DIAGNOSIS OF ECG ARRHYTHMIAS IN WIRELESS TELECARDIOLOGY

A THESIS SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology
In
Electronics and Instrumentation Engineering

BY

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NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA

CERTIFICATE

This is to certify that the Thesis Report entitled "**DIAGNOSIS OF ECG ARRHYTHMIAS IN WIRELESS TELECARDIOLOGY"** submitted by Sandeepa Bhuyan (Roll No. 109EI0104) and Priyesh Patel (Roll No. 109EI0170) in Partial fulfilment of the requirements for the award of Bachelor of Technology degree in Electronics and Instrumentation Engineering during session 2009-2013 at National Institute of Technology, Rourkela and this is an authentic work by them under my supervision and guidance. To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other university/institute for the award of any Degree or Diploma.

Date: 10/05/2013
Place: Rourkela

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ACKNOWLEDGEMENT

First of all, we would like to express our deep sense of reverence and gratitude towards our advisor, mentor and guide **Dr. Samit Ari**, who has been the guiding strength and the backbone behind this work. We are highly indebted to him for his constant encouragement, precious advice and for enforcing us further in every aspect of our academic life. His presence and sanguinity have provided an invaluable persuaded on our career and attitude for the future. We consider ourselves fortunate enough to have got an opportunity to work with such a magnificent person.

We also express our sincere gratitude to Prof S. Meher, Head of Department, Electronics and Communication Engineering for allowing access to all valuable facilities which were a necessity for us. We would also like to convey our gratitude to all the research scholars in our department who assisted us during the completion of this project work and their well-timed and valuable guidance that helped us to finish the work in the predetermined period of time.

We would like to extend our gratitude to our all faculty members and staffs of the Department of Electronics and Communication Engineering, NIT. Rourkela for their generosity in various ways for the completion of this thesis.

We would also like to thank all our dear friends and especially, our colleagues for all their thoughtful and mind stimulating discussions that we had with them, which provoked us to think past the obvious. We have enjoyed their camaraderie a lot during our stay at NIT Rourkela.

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ABSTRACT

Since many years ago, studies in the medical remote monitoring at home has taken a great consideration and care in wireless communication technology. The set of these studies is linked to needy people as aged ones, physically disabled in short time, in order to the adaptation with their environment domestically and build up their in capabilities. In this point of view, it is important to make a diagnostic in a real time and managed really the given data of patients between medical personnel with the permanent safety insurance of critical edge patients. Furthermore, the need to make a speed diagnostic of patients and to distinguish their health state with efficacy permits the gain of time in their taking off. Our attention has been aimed on the option of a relevant work. It concerns an function on a mobile terminal (MIDlet) for monitoring patient in a non-hospital environment.

This article evokes a complete structural design of an economic wireless communication system with the implementation of an efficient algorithm, adapted to the mobile terminal, allowing to the doctor to have the results of analysis of ECG information wirelessly.

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CHAPTER 1
INTRODUCTION

CHAPTER 1

INTRODUCTION

The cost of the life represents a significant importance in the economic balance sheet on International scale. Also, in many countries, the aging or mental shocks of the population tends to enhance the number of people strongly requiring medical monitoring even more or less intensive care and of this fact the global price of medical care.

The current technological advances of mobile telecommunications networks have led to the emergence of a wide variety of new ways for users to right of entry and use information. Then, today a simple mobile phone can donate effectively to safeguard of the human lives. This report describes the application using mobile wireless networks to pleasure and monitor the state of patient and aged ones at home. The majority of the works undertaken in this area carry out the analysis of the signals on huge server (great capacities, better resolution). We suggest in this project to introduce the complete analysis of ECG signal for the cardiac persons on a simple mobile phone by respecting its necessary constraints [1]. The recommended solution is an implement of an algorithm which transmits the statistics of the patient via a wireless communication in the purpose to utilize a mobile phone for medical monitoring (detection, calculation of cardiac frequency, etc. of ECG signal on the display of the mobile phone) [2], [3], [4], [5].

1.1 Literature Survey

In any typical telecardiology system**,** the ECG samples are transferred from the patient's phone to the doctor's phone or the medical server via various protocols like MMS/SMS/HTTP. The signal transmitter and the receiver is the mobile phone itself. Apart from the data transfer in the messaging protocol supports a limited no of characters, so limited amount of data was used here.

The motivation behind this project are challenges like fast and lossless transmission and efficient storage of data. In this project, it ensures faster detection because we do not go for compression and decompression as in paper by Sufi and Fang [2].This also dodges any lossless data transmission. The transmission is done through MMS messaging protocol which supports up to 600kb data transfer. With an sampling frequency of 360 Hz, about 2000 samples constitutes around 4-5 QRS peaks and occupies a size of about 60kb on the disk in the case of ECG of a normal subject.

Our project ensures cheap transmission of data. Unlike the method discussed by Merzougui and Feham [3], it does not involve any availability of internet connection like http. In case, where http web server was used to transfer of data, the doctor cannot access the data if his/her phone is not internet-enabled. But this problem can be easily solved by our project, here we use the MMS protocol which do not have internet connection as a pre-requisite criteria.

