EARLY DISEASE DETECTION BY EXTRACTING FEATURES OF BIOMEDICAL SIGNALS

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Technology

In

Industrial Design

By

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CERTIFICATE

This is to certify that the work in the thesis entitled, "**Early Disease Detection by Extracting Features of Biomedical Signals"**submitted by **Mr. Shivnandan Kumar Bhagat**in partial fulfilment of the requirements for the award of **Master of Technology Degree** in the Department of Industrial Design, National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the work reported in this thesis is original and has not been submitted to any other Institution or University for the award of any degree or diploma.

He bears a good moral character to the best of my knowledge and belief.

Place: NIT Rourkela
Date:

Prof. (Dr.) Bibhuti Bhusan Biswal
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Shivnandan Kumar Bhagat

ABSTRACT

Elderly people face a lot of health problems in day to day life due to old age and so many reasons. Therefore a regular health check-up is needed for them which is much more expensive and cannot be afforded by many people. Again the diagnosis is much more complicated to understand and in many cases there is a chance of mistreatment. There is another chance of delay in the detection of disease and late treatment causing risk in their lives. So, the disease should be detected in the early stage for lower cost and lower risk in life.

The present work is related to the different physiological parameters of a human being that are to be measured to accurately diagnose the related disease. Though there are numerous physiological parameters, this work emphasizes on some of the most common physiological parameters such as blood pressure, heart rate and ECG which are of primary importance to elderly people. Accurate measurement and analysis of these parameters can lead to diagnose of several lethal disease. In this work, the method of measurement and analysis of these physiological parameters are described. The simulation, processing and analyses of these signals are also done in the work.

The prime objective of the research work is to analyze and extract the features of ECG signal and blood pressure signal for early diagnosis of life threatening diseases.

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CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

Measurement of different physiological parameters is one of the essential features of medical treatment. The medical professionals rely on the basic measurement to determine the type of disease. Most of the instruments which provide basic information about the health of the patient are analogue in nature. The medical professionals measure the physiological parameter and try to diagnose the disease at the instant. This approach has some limitations such as there is no record keeping of the data and the interpretation of data varies from doctor to doctor. An experienced doctor can better diagnose the disease than any other doctor. The analogue nature of the instrument also possesses a challenge while reading the actual reading as there may be parallax error or human error. Record keeping of patient information is vital because the record allows the medical professional an insight about the patient's medical history.

Due to the rapid computerization in every aspect of human life now a day record keeping is not a very big challenge. Sincere efforts have been made to create computer interfaced medical measuring instruments which can reduce the human effort of storing the data.

1.2 MOTIVATION

The main motivation of the thesis is real time acquisition and analysis of bio signal. Using analysis of bio signals, different diseases can be detected in a real time manner. Bio signal acquisition is complex because amplitude of bio signal is low and there is noise in the acquisition process. Therefore, pre-processing of signal has to be done to remove the noise and other effects and amplify the signal before processing. This thesis considers two primary bio signals which are mostly used by doctors to ascertain the health of patient i.e blood pressure and ECG signals. The acquired ECG signal consumes a lot of space in the hard drive of measuring instrument. Compression of ECG signal is also essential because in telemedicine domain, the ECG signals are transmitted from one place to other. So for lossless transmission of signal, signal has to be compressed. Therefore, compression of ECG signal is essential. Different frequency domain techniques are used to compress the ECG signals.

In disease detection techniques, the features of the bio signals are used to detect the disease of the patient. This thesis provides disease detection using blood pressure and ECG signals.

1.3 OBJECTIVES

The main objective of the thesis is

1. Acquire bio signals (ECG and blood pressure) from real world or from internet database (MIT-BIH)
2. Compress the ECG signal using different frequency domain techniques
3. Compare the effectiveness of the compression techniques
4. Disease detection from the bio signals

1.4 THESIS ORGANIZATION

Chapter 1 presents the introduction of the thesis

Chapter 2 Literature Review

Chapter 3 presents different measurement techniques of bio signals

Chapter 4 presents the analysis and transform domain representation of bio signals

Chapter 5 presents disease detection techniques from bio signals

Chapter 6 presents the simulation results

Chapter 7 concludes the thesis

CHAPTER 2

LITERATURE REVIEW

2.1 LITERATURE REVIEW

Sl. No.	Title	Author(s)	Source	Material Used	Remarks
1	A Mathematical Study of Some Biomechanical Factors Affecting the Oscillometric Blood Pressure Measurement	Mauro Ursino	IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING, VOL. 43, NO. 8[1996]	Cuff,Pump, Valve, Sphygmomanometer	Calculation based on Basal Parameter. A very high error of 10-15%.
2	Development of a Non-invasive Continuous Blood Pressure Measurement and Monitoring System	Md. Manirul Islam	IEEE/OSA/IAPR International Conference on Infonnatics, Electronics & Vision[2012]	LCD, optical sensor network	It measures blood pressure using volume oscillometric method and photoplethysmography technique During a long time period continuously.
3	An Improved Approach for Non-invasive Blood Pressure Measurement System	Deng Chen	Fifth International Conference on Intelligent Human-Machine Systems and Cybernetics[2013]	ARM Cortex-M3, Arduino-like platform, Kiel Software.	Maximum Likelihood Technique, Embedded Pressure Monitoring using Microprocessor, Gauss Distribution

					Function to find the envelope of human Pulse Wave. Noise removed effectively.
4	Automatic Non-invasive Measurement of Arterial Blood Pressure	Meir Nitzan	IEEE Instrumentation & Measurement Magazine[2011]	Pressure Cuff, Mercury Manometer	Sphygmomanometer is most accurate blood pressure measuring device but for a single measurement may provide partial information because blood pressure varies suddenly.
5	Blood Pressure Estimation Using Maximum Slope of Oscillometric Pulses	Majid Mafi	34th Annual International Conference of the IEEE EMBS San Diego, California USA, 28 August - 1 September, 2012	Omron's software Model (HEM-790ITCAN).	Earlier Slope criteria were used to find Systole and Diastole pressure from the envelope of the signal but in these case slope criteria is used for derivation of envelope. Maximum Amplitude Algorithm is used.
6	Comparable Parameter related to arterial stiffness in Blood	Jung Soo Kim	Proceedings of the 5th International	PPG sensor (NONIN finger clip 8000A,	This method provides characteristic

	Pressure Estimation Method		Conference on Information Technology and Application in Biomedicine, in conjunction with The 2nd International Symposium & Summer School on Biomedical and Health Engineering Shenzhen, China, May 30-31, [2008]	USA), FINOMETER®PRO (Finapres Medical Systems)	estimation for only SBP, Here the parameters are more correlated with DSP than SBP. Photoplethysmography (PPG) is taken from second finger of left hand. Here we find TDB parameter from correlation.
7	Conceptual Design of Blood Pressure Monitoring for Old Haemodialysis Machine	W. Mohd Azhar Bin Wan Ibrahim	978-1-4673-5214-7/13/$31.00 IEEE[2013]	Microcontroller, Pressure Transducer, Comparator, Alarm,	Automated value of blood pressure is regulated by microcontroller through command code
8	Continuous, Non-invasive and Cuff-free Blood Pressure Monitoring System	Juan Franco	Andean Region International Conference, [2012]	Wireless Body Sensor Network (WBSN), photoplethysmographic (PPG) sensor,	Noninvasive method. Pulse arrival time(PAT) is taken from photoplethysmographic (PPG) and Electrocardiographic (ECG) sensors. PAT is calculated by WBSN network.
9	Cuffless and Noninvasive Measurement of	Mikyoung Park	Proceedings of the 29th Annual International	MINITAB 14	BP measures non invasively without Cuff.

	Systolic Blood Pressure, Diastolic Blood Pressure, Mean Arterial Pressure and Pulse Pressure using Radial Artery Tonometry Pressure Sensor with Concept of Korean Traditional Medicine		Conference of the IEEE EMBS Cité Internationale, Lyon, France August 23-26, 2007.		Applied pressure which has the maximum pulse pressure, was proposed as an alternative to PTT for predicting BP.
10	Development of a Cuffless Blood Pressure Measurement System	Liang-Yu Shyu	34th Annual International Conference of the IEEE EMBS San Diego, California USA, 28 August - 1 September, 2012	Microcontroller, Silicon rubber and pressure transducer	A novel cuff less blood pressure monitoring System. The device is lightweight and small enough can be fitted into a watch or the edge of a cellular phone.
11	*Design of ECG signal acquisition and processing system*	*Zeli Gao*	2012 International Conference on Biomedical Engineering and Biotechnology	USB-6008, LabVIEW2009.	ECG baseline drift is solved. After Wavelet filtering ECG signal is reconstructed with signal component for ideal effect.
12	Detecting ECG Characteristic Points by Novel Hybrid Wavelet Transforms: An Evaluation of Clinical SCP-ECG Database	JC Hsieh	Computers in Cardiology 2 005;32:751−754. 0276−6547/05 $20.00 © 2005 IEEE	Wavelet Transformation.	Here clinical E.C.G. data was used instead of MIT/BIH E.C.G. database. Algorithms

					developed in this study will be applied directly onto 12-lead E.C.G. records for waveform analyses with their high accuracy for characteristic point detection in various E.C. G. leads and Diseases.
13	ECG Feature Extraction Techniques - A Survey Approach	S.Karpagachelvi	(IJCSIS) International Journal of Computer Science and Information Security, Vol. 8, No. 1, April 2010	Fuzzy Logic Methods, Artificial Neural Networks (ANN), Genetic Algorithm (GA), Support Vector Machines (SVM)	Various transformation and technique are present for feature extraction of ECG signal.
14	ECG Parameter Extraction Algorithm using (DWTAE) Algorithm	Abdulrhman Elbuni	International Conference on Computer Technology and Development 2009	DWT transformation techniques	There are three steps present in this technique like removing low frequency component from ECG signal then noise removal from signal and finally feature extraction from ECG signal.
15	Latent Topic Multi-	Li Sun	978-1- 61284-	Multiple instance	This paper

