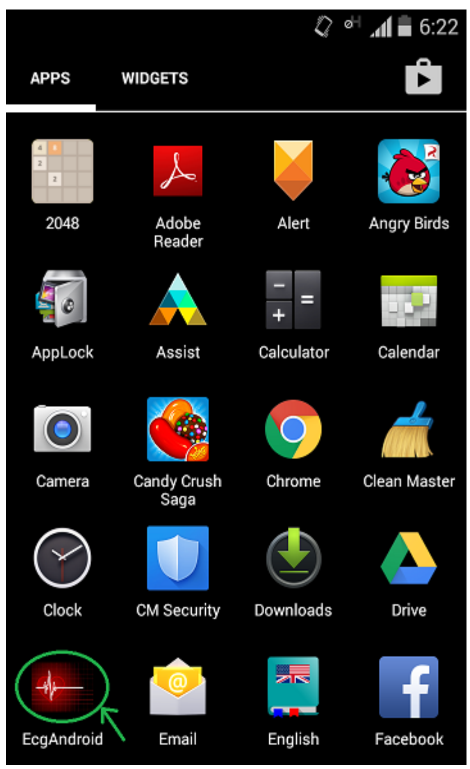

Figure 7. Designed android app

Figure8. Output of android system

V. CONCLUSION

Nowadays detection of irregularities in the heart rate is an emerging field in biomedical. In this paper we tried to discuss our system for patient monitoring as well as QRS detection. It comprises two parts hardware as well as software. Actual aim is to develop a system which can collect data and send it to concern physician whenever required. We can also keep the data for analyzing purpose. Software part is done using android phone and also a system for QRS detection is developed. Main focus is given on detecting heart disease type such as tachycardia and bradycardia. Taking these irregularities into consideration we can determine actual status of heart patient and hence we can use the system for the betterment of society.

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