1.2 ECG Signal

ECG is the electrical demonstration of the contractile activity of the heart. They are detected by electrodes which are attached to the skin's surface and can be recorded by a device which is outside the body. This noninvasive procedure of recording is known an **Electrocardiogram.**

An ECG is used not only to compute the regularity and rate of the heartbeats but also to know the size and position of the heart's chambers, any damage's present in the heart, and the special effects of drugs/ devices which are used to control the heart, for instance pacemaker.

A typical ECG signal constitutes the PQRST complex. A PQRST complex consists of a complete cardiac cycle. One cardiac cycle: a P wave, QRS Complex, and a T wave. The baseline of the ECG can be determined by measuring the part of the Signal preceding the P wave and the part following the T wave. For normal person, generally, the baseline is almost isoelectric at about 0mV. However, in a sick heart the baseline may be above or below the isoelectric line. In the figure 1.2, a cardiac cycle is shown denoting the PQRST Complex.

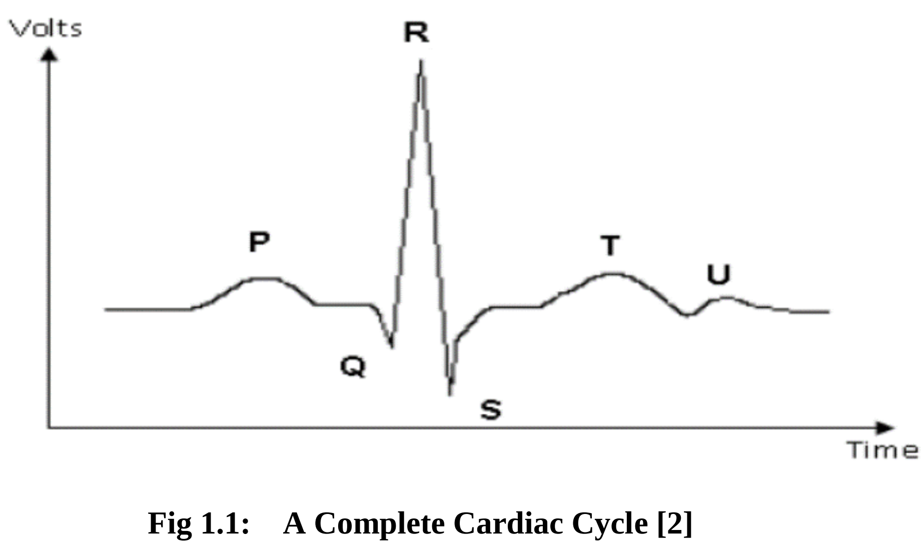

Fig 1.1: A Complete Cardiac Cycle [2]

Each of these waves is considered by its amplitude and its duration. In the table 1.2, the parameters of the ECG Signal of a normal person are summarized.

TABLE 1.2: Parameters of an ECG signal [3]

Type of wave in ECG signal	Source	Amplitude in mV	Duration in Seconds
Wave P	Atrial depolarization or contraction	<=0.2 mV	Interval :P-R 0.12 A` 0.22
Wave R	Repolarization of the atria and the depolarization of the ventricles	1.60	0.07 A` 0.1
Wave T	Ventricular repolarization (Relaxation of myocardium)	0.1-0.5	Interval :Q-T 0.35 A`0.44
Interval S-T	Ventricular contraction		Interval :S-T 0.015 A` 0.5
Wave U	Slow repolarization of the interventricular (Purkinje Fibres)	<0.1	Interval :T-U 0.2

During the period of normal atrial depolarization, the prime electrical vector is focussed from the SA node in the direction of AV node, and spreads till the left atrium from the right atrium which forms the P wave. The R wave is the maximum amplitude wave in the ECG .It is the main feature considered for detecting ECG arrhythmias. The QRS complex depicts the swift depolarization of the right and of the left ventricles. Since, they have a huge muscle mass as

Compared to the atria, so they always have a very large amplitude than the P-wave and the T-wave. The Q wave signify the interventricular septum's depolarisation. S wave is any downward deflection found after the occurrence of the R wave. The T wave represents the ventricle's repolarization. The period from the start of the QRS complex to the peak of the T wave is demoted as the absolute refractory period when another action potential cannot be triggered by an external stimuli. The second part of the T wave is denoted to as the relative refractory period/vulnerable period where easily a new action potential can be triggered. Sometimes, a U wave may follow a T wave. Any deviation from the described values, results in a disease [6], [7], [8], [9], [10].

1.3 Wireless Telecardiology

In terms of remote exploitation of the stored data on a computer at home, the most tailored solution consists to use a simple mobile phones correlated by a GSM / GPRS to this database. It is a technology, easy and speedy to be implemented. For the faster and efficient detection of any arrhythmias, use of Wireless Telecardiology was preferred by us. Wireless telecardiology system helps us in faster cardiac abnormality detection and so also its confirmation by the doctor. This implies the existence of a GSM/GPRS connection between doctor's mobile terminal and monitoring home automation scheme to recover statistics of ECG signal [11], [12].

The figure 1.2 describes the complete architecture of the procedure followed by us. The implemented function on a mobile phone, functions on all mobile terminals or Personal Device Assistance capable of with a J2ME virtual machine. This algorithm allows communications GSM / GPRS with other devices. In this case, the transmitted statistics concerns the ECG signal collected on remote sites. First of all from alive hear monitor or the ECG machine the ECG signals of a patient are acquired which are transferred to patients phone through Bluetooth technology and then these signals are transmitted to doctor's phone via MMS method and then doctor inquires and analyse the form of patient.