	Instance Learning approach for Automated ECG Classification		704-7/11/$26.00 ©2011IEEE	learning and Supervised machine learning algorithms.	proposes a new multiple instance learning strategy for automated ECG classification.
16	New Approaches in Philips ECG Database Management System Design	S Zhou	02766547103 $17.00 &) *u)o3* lEEE	*Philips ECG Management System (EMS)*	This is three tier client models. it is highly configurable to a wide variety of requirements in diagnostic cardiology departments for enhanced patient care
17	Time Plane ECG Feature Extraction Using Hilbert Transform, Variable Threshold and Slope Reversal Approach	S.K.Mukho padhyay	IEEE	MATLAB 7.1.Hilbert Transform	Algorithm is very simple for ECG signal processing. Variable threshold and slope reversal approach is proposed in this paper
18	Noninvasive Fetal QRS Detection using a Linear Combination of Abdomen ECG Signals	Or Perlman	Computing in Cardiology 2013; 40:169-172. ISSN 2325-8861	Electrode, Least Mean Square Algorithm.	Non-invasive PQRS detection using AECG.
19	Design of a novel portable ECG monitor for heart health	Jun Liu	2013 Sixth International Symposium on Computational Intelligence and	ECG analogue front-end, ARM Cortex-M3 processor, STM32 core unit,	This is a dual core system. It uses high performance integrated chip.

			Design	ADS1292 as an acquisition analogue frontend	
20	An Approach of Neural Network Based Fetal ECG Extraction	Mamun Bin Ibne Reaz	0-7803-8453-9/04/$20.00 ©2004 IEEE	ADALINE (Adaptive Linear Network), MATLAB.	In this paper Neural Network is used for extract ECG feature and it is well designed implemented and tested.

CHAPTER 3

DIFFERENT MEASUREMNT TECHNIQUES OF BIOSIGNAL

3.1Overview

Bio signal acquisition is one of the first steps of bio medical signal processing. There are different sensors used for bio signal acquisition and some of the bio signals can also be obtained from the online data sets. This chapter provides the origin of bio signals and different data acquisition methods of bio signal acquisition.

3.2 Biosignals

The term Bio signal alludes for all the signs that is being created in human body or some different living organic entity and all the most particularly it's utilized for speaking to each one of those signs from living life forms that are observed to get certain valuable data. Fundamentally, the term alludes to flags that are electrical in nature at the same time, some non-electric signs are checked also. Commonly, the adjustments in potential distinction over a certain tissue is measured in the body in the event of bio-medical signals.

A bio signal is that kind of signal in human beings which can be continuously monitored and measured. The term bio signal is generally used for referring to bio medical signs, but it also refer for both electrical and non-electrical signals. The usual understanding is to refer only to time-varying signals, although spatial parameter variations (e.g. the nucleotide sequence determining the genetic_code) are sometimes subsumed as well.

Electrical bio signals, or bioelectrical time signs, generally refer to the difference in electric current generated by the sum of the electrical_potential difference between a specialized tissue, organ or cell system like the nervous_system. Thus, between the most suitable known bioelectrical signs are:

1. Electroencephalogram (EEG)
2. Electrocardiogram (ECG)
3. Electromyogram (EMG
4. Electrooculography (EOG)

5. Magneto encephalogram (MEG)

Electroencephalogram, Electrocardiogram , Electrooculography and Electromyogram are measured with a differential enhancer which enlists the distinction between two anodes connected to the skin. Nonetheless, the galvanic skin reaction measures electrical resistance and the Magneto encephalogram measures the attractive field affected by electrical current (electroencephalogram) of the mind. Electrical current and changes in electrical resistances crosswise over tissues can likewise be measured from plants. A wide meaning of a sign is a 'quantifiable evidence or representation of a real wonder', which in the field of bio signs, alludes to recognizable actualities or jolts of organic frameworks or life frames. With a specific end goal to concentrate and record the significance or the reason for a flag, a doctor may use straightforward examination techniques, for example, when measuring the temperature of the human body is need to turn to exceedingly concentrated also in some cases meddlesome gear, for example, an endoscope. Taking after sign procurement, doctors go ahead to a second step, that of deciphering its importance, typically after a sign improvement or 'pre-processing', that isolates the caught data from clamor and sets it up for specific preparing, grouping and choice bolster calculations.

Bio signals oblige a digitization venture so as to be changed over into a computerized structure. This procedure starts with gaining the crude flag in its simple structure, which is then nourished into a simple to-advanced (A/D) converter (Figure 3.1). Since PCs can't deal with or store ceaseless information, the first stride of the transformation technique is to create a discrete- time arrangement from the simple type of the crude sign.

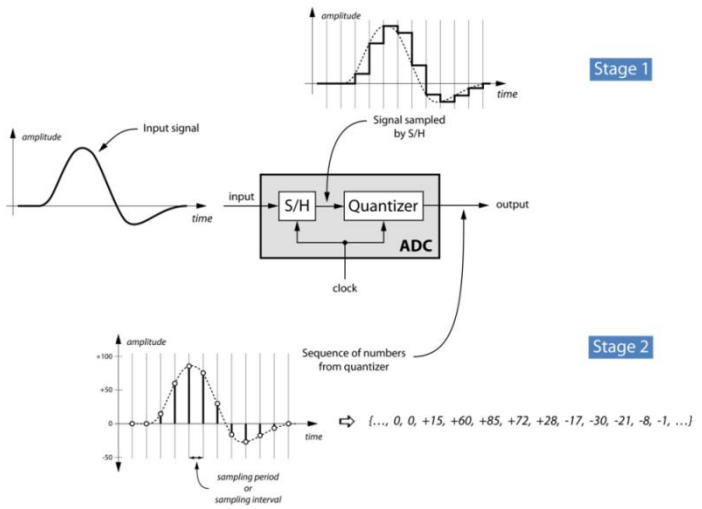

Figure 3.1: Analog to digital conversion

This stride is known as "examining" and is intended to make an arrangement of qualities tested from the first simple signs at predefined interims, which can loyally reproduce the introductory sign waveform. The next stride of the digitization process is quantization, which chips away at the transiently examined estimations for the introductory flag and produces a signal, which is both transiently and quantitatively discrete in nature; that implies the starting qualities are changed over and encoded by, for example, bit designation and quality extent. Basically, quantization maps the examined sign into the scope of qualities which is both minimized and also effective for calculations for working with. The mostly used bio signals recommended by doctors in the medical assessment and also utilized by the medical and health applications are summarized in the Table 3.1.

Table 3.1: Summary of different bio signals

Biomedical Parameter	Voltage (V)	Number of used sensors	Information rate (b/s)
Electrocardiogram	0.50-4.0 mV	05-09	15000
Heart Beat Sound	Very Less	02-04	120000
Heart rate	0.50-4.0 mV	02	600
Electroencephalogram	2-200 μV	20	4200
Electromyogram	0.1-5 m	02+	600000
Respiration rate	Less	01	800
Temperature of body	0-100 mV	01+	80

In the event of EEG, the movement of human cerebrum is diagnosed. Ordinarily, in a neurotransmitter (intersections in between of the cells of the human sensory system), stream of the particles happens. These outcomes in the arrangement for different signals which are used by the human body for exchanging data. Voltage varieties which are brought on by the signals are recorded and therefore, action of mind is calculated.

In Magneto encephalography, attractive fields which are delivered for the varieties of electric streams which frame in the mind action are checked. In this, gadgets, for example, SQUID (Superconducting Quantum Interface Devices) are used as these have very high affectability. Countless are confronted when one tries to quantify the similar as the encompassing attractive commotion in developed territories is high. Indeed, with the utilization of SQUID, around 50000 neurons which need to be dynamic for a given minute so as for gauge the field.

The ECG is delivered by capturing the electrical signals that are created by an individual's heart. The human heart delivers the signals when it starts pumping blood in the human body. The signals which are calculated by anodes are appended to the individual's skin. The rhythms which are created by the heart pulsates are dissected so as to distinguish shortcomings in the muscles of heart or some other irregularities. EMG is like ECG in any case, it’s utilized for every muscle as a part of the body and not the heart muscles specifically. Like the muscles of heart, the muscles in different parts of the human body additionally create electric signals when these muscles contracted. Their unusual action can be recognized by the variances in the diagram which are recorded.

Notwithstanding last bio signals, understanding physiological information (e.g., body development data in view of accelerometer qualities), and connection mindful information (e.g., area, age bunch data and environment) had additionally being utilized by the wellbeing applications in deciding the patient’s status or distinguishing crisis cases.

Organic sign is a condensing term for a wide range of signs that can be (consistently) measured and checked from natural creatures. It demonstrates substance and physical amounts which portray the condition of the human being. The term bio medical signal is regularly utilized to mean the bio-electrical flag however truth be told, bio signal alludes to electrical and non-electrical signals. The term electrical Bio signals alludes to changes in electric streams created by the whole of electrical potential contrasts over a specific tissue, organ or cell framework.