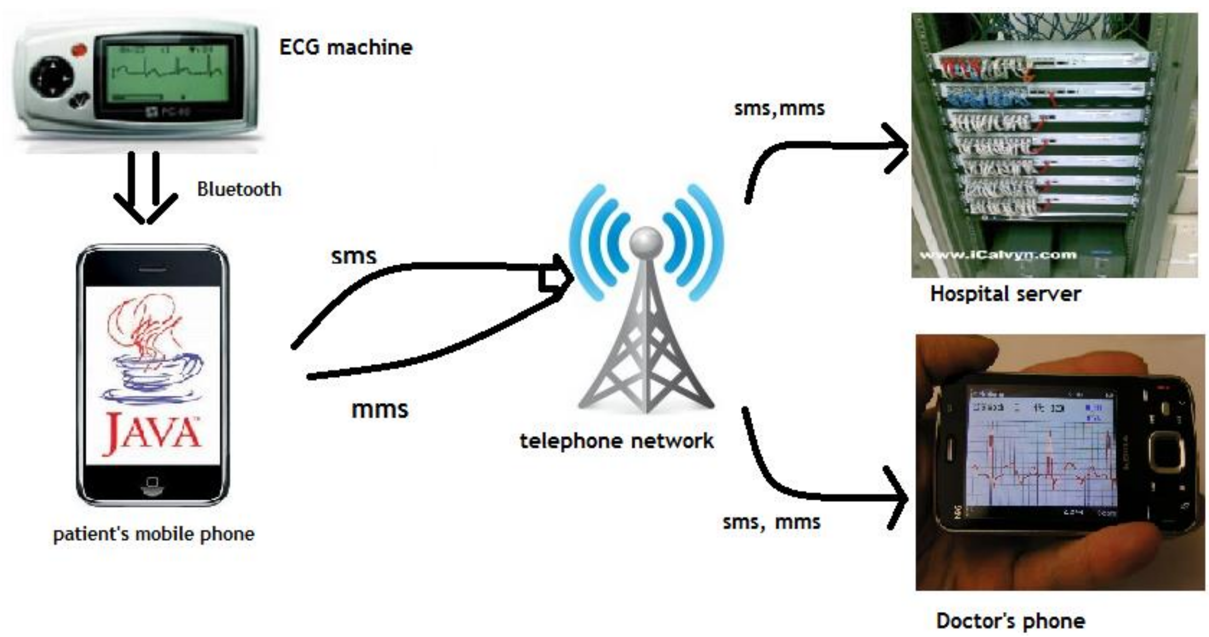

Figure 1.2 Complete Architecture of the Wireless Telecardiology followed by us. [2]

The recording and the acquisition of the ECG statistics were carried out using MATLAB r2010a. Java applications have been implemented under NetBeans IDE 7.0.1 environment. A simulation tool Sun Java ™ Wireless Toolkit 2.5 for CLDC was exploited to scrutinize all the possible wireless communications. It allows applications on devices with small resources calculations such as a mobile phone [13], [14],

As mentioned before, our implementation achieves the medical examination which provides the Continuity of remote monitoring at home and immediate alarms to contract with the patient in the event of need. The implementation of this examination requires the development of two distinctive applications:

- First to be downloaded on the patient's mobile phone to sense and treat the crucial situations of patient via wireless support.
- Second to be downloaded on the doctor's mobile in order to obtain and record data relating to the patient.

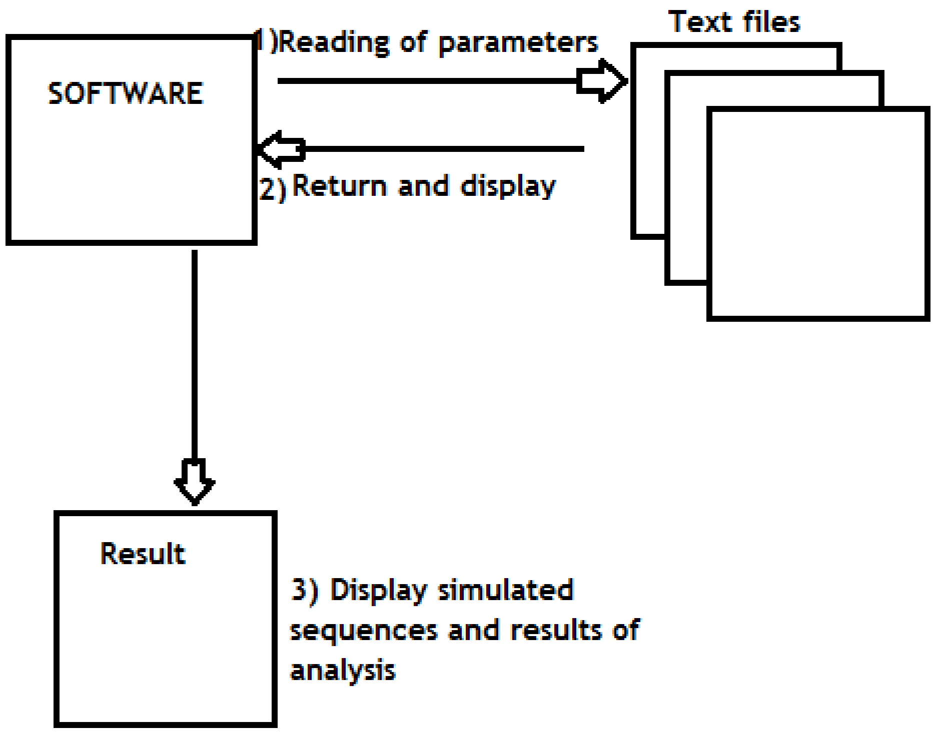

Figure 1.3 Principle of the process implementation of simulation [2]

The entire principle of the process of simulation is described in the figure 1.3.2. The ECG Signal are acquired by the ECG machine and saved in the .txt format and transferred to the mobile phone through the Bluetooth JSR-75 and the application loaded on the patient's phone is run accordingly and if any critical situation arises, then the data is sent to the doctor's for further confirmation and analysis.

1.3.1 Development on phone

JAVA 2 MICRO EDITION (J2ME) combines a resource inhibited JVM and a set of Java APIs For budding applications for mobile devices. The expansion of applications on mobile phones is based on the employment of the CLDC configuration and profile MIDP. In addition to these two standards, we have subjugated some optional packages such as WMA for the managing of services SMS / MMS.

The libraries necessary for the execution for each component of J2ME are as follows:

API MIDP: is, till now, what is downloaded on mobiles "compatible J2ME":

-javax.microedition.Icdui: it supplies the graphic components compulsory to the creation of applications.

-javax.microedition.midlet: It supplies the component application as well as the primitives supervising the life of the application.

API CLDC:

-javax.microedition.io: It consists the classes making it possible to connect itself via *TCP/IP* or *UDP*. The principal object of this package is the class *Connector*. This function on the client, called MIDlet, is conceded with the virtual machine java (KVM) on the mobile terminal. It has as the role to receive dimension of the devices of the patient at home, to treat these data or to store them if required. It also allows to the doctor to convey an alarm in case of a critical situation.

***API File Connection*:**

-javax.microedition.io: it can help to read and write files and can create and remove directories from the exposed file systems [15], [16].

1.3.2. Development on doctor's phone

The second application (on the Doctor's phone) is comprised of different sub-programs. They have purpose to accept the data and allow the Doctor to establish the diagnosis of the patient either by implementation of an algorithm built-in into his cell phone, or by exploiting the inward data.

1.4. Cardiac Diseases: An Overview

Cardiac disease/ heart disease is a group of diseases that engages the heart/blood vessels. Heart disease denotes to any disease that have an effect on the cardiovascular system. With aging comes a huge number of physiological and morphological transforms that can vary ones cardiovascular function and can lead to enhanced risk of cardiac disease, even in healthy individuals. Arrhythmia is the condition of abnormality of heart.

Tachycardia is caused due to heart rate variability from the normal conditions. It occurs due to various factors: Damage of heart tissues, Abnormality in the electrical pathway present in the heart during birth, high blood pressure, etc.

Bradycardia is also caused due to variation in the heart rate. This arrhythmia can be attributed to several causes: cardiac and noncardiac. Noncardiac causes involves drug abuse, prolonged bed rest, etc. Cardiac causes involve acute/chronic ischemic heart diseases, valvular heart disease, etc.

QRS duration variability leads to bundle branch block syndrome. It refers to any defect in heart's electrical conduction system. When a bundle branch becomes injured due to underlying cardiac infarction, it may stop to conduct electrical impulses appropriately. Bundle Branch Block is divided into further two diseases: Left Bundle Branch Block (LBBB), and Right Bundle Branch Block (RBBB). In LBBB, commencement of the left ventricle is postponed, which causes the left ventricle to indenture later than that of the right ventricle. In RBBB, the right ventricle is not directly initiated by impulses which are travelling via the right bundle branch.

CHAPTER 2
HEART RATE CALCULATION

CHAPTER 2

HEART RATE CALCULATION

Heart rate is the number of heartbeats per unit of time, normally expressed as *beats per minute* (bpm). Heart rate can vary as the body's need to absorb oxygen and excrete carbon dioxide fluctuations, such as during physical exercise, sleep, illness, or as a outcome of ingesting drugs:

1.Central nervous system stimulants such as amphetamines increase heart rate.

2.Central nervous system depressants or sedatives decrease the heart rate (apart from some particularly odd ones with equally strange properties, such as ketamine which can cause -among many other things - stimulant-like properties such as tachycardia).

There are many ways in which the heart rate haste up or slows down. Most involve stimulant-like endorphins and hormones being released in the brain, many of which are those that are forced out by the ingestion and dispensation of drugs.

Heart rate is sedate by finding the pulse of the heart. This pulse rate can be located at any point on the body where the artery's pulsation is transmitted to the surface by coercing it with the index and middle fingers; often it is compacted against an underlying structure like bone. The thumb should not be used for computing another person's heart rate, as its strong pulse may obstruct with the correct acuity of the target pulse.

Period calculation is usually done using *autocorrelation:* In the proposed process, about 1000 samples is extracted from the filtered ECG signal to discover the exact duration of one cardiac cycle in that specific ECG signal. The approximate R-R interval between two cardiac cycles is 0.2s to 1.2s. So an array *lag_sec* is created by taking a fixed length signal of 1000 samples duration whose sampling frequency (*fs*) =360 Hz. The array length lies in between the range 0.4s to 1.2s with a time lag 0.02s. The number of samples corresponding to each *lag_sec* is found out by multiplying the sampling frequency (*fs*) and by storing these values in an array *lag_index* as discussed below [17], [18], [19], [20], [21].