Describing Bio signals:

- Continuous signals are represented by a continuous function *x(t)* which will give information at any time. Most biomedical signals are continuous in nature.
- Discrete signals are represented by a sequence *x(n)* which will give information about signal at a particular time.

- Deterministic signals are those signals which are represented and described using graphical and mathematical properties. Real world bio signals are never deterministic. Periodic signals are also a deterministic signal which can be represented as $x(t)= x(t+nT)$. Where n is any integer and T is time period of the signal. Blood pressure is also an example of complex periodic signal

- Stochastic signals are those signals which are not exactly represented but we can express it as probabilities. Stationary stochastic signals are time independent. The expectations of such a process are time independent. Most of bio medical signals are non-stationary stochastic in nature EEG signal is also an example of non-stationary stochastic signal.

Classification by existence

- Permanent bio signals:

  Those signal which are always available by without artificial triggering. The source of permanent bio signals are always inside the body.

- Induced bio signals:
  Those signals which are artificially generated or induced inside body is called as induced bio signal. These signals are disappear after the time of generation.

Classification by dynamic nature

- A static bio signal carries the information of its steady. Steady state of signal always shows the very small changes over the time.
- A dynamic bio signal shows very large changes over its time domain. A dynamic process of signal has many physiological information.

Classification by origin

- Magnetic bio signals:

  Magnetic bio signal covers the area of pressure signals, flow signals displacement signals and others.

- Optic bio signals:

  These are those signals which are generated by using optical function for a biological system, which occurs naturally or induced in the measurement (Blood oxygenation).

- Acoustic bio signals:
- Numerous physiological phenomena make clamour like the stream of blood in the heart or through veins likewise the stream or air through the aviation routes makes acoustic sounds.
- Chemical bio signals:

  Chemical bio signal shows the temporary change of solid, liquid or gases in the body. Measuring the concentration of various ions and vicinity of a cell by using specific ion electrodes can be done by using the property of chemical bio signal.

- Thermal bio signals:

  Temperature measurement of body shows the physical and biochemical processes proceeded in organism.

According to Bio medical signal and system, a Bio signal is described as a physiological phenomenon. There are unlimited numbers of Bio signals and physiological mechanisms are present. The type of Bio signal depends on the visual inspection of the patient using sensors and final recorded value of signal from human body. e.g., electrocardiography, electroencephalography, etc.

To give an example of *a* bio signal from its generation up to its registration, it depicts the formation of acoustic bio signals which are used, for instance, for the assessment of cardio respiratory pathologies. The corresponding bio signal source in the heart is given by the periodic closure of heart valves, which yields heart sounds. In addition, the lung sounds are generated by air turbulences in the branching airways of the lung, whereas the snoring sounds arise in the upper airways due to elastic oscillation of the pharyngeal walls. The sounds propagate throughout the tissue and undergo attenuation due to increasing distance from the source and damping by the medium itself. By intensity decay, the attenuation is different for different sounds, since their spectral components differ. In particular, the attenuation is less for the heart sounds than for the lung and

snoring sounds, since the latter sounds exhibit more high-frequency components facing a stronger damping. The coupling (and amplification) of sounds is performed by a stethoscope chest piece with an oscillating diaphragm and a resonating volume. Lastly, the conversion of the acoustical pressure vibrations into an electric signal is carried out by an electro acoustic transducer, a microphone.

ECG

Electrocardiography (ECG) is a non-invasive technique that shows the electrical activity of the heart. This is achieved by placing electrodes on the skin at specific points on the body. Since the electrical activity is directly correlated to heart functioning, it can be used to inspect the regularities and rate of heart rhythms. Therefore any change in heart rhythm caused by cardiac arrhythmias will reflect in the person's ECG also. In General, ECG provides following information.

• Position of the heart and the size of the chambers

• Origin of impulse and its propagation

• Heart rhythm, Heart rate and disturbances in conduction

• Variations in electrolyte concentrations

• Position of myocardial ischemia

Therefore, Electrocardiogram is a main diagnostic tool which is used by the physician throughout the world to determine the heart condition. Muscle of Heart possesses a negative polarity and when this negative polarity becomes zero then we can assume that the Muscle of Heart becomes depolarised. During each cardiac cycle, depolarization occurs due to which results in the contraction of atria and ventricles which constitute a heartbeat. ECG detects these small changes in electric charges which is displayed by the monitor.

Anatomy of Heart:

The heart is the central part of the cardiovascular system of human body. Cross section of the human heart is shown in Fig.3.2. The arteries carries blood from the human heart to different sections of the body and the veins carry the blood from all the parts of human body back to heart. The heart consists of four chambers: The upper chambers are known as atria and the

bottom chambers are known ventricles. These atria and ventricles are distinguished by A-V valves.

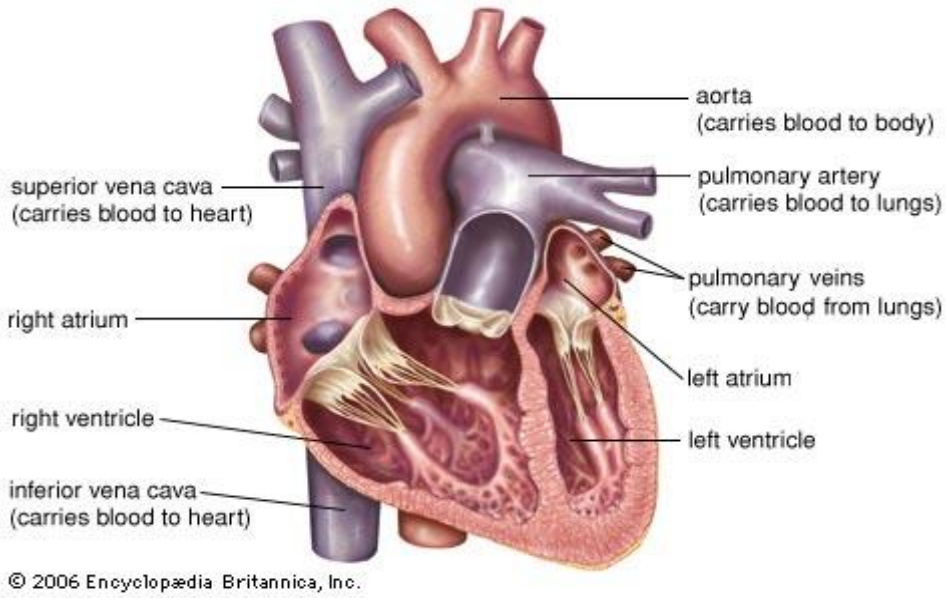

Figure 3.2: Cross section of Human Heart

The right atrium and right ventricle circulate blood between the heart and lungs. The oxygen poor blood from the veins flows to the right atrium through the superior venacava and inferior venacava. When the right atrium contracts this blood flows to the right ventricle through which the tricuspid A-V valve. Right ventricle then pumps the blood from the heart to the lungs through left pulmonary artery. The blood gets oxygenated at the lungs.

Left atrium and left ventricle circulates the oxygen-rich blood in between the heart and rest of the human body. The oxygenated blood from the lungs flows to the left atrium from the left pulmonary veins. When the left atrium contracts blood is pumped to the left ventricle by the mitral valve. The left ventricle pump this blood to rest of the human body through the aorta.

3.3 Leads in ECG:

A lead is a particular ”view” of electrical activity of human heart which are obtained by a pair of electrodes placed on designated location on the human body. The standard ECG has 12 leads which belong to the following three classes.

3.3.1 Bipolar Leads:

These leads are obtained with electrodes of opposite polarity (+ve and -ve).

Leads I, II and III belong to this category(Figure: 3.4).

• Lead I: Difference between left arm electrode potential and right arm electrode potential.

• Lead II: Difference between left leg electrode potential and right arm electrode potential.

• Lead III: Difference between left leg electrode potential and left arm electrode potential.

3.3.2 Unipolar Leads:

These leads are obtained with a single positive electrode and a reference point that lies in the centre of heart's electric field. Leads AVR, AVL and AVF are unipolar limb leads(Figure: 3.4).

• Augmented Vector Right: The potential difference between the centre of heart's electric field and right arm electric field.

• Augmented vector left : The potential difference between centre of heart's electric field and left arm electric field.

• Augmented vector foot: The potential difference between the centre of the heart's electric field and left leg electric field.

Unipolar limb leads are shown in Figure 3.3

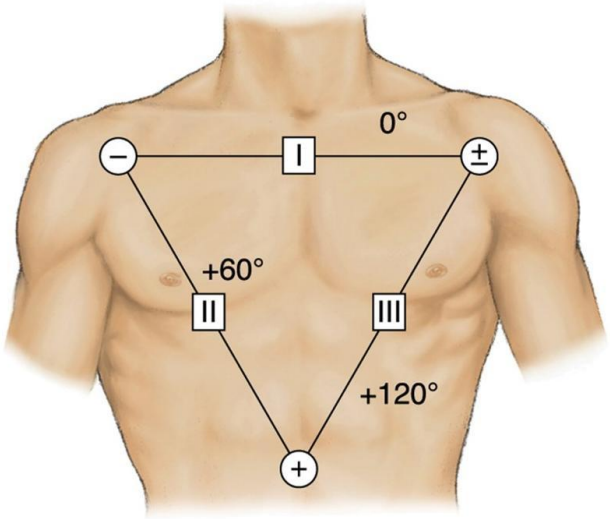

Figure 3.3: Unipolar limb leads

Leads V1-V6 are the unipolar leads on the chest. Here positive electrodes of the leads V1-V6 are situated at the specific points on the chest as given in the Figure. 3.5. The leads shows the

potential difference between the centre of the heart's electric field and positive electrode. The palce of the positive electrodes for V1-V6 leads are shown below:

- V1:4th intercostals space situated in the right part of the sternum.
- V2: 4th intercostals space in left part of the sternum.
- V3: Directly in between the V2 and the V4.
- V4: 5th Intercostals space on the left of the midclavicular line.
- V5: In the same height of the V4 at the anterior axillaries line on the left side.
- V6: In the same height of V5 at the midaxillary line at the left side.