Lag_index(i)=floor(lag_sec(i)*fs)

ALGORITHM 5.1 Period calculation of one cardiac cycle in ECG signal using autocorrelation [28].

1. An ECG signal of length 5s is taken and it is denoted as (X(t)
2. An array lag_sec in the range 0.4s to 1.2 s is assigned with step size 0.02s
3. Lag_index=lag_sec*fs;
4. Autocorrelation is calculated

```
For j=1: length(lag_index) do:
For i=1: length(X)-lag_index(j)) do:
Sum(j)=sum(j)+abs(X(i))*abs(X(i+lag_index(j)));
End for
Sum(j)=sum(j)/((length (X))-(lag_index(j)));
End for
```

5. The position is found out where the sum is maximum and a variable index is assigned to it.
6. The corresponding lag_sec value is found out which is the period of one cardiac cycle in the ECG signal

The filtered ECG signal is separated in to several sub-windows whose length equal to the one cardiac cycle period. The one cardiac cycle length is acquired from the output of autocorrelation .The sub window creation helps to compute the accurate number of R-peak and their position.

CHAPTER 6

QRS DETECTION

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QRS DETECTION

QRS complex is a name for the mixture of three of the graphical deflections realised on a typical electrocardiogram (ECG). It is typically the central and most visually palpable part of the tracing. It resembles to the depolarization of the right and left ventricles of the human heart. In adults, it normally persists 0.06 - 0.10 s; in children and during physical action, it may be shorter.

Naturally an ECG has five deflections, arbitrarily named "P" to "T" waves. The Q, R, and S waves occur in fast succession, do not all appear in all leads, and mirror a single event, and thus are frequently considered together. A Q wave is any descending deflection after the P wave. An R wave follows as an upward bend, and the S wave is any downward bend after the R wave. The T wave tracks the S wave, and in some circumstances an additional U wave follows the T wave

Formation of QRS wave: these systems of Purkinje fibres stimulates contraction of ventricular muscles in a rapid sequence from the apex upwards. The almost simultaneous contraction of entire ventricular musculature marks in a sharp and tall QRS complex of about 1mV amplitude or less and 100 ms duration. The event of ventricular contraction was show by the QRS epoch itself.

Murthy and Rangaraj proposed a QRS detection algorithm which is based upon a weighted and squared first derivative operator and an MA filter method. In this process, we first used a filtered derivative operator was defined as below [23], [24], [25], [26]

$$g_1(n) = (\sum_{i=1}^{N}(|x(n-i+1)-x(n-i)|)^2(N-i+1)$$

where x(n) is the ECG signal ;N is the width of a window within which first order differences are computed, squared and weighted by the factor (N-i+1). The weighting factor lessens linearly from the current difference to the difference N samples earlier in time and provides a smoothing effect. Further smoothing of the result was performed by an MA filter over M points to obtain

$$g(n) = \frac{1}{M}\sum_{j=0}^{M-1} g_1(n-j)$$

With a sampling rate of 360 Hz the filter window widths were put as M=N=30. This algorithm provides a single peak for each QRS complex and supresses P and T waves.

Searching for the peak in a processed signal such as g(n) may be skilled by a simple peak-searching Technique as follows:

1. We Scanned a portion of the signal g(n) that was expected to contain a peak and determined the maximum value $g_{max.}$

2. We defined a threshold as a fraction of the maximum, for example, Th=0.5 g_{max}

3.For all g(n)> Th , We selected those samples for which the corresponding g(n) values are greater than a certain previously mentioned number M of preceding and succeeding sample of g(n) that is

{p}= [n | g(n)>Th] AND

[g(n)>g(n-i), i=1,2,……,M] AND

[g(n)> g(n+i) ,i=1,2,…..,M]

The set {p} defined as above consists of the indices of the peaks in g(n).

Additional conditions may be used to reject peaks due to artefacts, for instance a minimum interval between two adjacent peaks.

Figure 6.1, displays the plots of ECG samples , and after first-order derivative and squaring $g_1(n)$ and smoothing the first –order derivative by the MA filter yields the plot g(n).In g(n),Single QRS peaks are obtained in the window locality [27], [28], [29], [30].

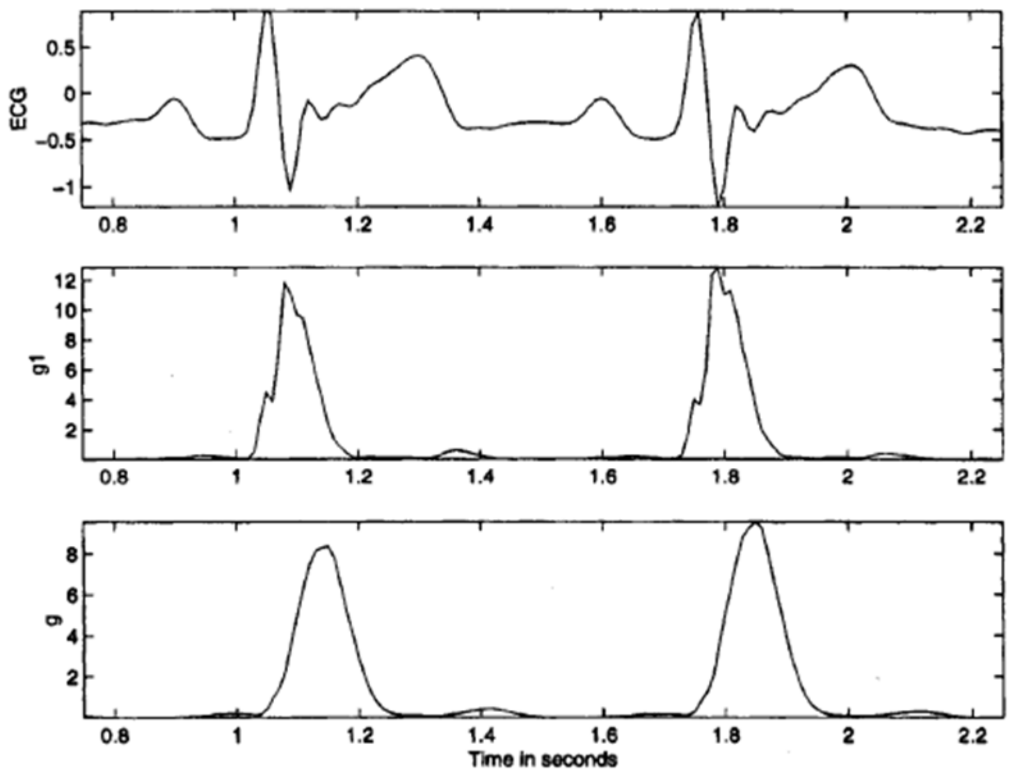

Figure 6.1 from top to bottom: two cycles of a filtered version of the ECG signal.

Output $g_1(n)$ of the weighted and squared first derivative operator in the equation[23]

CHAPTER 7
ECG
ARRHYTHMIAS

CHAPTER 7

ECG ARRHYTHMIAS

An arrhythmia is a problematic with the rate or rhythm of the heartbeat. During the period of arrhythmia the heart can beat too profligate, too slow, or with an uneven rhythm.

A heartbeat that is too fast is called tachycardia. A heartbeat that is too sluggish is called bradycardia.

Most arrhythmias are harmless, but some can be serious or even life threatening. Through an arrhythmia, the heart may not be able to impel enough blood to the body. Lack of blood flow can harm the brain, heart, and other organs.

7.1 DISEASES RELATED TO HEART RATE VARIABILITY:

7.1.1 Tachycardia- When the Heart rate becomes greater than 100 BPM, then the arrhythmia is called as tachycardia.

7.1.2 Bradycardia-When the Heart rate becomes less than 60 BPM, then the arrhythmia is called as bradycardia

7.2 DISEASES RELATED TO QRS DURATION:

Bundle Branch Blocks

When a bundle branch or fascicle becomes injured (due to underlying heart diseases, myo-cardial infarction, or cardiac operation), it may stop to conduct electrical impulses properly. This results in changed pathways for ventricular depolarization. From the time when the electrical impulse can no longer practice the preferred pathway across the bundle branch, it may move as an alternative over and done with muscle fibres in a way that both slows the electrical movement and changes the directional propagation of the impulses. As an outcome, there is a loss of ventricular synchrony and ventricular depolarization is extended, and there may be a corresponding drop in cardiac output. When heart failure is present, a focused pacemaker may be used to resynchronize the ventricles. In theory a pacemaker like this will curtail the QRS interval, thus fetching the timing of narrowing of the left and right ventricles nearer together and possibly tuning up the Ejection Fraction.

7.2.1 Left Bundle branch block- if the QRS duration width is greater than 120 milliseconds and if the QRS complex is widened and downwardly deflected in lead V1, a left bundle branch block (LBBB) is present then left bundle branch block occurs

7.2.2Right Bundle branch block- If the QRS duration width is greater than 120 milliseconds and the QRS complex is widened and upwardly deflected in lead V1, a right bundle block is present then right bundle branch block (RBBB) occurs

CHAPTER 8
RESULTS
AND DISCUSSION

CHAPTER 8
RESULTS AND DISCUSSION

The samples for the calculation of various parameter were taken from either MIT-BIH or the ECG Machine. The subject 1 ECG sample was from MIT-BIH [22] where as others from the ECG machine

TABLE 8.1: Parameter Calculation from ECG Signals from Different Subjects.