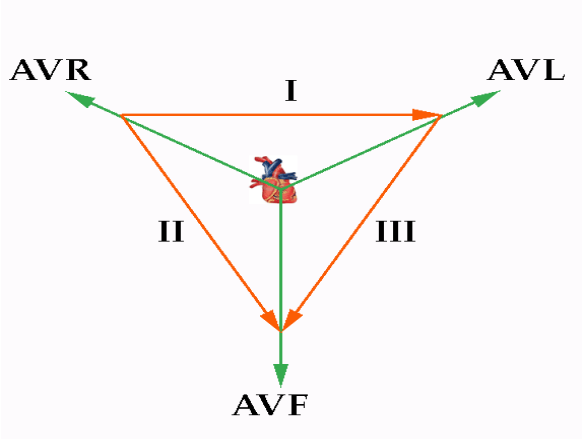

Figure 3.4: leads I, II and III

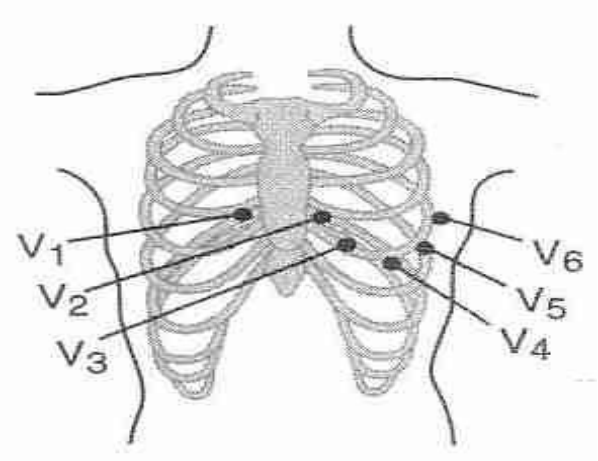

Figure 3.5: Unipolar chest leads

3.4 ECG wave pattern

In Figure 3.6, one cycle ECG signal contains of a P wave, a QRS complex, a T wave and U wave which can be visible rarely. The baseline voltage, which is also known as iso-electric line, is considered as the line capturing from T wave to next P wave.

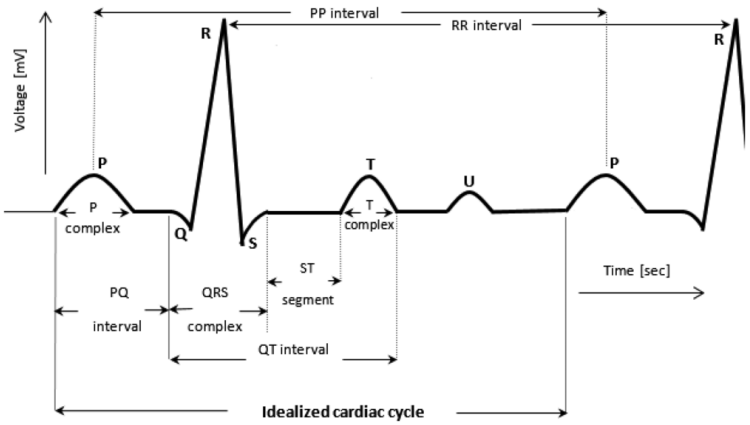

Figure 3.6: General ECG Signal

- P wave: First wave seen and indicates depolarization of atria. During this time the electrical impulse starts from SA node to AV node spreading through both the atria. The amplitude of this signal is approximately 1mV.
- QRS complex: This indicates the depolarization of the ventricles. QRS complex consists of three peaks: Q and S are negative peaks and R is the positive peak. It is the largest voltage deflection of around 10-20mv and has a duration of 80 - 120 ms.
- PR Segment: This is the time duration between the outsets of P wave towards the outset of QRS complex. During this time, the electrical impulse travels from the atria to the ventricles through the AV node.
- T wave: This is a positive deflection soon after the QRS complex and indicates repolarisation of the ventricles.
- ST Segment: This is the time duration between S wave and the outset of Twave and occurs between the depolarization and repolarisation of ventricles.ST segment always aligns with the isoelectric line.
- U wave: It is a small deflection following T wave and represents the repolarisation of purkinje fibres.

3.5 Noises in ECG

Different types of noises can also affect ECG signal during the acquisition and transmission. These noises corrupts the ECG signals and hence analysis of the ECG becomes difficult. The probable types of noises which affect ECG are described below.

Muscle Artifacts

Muscle artifacts are also known as Electromyography (EMG) noise. These noises occur due to the muscle activity during ECG acquisition especially during a stress test. Muscle artifacts are assumed to be transient bursts of gaussian noise and is band limited and have zero mean. Burst duration can be upto 50ms with a maximum frequency of 10 KHz.

Electrode Motion

Electrode motion or motion artefacts occur due to the shift in the electrode position during exercise ECG. The motion of electrodes can introduce higher amplitude signal in the ECG signal. Generally it can have duration of 100-500ms and have frequency components overlapping with the frequency contents of the ECG signal.

Baseline wander

Baseline wander is that variation in the isoelectric line of the ECG signal. This usually occurs due to respiration or cough which causes in a large movement of chest for a chest-lead ECG and movement of arm or leg for a limb-lead ECG. The effect of bias variations and temperature on the components and amplifiers also causes drift in ECG baseline voltage. This is generally a low frequency signal with a frequency range of 0-0.5 Hz.

Channel noise

Poor channel status can also start noise to ECG when ECG is in transmission. Usually it is modelled by using the white gaussian noise that contains all the frequency components.

3.6 Summary

This chapter provides a summary of different bio signals and their acquisition methods. Special attention is given to ECG signals. The origin of ECG signal, the attributes of the ECG signals and different noises and artefacts of ECG signals are summarized here.

CHAPTER 4

ANALYSIS AND TRANSFER DOMAIN REPRESENTATION OF BOI SIGNALS

4.1 Overview

After bio signal acquisition, the first step is pre-processing of the acquired signal. The pre-processing step is required to remove different noises, artefacts from the signal. Different filtering techniques are used to remove the undesired noises from the signal. Different frequency domain transformation techniques are applied in time domain signal to extract relevant features from the signal. Some of the widely used frequency domain techniques are Fourier transform, discrete cosine transform, discrete sine transform and wavelet transform.

4.2 Analysis and transform domain representation of biosignal

Bio sign checking in intelligent expressions, albeit present for more than fifty years, remains a moderately minimal known field of exploration inside of the creative group when contrasted with other detecting innovations. Since the mid-1960s, a constantly expanding number of specialists have worked together with neuroscientists, doctors and electrical architects, so as to devise implies that take into account the securing of the tiny electrical possibilities produced by the human body. This has empowered direct indications of human physiology to be joined into intuitive fine arts. Notwithstanding, the advancement of this field has not been a ceaseless procedure. Little doubt remains as though there has been little correspondence amongst professionals, and verifiably there have been different sudden times of movement that appear to have almost no connection to past works furthermore an exceptionally constrained impact in later works past some specialized approaches and general working analogies.

Ultimate goal of bio-signal processing: to extract useful information from measured data

- Noise reduction and signal enhancement
- Signal conditioning
- Feature extraction
- Pattern recognition
- Classification such as diagnosis
- Data compression etc.

The different stages of bio signal processing is shown below:

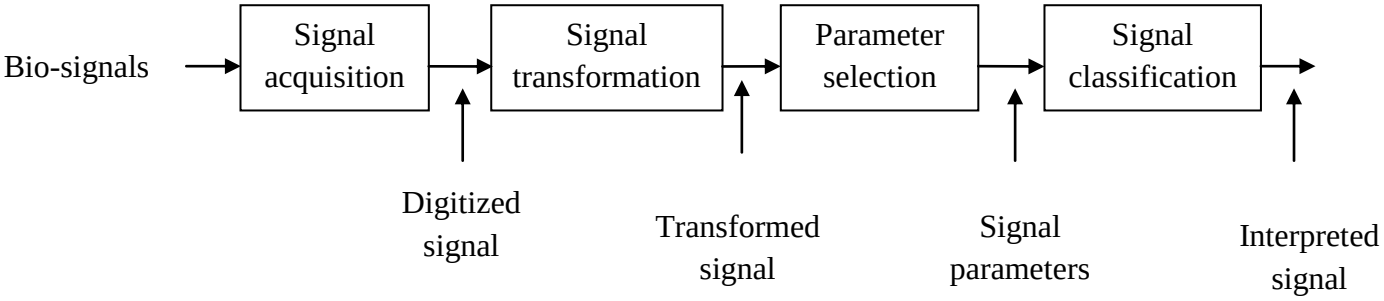

Figure 4.1: Steps of signal processing

Time Domain Analysis

The traditional path of recording signals is in viewing them in the domain of time. The time domain is a measure of what happens to the parameter in the system and time. For example in a system which have spring mass, here we had attached a pen in the mass and while pulling a part of the paper passing the pen in the same rate. The result shown in graph is the record of displacement of the time versus mass. That direct recording schemes are mostly used, but usually are much practical for converting the parameter of the interest into the electrical signal while using transducer.