ECG SIGNAL	SOURCE	SAMPLING FREQUENCY	HEART RATE	Q PEAK	R PEAK	S PEAK	QRS WIDTH	CONDITION
SUBJECT 1	MIT-BIH [22]	360 Hz	61 BPM	0.18s 0.99s	0.20s 1.02s	0.24s 1.06s	0.06388889s 0.07361111s	HEALTHY
SUBJECT 2	ECG MACHINE	400 Hz	64 BPM	0.157s 0.955s 1.65s	0.212s 0.975s 1.71s	0.285s 1.047s 1.79s	0.06375s 0.04625s 0.06625s	HEALTHY
SUBJECT 3	ECG MACHINE	400 Hz	63 BPM	0.18s 0.92s 1.727s	0.197s 0.997s 1.747s	0.27s 1.07s 1.82s	0.045s 0.075s 0.04625s	HEALTHY
SUBJECT 4	ECG MACHINE	400 Hz	63 BPM	0.167s 0.907s 1.715s	0.185s 0.985s 1.735s	0.257s 1.057s 1.807s	0.0452s 0.0758s 0.046355s	HEALTHY
SUBJECT 5	ECG MACHINE	400 Hz	65 BPM	0.17s 0.965s 1.67s	0.22s 0.985s 1.725s	0.295s 1.055s 1.8s	0.06388s 0.04630s 0.06635s	HEALTHY
SUBJECT 6	ECG MACHINE	400 Hz	63 BPM	0.182s 0.922s 1.73s	0.195s 0.992s 1.747s	0.272s 1.067s 1.82s	0.045s 0.085s 0.04630s	HEALTHY
SUBJECT 7	ECG MACHINE	400 Hz	61 BPM	0.337s 1.795s	0.375s 1.86s	0.445s 1.925s	0.06480s 0.07455s	HEALTHY
SUBJECT 8	ECG MACHINE	400 Hz	66 BPM	0.162s 0.96s 1.665s	0.217s 0.98s 1.72s	0.29s 1.05s 1.795s	0.06480s 0.04630s 0.06625s	HEALTHY
SUBJECT 9	ECG MACHINE	400 Hz	64 BPM	0.162s 0.96s	0.2175s 0.97s	0.29s 1.045s	0.06480s 0.04525s	HEALTHY
SUBJECT 10	ECG MACHINE	400 Hz	64 BPM	00.15s 0.9375s 1.65s	0.20s 0.962s 1.71s	0.282s 1.045s 1.782s	0.06370s 0.04420s 0.066188s	HEALTHY

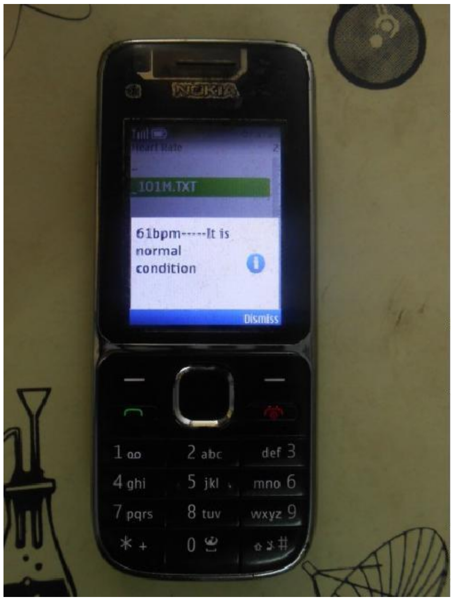

Figure 8.1(a) Heart Rate calculation

Figure 8.1(b) Q Peak Detection

Figure 8.1(c) R Peak Detection

Figure 8.1 (d) S Peak Detection

FIGURE 8.1(a)-(d): Heart rate calculation, Q peak detection, R peak detection, S peak detection respectively.

Figure 8.1 (e) QRS Detection

Figure 8.1(f) Condition of the Subject

FIGURE 8.1.(E)-(f): QRS width detection and the condition of the subject respectively.

CHAPTER 9

CONCLUSIONS AND SCOPE FOR FUTURE WORK

CHAPTER 9

CONCLUSIONS AND SCOPE FOR FUTURE WORK

This project work pacts with analysis of electrical bio potentials of a patient, recorded at home and

Perceived on the mobile phone of his/her doctor. This technique allows medical remote monitoring of many cardiac/ hypertensive/hypersensitive patients. Also, the identification, by the developed algorithm, of the medical profile of a patient at home and the notification of critical situations cannot cover all medical indicators corresponding to each of the patients. Thus, the improvements of this technique must be adopted for the diagnosis of the new pathologies. This solution is at all not costly and can be easily realizable, is adopted to the portable devices ensuring medical monitoring anywhere, anytime magnificently..

Detection of P waves and T waves for analysis of variety of other heart diseases can be done further extension of the project. Compression of ECG SIGNAL for efficient and cheaper transmission of the signal without any heavy loss of data or lossless data transmission.

REFERENCES

[1] American National Standard for Ambulatory Electrocardiographs, publication ANSI/AAMI EC38-1994, Association for the Advancement of Medical Instrumentation, 1994.

[2] Fahim Sufi, Qiang Fang, Ibrahim Khalil, and Seedahmed S. Mahmoud, "Novel Methods of faster Cardiovascular Diagnosis In Wireless Telecardiology," *IEEE Journal on Selected Areas In Communications, Vol. 27, No. 4,* May 2009.

[3] Rachid Merzougui, Mohammed Feham, "Algorithm of remote monitoring ECG using mobile phone: Conception and implementation", *Third International Conference on Broadband Communications, Information Technology & Biomedical Applications*.

[4] Turker Ince, Serkan Kiranyaz, and Moncef Gabbouj, "A Generic and Robust System for Automated Patient-Specific Classification of ECG Signals," *IEEE Trans. Biomed. Eng.* vol.56, pp.1415-1426, 2009.

[5] B.G. Celler, T. Hesketh, W. Earnshaw, E. Ilsar, "An instrumentation system for the remote monitoring of changes in functional health status of the elderly at home," *in Proc. of the 16th Annual IEEE Engineering in Medicine and Biology Society,* Baltimore, USA, 1994, pp. 908-909.

[6] L. Chwif, R.J. Paul, "On simulation model complexity", *in Proc. of the 32nd conference on winter simulation,* Orlando, Florida, 2000, pp. 449-455.