Some commonly used time-domain statistical measurements of biomedical signals. Root-mean-square

$$\text{RMS} = \sqrt{\frac{\sum_{n=0}^{N-1} x^2(n)}{N}} \qquad (4.1)$$

Average rectified value

$$\text{ARV} = \frac{\sum_{n=0}^{N-1} x^2(n)}{N} \qquad (4.2)$$

For example, the RMS value of an EMG signal is used to express the power of the signal, which can determine the strength of the force, fatigue and the ability of the muscle while handling the mechanical resistance.

The ARV describes the smoothness of the EMG signal.

Frequency domain analysis of bio signals

Frequency domain representation of the time domain signal x(t) can be represented as

$$x(t) = \frac{a_0}{2} + \sum_{n=1}^{\infty}\left(a_n \cos\frac{n\pi}{L}t + b_n \sin\frac{n\pi}{L}\right) \quad (4.3)$$

$$a_n = \frac{1}{L}\int_{-L}^{L} x(t)\cos\frac{n\pi}{L}tdt \quad (4.4)$$

$$b_n = \frac{1}{L}\int_{-L}^{L} x(t)\sin\frac{n\pi}{L}tdt \quad (4.5)$$

Fast Fourier Transform

As the DFT transform in the above will be applied for every complex series, in the practice for the large series it can also take considerable amount if the time for computing, the time which is taken being in ratio with the square of number on the points in the complex series. A comparatively faster algorithm has also been generated by Cooley and Tukey at the year 1965 known the Fast Fourier Transform. The only condition for the best popular implementation of this algorithm is that number of the points in series is to be of power 2.

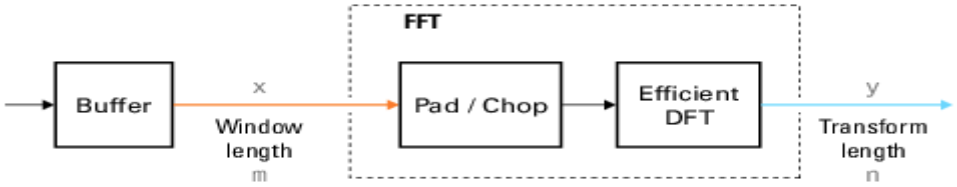

Figure 4.2: Fast Fourier Transform

Fast Fourier transform of a signal can be represented as $X(k) = \sum_{n=0}^{N-1} x(n) e^{\frac{-j2\pi nk}{N}}$ (4.6)

Here X(k) is the representation of the transformed signals and x(n) is of the original signal

Discrete Cosine Transform

DCT is mostly used in signal and image compression schemes because of its strong energy compaction proper. A DCT depicts a finite sequence of data which are sampled in terms of the sum of the cosine functions oscillating at the different frequencies.

The most common Discrete Cosine Transform definition of a one-dimensional (1D) sequence of length N is represented as $C(u)=\alpha(u)\sum_{x=0}^{N-1} f(x)\cos\left[\frac{\pi(2x+1)u}{2N}\right]$

(4.7)

$u=[0 \quad 1 \quad 2 \quad .. \quad N-1]$

Also, the inverse transformation shown as $f(x)=\sum_{u=0}^{N-1}\alpha(u)C(u)\cos\left[\frac{\pi(2x+1)u}{2N}\right]$ (4.8)

To reduce the computational complexity in transformation the image is portioned into blocks and DCT is performed individually to all blocks (Block Transform Coding). At the decoder the inverse takes place. The only disadvantage in Block Transform Coding is the blocking artefacts occurring at the boundaries of the block. DCT removes the correlation among the pixels in the input data packing most of the information near to the origin i.e. (0, 0) position of the matrix. This produces many irrelevant coefficients as we move far away from the origin. These coefficients can be truncated for compression purposes.

$$\alpha(u)=\begin{cases}\sqrt{\frac{1}{N}} & u=0\\ \sqrt{\frac{2}{N}} & u\neq 0\end{cases} \qquad (4.9)$$

$x=[0 \quad 1 \quad 2 \quad .. \quad N-1]$

2-d Discrete Cosine Transform

The pictorial representation of 2-d DCT is represented in Figure 8.

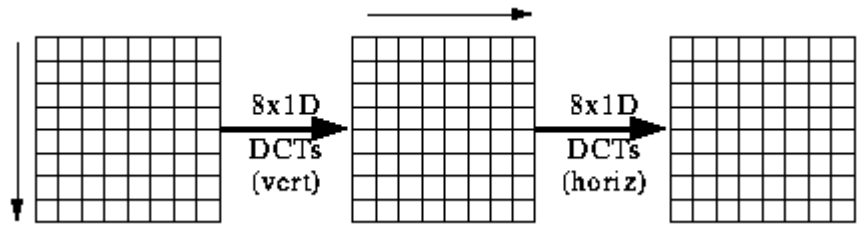

Figure 4.3: 2-d DCT

2-d Discrete Cosine Transform can be represented as

$$C(u,v)=\alpha(u)\alpha(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1}f(x,y)\cos\left[\frac{\pi(2x+1)u}{2N}\right]\cos\left[\frac{\pi(2y+1)v}{2N}\right] \quad (4.10)$$

$$f(x,y)=\alpha(u)\alpha(v)\sum_{x=0}^{N-1}\sum_{y=0}^{N-1}C(u,v)\cos\left[\frac{\pi(2x+1)u}{2N}\right]\cos\left[\frac{\pi(2y+1)v}{2N}\right] \quad (4.11)$$

Discrete Sine Transform

Discrete sine transform can be represented as $X_k=\sum_{n=0}^{N-1}x_n\sin\left[\frac{\pi}{N+1}(n+1)(k+1)\right]$

4.3 Summary

This chapter provides the theoretical background of different transformation techniques used for signal processing applications. Some of the popular transformation techniques are DCT, DWT, FFT and DST.

CHAPTER 5

DISEASE DETECTION TECHNIQUE OF BIOSIGNALS

5.1 Overview

This chapter provides a summary of different feature extraction techniques of ECG and blood pressure signals and disease detection techniques.

5.2 Process the acquired signal (ECG and Blood pressure):

This imperative understanding can also be exemplified by the help of separating in the evacuation of electrical cable obstruction. Separating is very suitable in the framework for the examination of the variation in the heart rate, while its unseemly in a framework for the investigation of miniaturized scale possibilities; all things considered possibilities frightfully cover the electrical cable impedance. Electromagnetic fields brought on by an electrical cable speak to a typical commotion sources in the ECG which is described by the 50 or 60 Hz sinusoidal impedance, perhaps is joined by various music. Such narrowband clamour renders examination and understanding of the ECG to be more troublesome, as the depiction of low-abundance waveforms gets to be problematic and spurious waveforms may be presented. Albeit different precautionary measures can be produced to decrease the results of electrical cable obstruction, for instance, by selection of a recording area with very few encompassing electrical gadgets and by fittingly protecting also be establishing the area, it may be in any case important for performing sign handling for evacuating in such impedance. A few procedures have been exhibited for this reason, running from direct straight, band-quit sifting to more propelled methods that handle varieties in electrical cable recurrence and stifle the impact of homeless people showed by the event of QRS edifices. A real concern when separating out electrical cable impedance is the extent to which of the QRS buildings impacts the yield of the channel. The QRS complex plans, actually, as an undesirable, vast abundances drive data to the channel. As direct, time-invariant indent channels are by and large more delicate to the vicinity of such driving forces, electrical cable channels with a nonlinear structure may be best. Keeping in mind the end goal to guarantee that a channel does not present unsatisfactory contortion, its execution ought to be surveyed by method for mimicked flags so twisting can be precisely evaluated.

Find out the PQRST location of ECG signal

The vicinity of a pulse and its event time is fundamental data needed in a wide range of ECG sign handling. As the QRS complex is that form of waveform which is most effectively observed in the ECG, beat recognition is synonymous to the location of QRS buildings. The outline of the QRS locator is generally of significant significance in light of the fact that poor identification execution may spread to consequent preparing steps and, thus, constrain the general execution of the framework. Beats which are generally undetected constitute of more serious slip than of the false recognitions; the previous sort of mistake can be hard to right at the next stage of the path of handling calculations, though, ideally, false identifications can be dispensed with by, for instance, performing characterization of the QRS morphologies. QRS finder must have the capacity for identifying a substantial way of distinctive QRS morphologies with a specific end goal which is clinically helpful and ready to take after steady change of the predominant QRS morphology. Besides, the locator shouldn't bolt onto certain sorts of cadence, but rather regard the following conceivable occasion as though it could happen at whatever time which is after the most as of late identified beat. A few indicators basic sorts of clamour and relics exist relying upon the ECG utilization of hobby. The commotion can be profoundly transient in the nature or can be of a very tenacious nature, as exampled by the vicinity of electrical cable impedance. On account of an ECG recording with scenes contains unreasonable clamour that might very important for rejecting such scenes from further examination.

Most finders' depiction in the writing has been produced from specially appointed thinking and test understanding. Inside such an identifier structure, the reason for the pre-processor is for to improve the QRS buildings as smothering clamour and antiques; the pre-processor is generally for normally executed as a direct channel took after by a nonlinear change. The yield of the pre-processor is then bolstered to a choice tenet for identification. The reason for every preparing square is abridged beneath. The straight channel is intended to have band-pass attributes such that the crucial ghostly substance of the QRS complex are saved, as undesirable ECG segments, for example, the T and P waves are smothered. Middle recurrence of the channel is from 10-25 Hz and the transmission capacity from 5-10 Hz. Rather than different sorts of ECG sifting, waveform bending is not a Detection of illness utilizing the PQRST bend attributes discriminating issue in QRS location. The emphasis is rather on enhancing the SNR to accomplish great indicator execution. The nonlinear change further improves the QRS complex in connection to the foundation clamour and also

changing every QRS complex into a solitary positive top more qualified for limit recognition. The change may comprise of a memory less operation, for example, correction or squaring of the band-pass-separated sign, or a more intricate change with memory. Not all pre-processors utilize an un-linear change, and rather sifted sign are rather sustained specifically choice standard. Choice principle takes the yield of the pre-processor. The choice principle can be actualized as a basic abundances limit technique, yet generally incorporate extra , instance, on sensible waveform span, guarantee best resistance in different sorts of commotion. The edge is generally adjusted to the latest amplitudes so steady changes in the plentifulness also be followed.

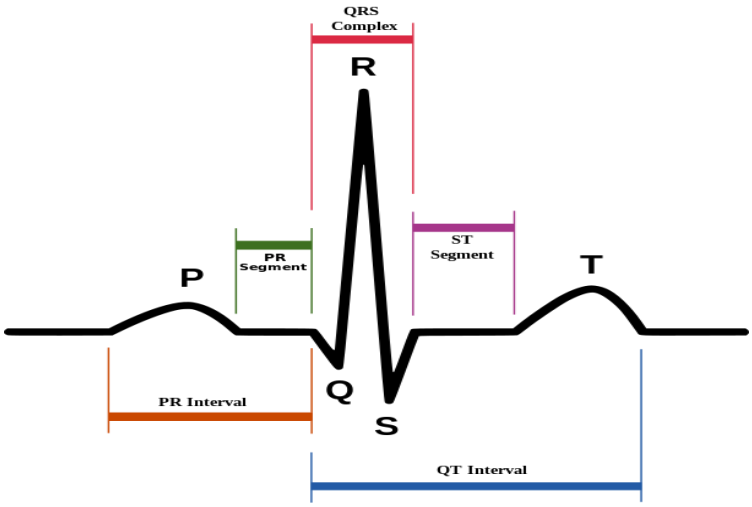

Figure 5.1: Features of ECG signal

Detection of systolic and diastolic pressure BP signal

Blood pressure is called as the pressure applied by the flowing blood at surface of the blood vessel. Blood pressure is measured in terms of diastolic and systolic blood pressure in terms of mmHg. Blood pressure varies according to situation, activity and disease. Direct blood pressure measurement was first done by Stephen Hales in 1714. Indirect blood pressure measurement (non-invasive method) was firstly used in 1896 using Riva-Rocci sphygmomanometer. Nicolai Korotkoff reevaluated indirect blood pressure measurement and from his name “Korotkoff noise” was used.

Now a days there are many methods for measuring blood pressure are available. Some of well-known methods for measurement of blood pressure are Palpatory method (Riva-Rocci method), Ausulatory method, Oscillatory method, Volume clamp method and Tonometry method. Measurement of blood pressure using auscultation is considered as golden standard

among the medical professionals. Figure 5.2 shows the conventional method of blood pressure measurement using sphygmomanometer. Figure 5.3 shows the relationship between cuff pressure, diastole and systole.

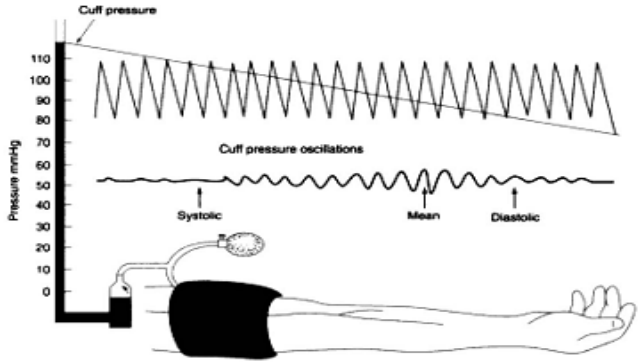

Figure 5.2: Blood pressure signal

There are different types of sphygmomanometers such as mercury, aneroid and digital sphygmomanometers. The range of human blood pressure is summarized in Table 5.1.

Table 5.1: Range of Blood Pressure

	Systolic (mm of Hg)	Diastolic (mm of Hg)
Normal	Less than 120	Greater than 80
Pre-Hypertension	Between 120 and 139	Between 80 and 89
Stage1 hypertension	Between 140 and 159	Between 90 and 99
Stage 2 hypertension	Greater than 160	Greater than 100

Mean Arterial Pressure (MAP): It is a method for the time-weighted average of the applied blood pressure on arteries for a cardiac cycle.

Diastolic Blood Pressure (DP): It is the lowest calculated blood pressure in the arteries. It is also the least value which is found just before the onset of each ventricular systole.

Pulse Pressure (PP): it is the subtracted value of diastolic blood pressure (DBP) and systolic blood pressure (SBP).

$$MAP = DP + 0.33PP$$

$$PP = SBP - DBP$$

Figure 5.3 shows the different aspect of blood pressure measurement. Figure 5.4 shows the position of diastolic, systolic and MAP in the cuff pressure graph.

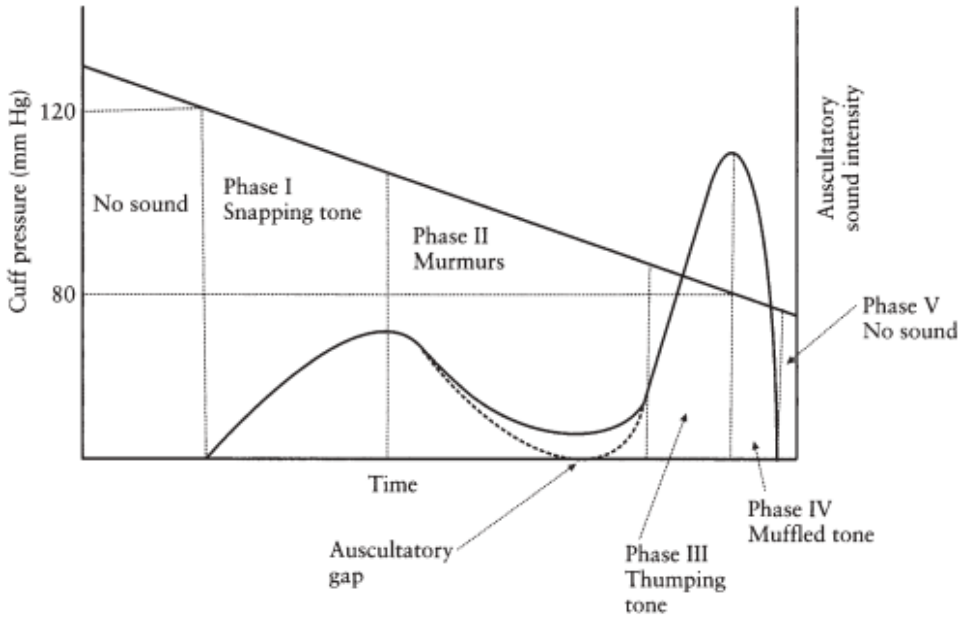

Figure 5.3: Representation of cuff deflation

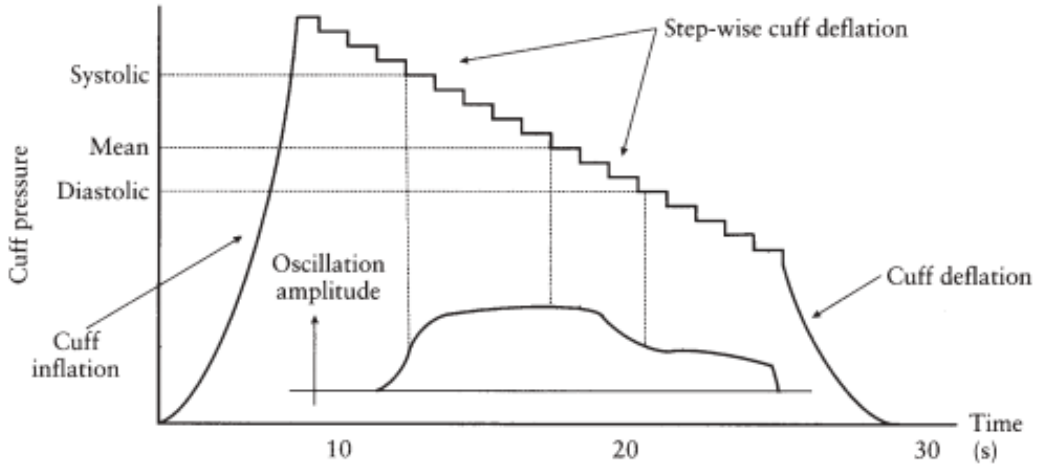

Figure 5.4: Graph for cuff pressure v/s time

The output terminal window of the LabVIEW model is shown in the figure 6.13. First two plots are the ECG signal capture from the MIT-BIH database. Second two plots are the FFT

filtered one of the same signals. Right side numeric indicator displayed the detected feature like R-R interval, R-S interval, Heart Rate etc.

5.3 Summary

This chapter summarizes different feature extraction techniques and different disease detection techniques from ECG and blood pressure signals.