[7] O. Fouial, I. Demeure, "Fourniture de services adaptables dans les environnements mobiles". *Proceedings of European Conference of Systems with adaptable and extensible components.* Grenoble, France, 2004.

[8] L. Biel, O. Pettersson, L. Philipson, and P. Wide."Ecg analysis: a new approach in human identification,".*IEEE Trans. Instrum. Meas.*, 50(3):808–812, Jun 2001.

[9] F. Sufi, Q. Fang, S. Mahmoud, and I. Cosic. A mobile phone based intelligent telemonitoring platform. *Medical Devices and Biosensors, 2006. 3rd IEEE/EMBS International Summer School on ISSMDBS*, pages 101–1/04, Sept. 2006.

[10] F. Sufi and I. Khalil."Enforcing secured ecg transmission for realtime telemonitoring: A joint encoding, compression, encryption mechanism," *Security and Communication Networks,* 1(5):389405, 2008.

[11] G. Wubbeler, M. Stavridis, D. Kreiseler, R.-D. Bousseljot, and C. Elster."Verification of humans using the electrocardiogram," *Pattern Recognition Letters*, 28:1172–2275, 2007.

[12] X.Afonso, W.J. Tompkins, T.Nguyen, S.Luo, "ECG beat detection using filter banks," *IEEE Trans. Biomed. Eng.* vol. 46, pp. 230-236, 1999.

[13] Vikram Goyal, "J2ME Tutorial, Part 1: Creating MIDlets," February 2005.

[14] Vikram Goyal ,"J2ME Tutorial, Part 2: User Interfaces with MIDP 2.0," May,2005.

[15] Quintas. A. F, "Bluetooth J2ME Java 2 micro edition*," manual de usuario y tutorial*, Madrid: Ra-Ma, 2004.

[16] Knudsen. J, "Wireless Java Developing with J2ME*", Second Edition, Apress, Berkeley*, United States, 2003

.

[17] S. Akselrod, D. Gordon, F. A. Ubel, D. C. Shannon, A. C. Barger, and R. J. Cohen."Power spectrum analysis of heart rate fluctuation: A quantitative probe of beat to beat cardiovascular control". *Science*, 213(1981):220–222, Oct. 2007.

[18] M. Kumar, M. Weippert, R. Vilbrandt, S. Kreuzfeld, and R. Stoll."Fuzzy evaluation of heart rate signals for mental stress assessment," *IEEE Trans. Fuzzy Syst.*, 15(5):791–808, Oct. 2007.

[19] S. Seydnejad and R. Kitney."Real-time heart rate variability extraction using the kaiser window," *IEEE Trans. Biomed. Eng.*, 44(10):990–1005, Oct 1997.

[20] F. Sufi, Q. Fang, and I. Cosic.:"Ecg r-r peak detection on mobile phones. Engineering in Medicine and Biology Society," *2007. EMBS 2007. 29th Annual International Conference of the IEEE*, pages 3697–3700, Aug.2007.

[21] S. Ari, K. Sensharma, and G. Saha., "DSP implementation of a heart valve disorder detection system from a phonocardiogram signal," *Journal of Medical Engineering & Technology*, vol. 32, no. 2, pp.122 – 132, 2008.

[22] MIT-BIH Database distribution, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139, 1998. http://www.physionet.org/physiobank/database/mitdb/

[23] R.M. Rangayyan,"Biomedical Signal Analysis: A Case-study Approach," Wiley–Interscience, New York, 2001, pp.18-28.

[24] P. S. Hamilton and W. J. Tompkins."Quantitative investigation of qrs detection rules using the mit/bih arrhythmia database,"*Biomedical Engineering, IEEE Transactions on*, BME-33(12):1157–1165, Dec. 1986.

[25] P. S. Hamilton and W. J. Tompkins."Quantitative investigation of qrs detection rules using the mit/bih arrhythmia database,"*Biomedical Engineering, IEEE Transactions on*, BME-33(12):1157–1165, Dec. 1986.

[26] N.V. Thakor, J.G. Webster and W.J. Thompkins, “Estimation of QRS complex power spectra for design of a QRS filter,” *IEEE Trans. Biomed. Eng.*, vol. 31, pp. 702–705, 1984.

[27] J. Pan, W. J. Tompkins, “A real time QRS detection algorithm,” *IEEE Trans. Biomed. Eng.* vol. 32, pp. 230–236, 1985.

[28] Jaya Prakash Sahoo, Sheemarani Behera, Samit Ari , “A Novel Technique for QRS Complex detection in ECG Signal based on Hilbert Transform and Autocorrelation,” *Dspace NIT Rkl*, January 2011.

[29] Yun-Chi Yeha and Wen-June Wang, “QRS complexes detection for ECG signal The Difference Operation Method (DOM),” *Computer methods and programs in biomedicine*, vol. 9, pp. 245–254, 2008.

[30] D. Beniteza, P.A.Gaydeckia, A. Zaidib, A.P. Fitzpatrick” The use of the Hilbert transform in ECG signal analysis,” *Computers in Biology and Medicine*, vol. 31, pp.399–406, 2001.

[30] Patrick S Hamilton ,Willis J Tompkins “Quantitative Investigation of QRS Detection Rules Using MIT/BIH Arrhythmia Database,”*IEEE transactions on Bio medical engineering, vol BME-33, NO-12,* Dec 1986.