CHAPTER 6

SIMULATIONS AND RESULTS

6.1 Overview

This chapter provides results and discussion of different techniques mentioned in previous techniques. The detected BP signal is shown in figure 6.1.

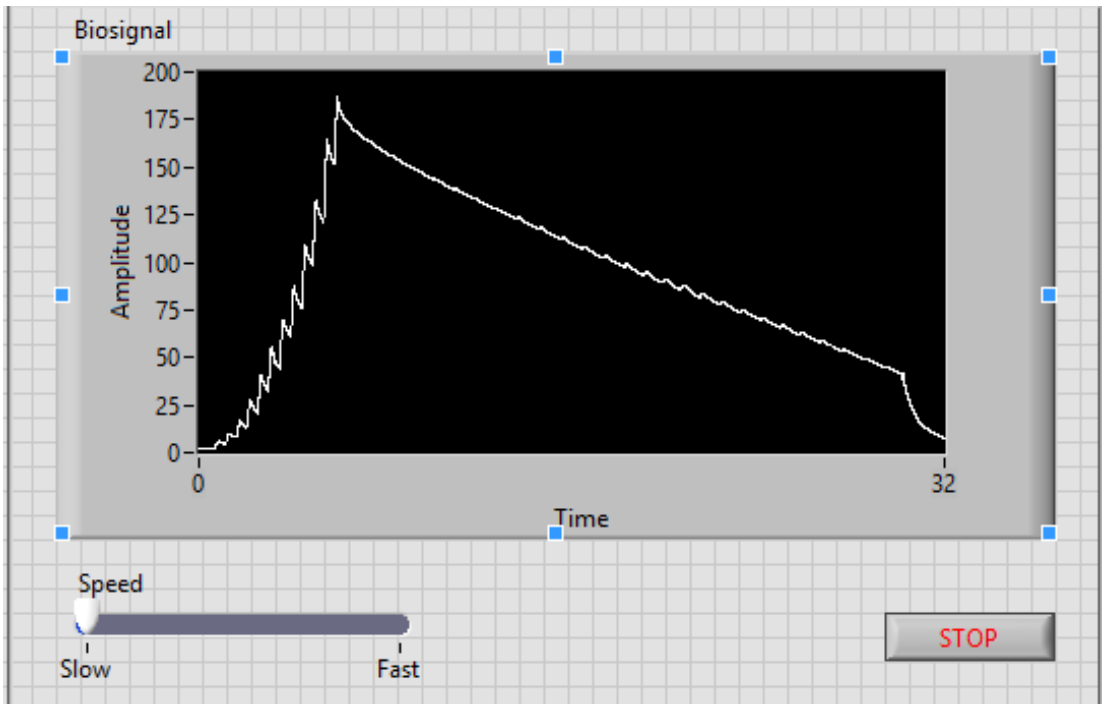

Figure 6.1: Acquired blood pressure signal

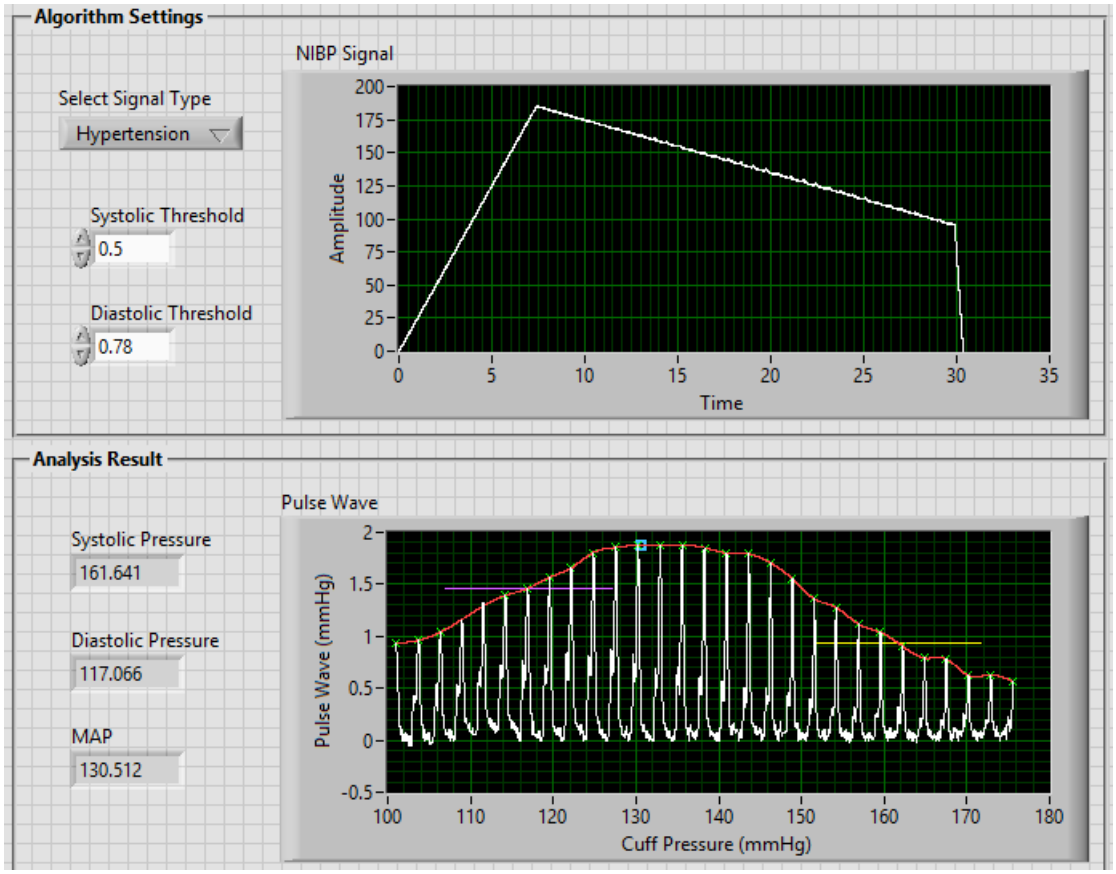

Figure 6.2: Acquired blood pressure signal of hyper tension patient

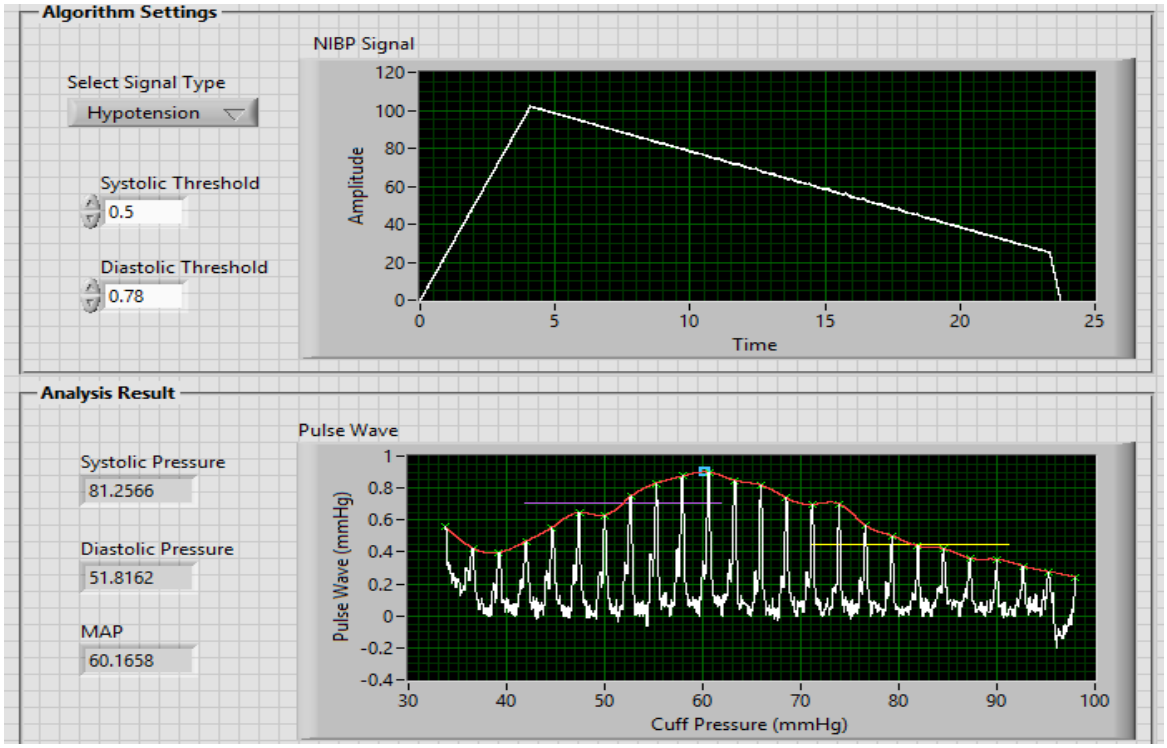

Figure 6.3: Acquired blood pressure signal of hypotension patient

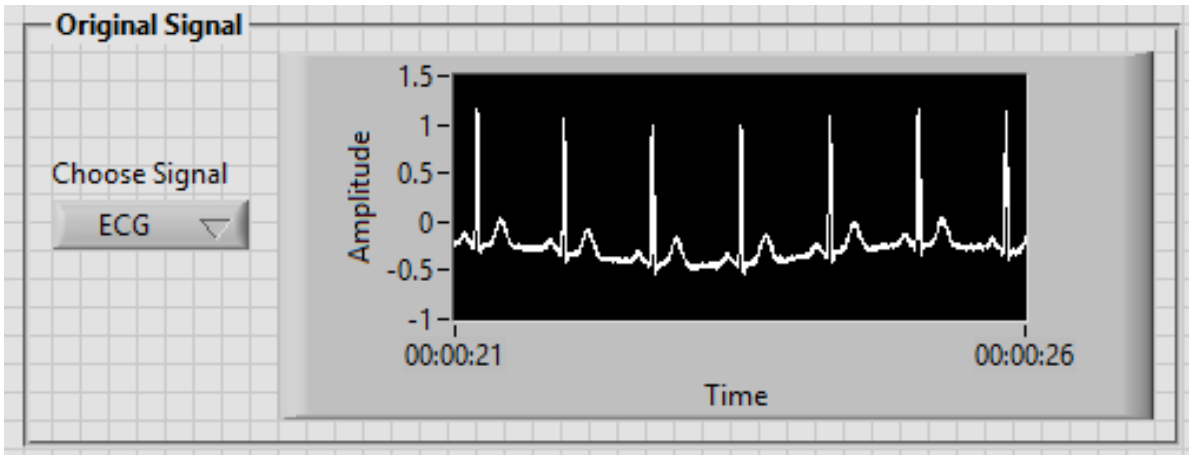

Figure 6.4: Acquired ECG signal

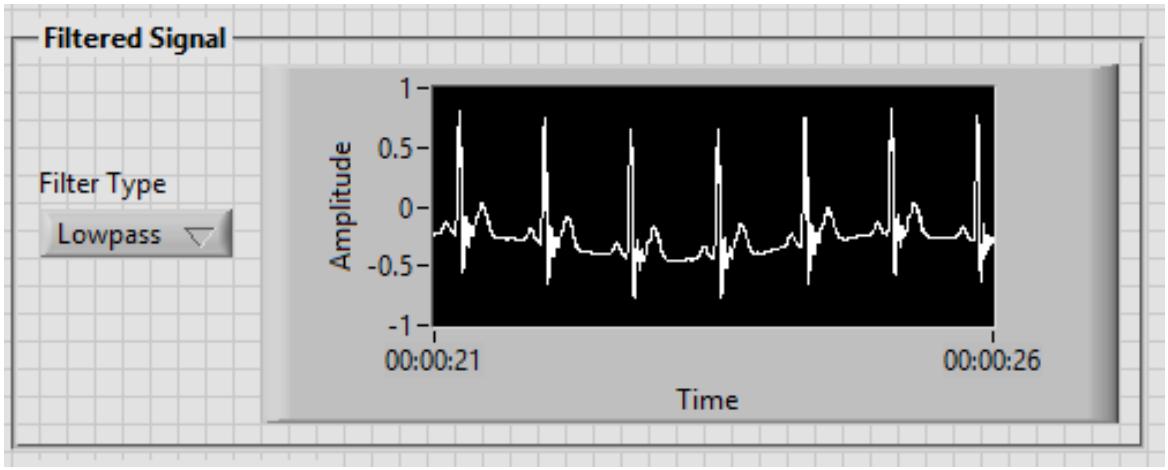

Figure 6.5: Filtered ECG signal

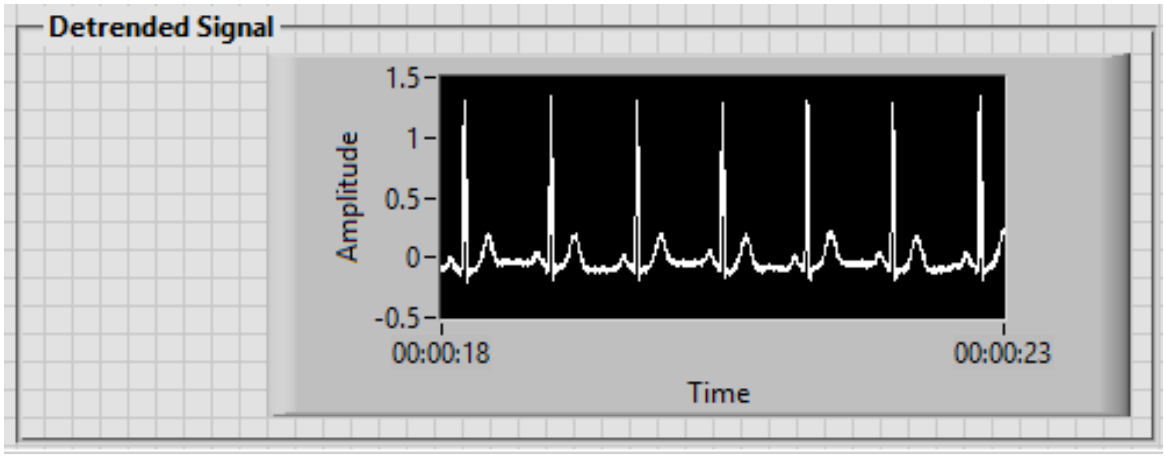

Figure 6.6: Detrended ECG signal

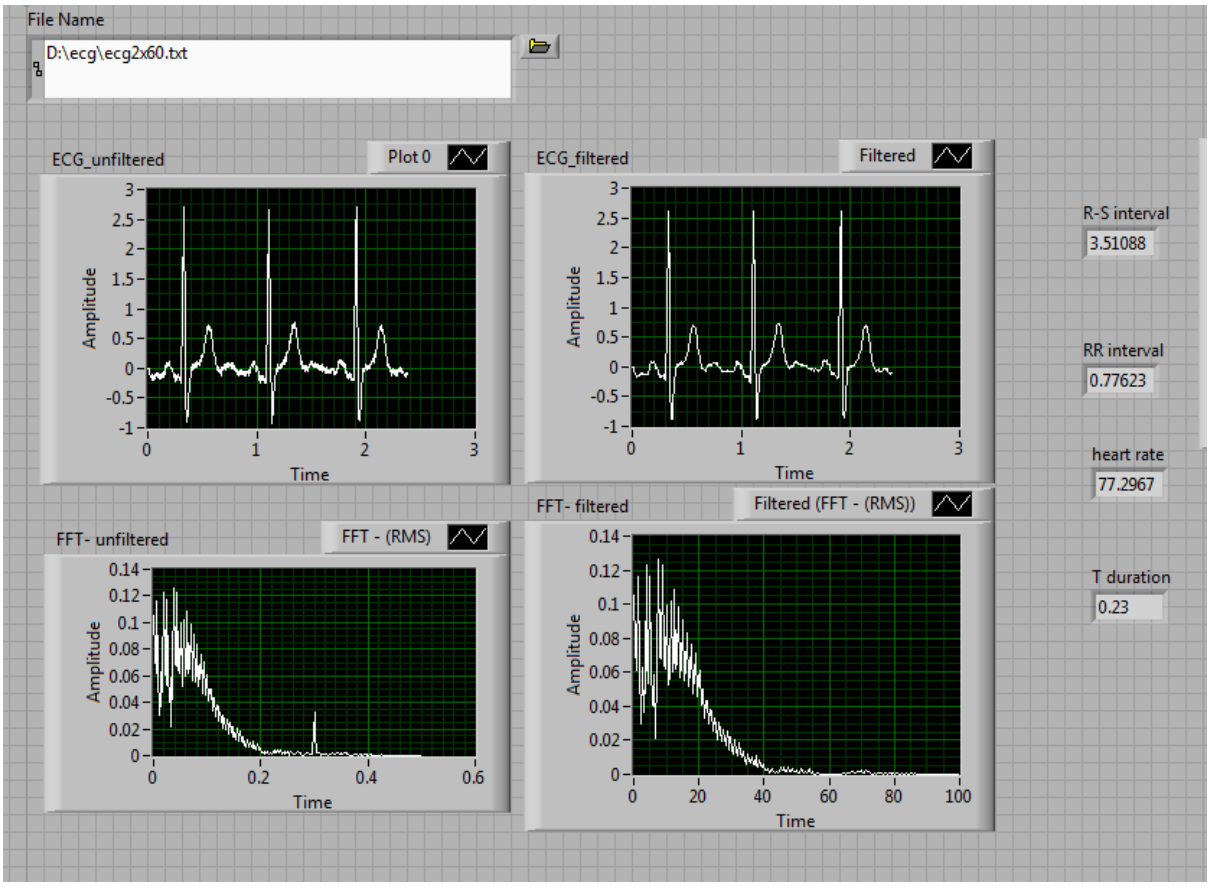

Figure 6.7: ECG signal filtering and feature extraction

The output terminal of the detected BP signal is shown in the Figure 6.2 and Figure 6.3. On the Left side the detected signals, systolic and diastolic pressure are displayed. On the upper left half of the Figure we can see the disease related to acquired Blood Pressure signal according to predefined range. Various acquired signal and their corresponding post processings are shown in figure 6.4, 6.5, 6.6 and 6.7 respectively.

In between the preprocessing of Bio medical signals we can use many type of transformation technique. Comparision of so many transformation technique like Discrete Cosine Transformation, Fast Fourier transformation, Discrete Sine transformation and 2-d Discrete Cosine Transformation using Compression Ratio and Percent Root Difference(PRD) of all mentioned transformation are done here. The compare of different mentioned technique is done by MATLAB software. After compare of transformed signal we can find that which transformation is most reliable for Bio medical signal processing. Figure 6.8 shows Heart

Rate Measurement using DWT Technique. Figure 6.9, 6.10, 6.11, 6.12 shows the compare of ECG signal using 2-d DCT, DST, FFT and DCT respectively.

Measurement of heart rate using Discrete Wavelet Transform

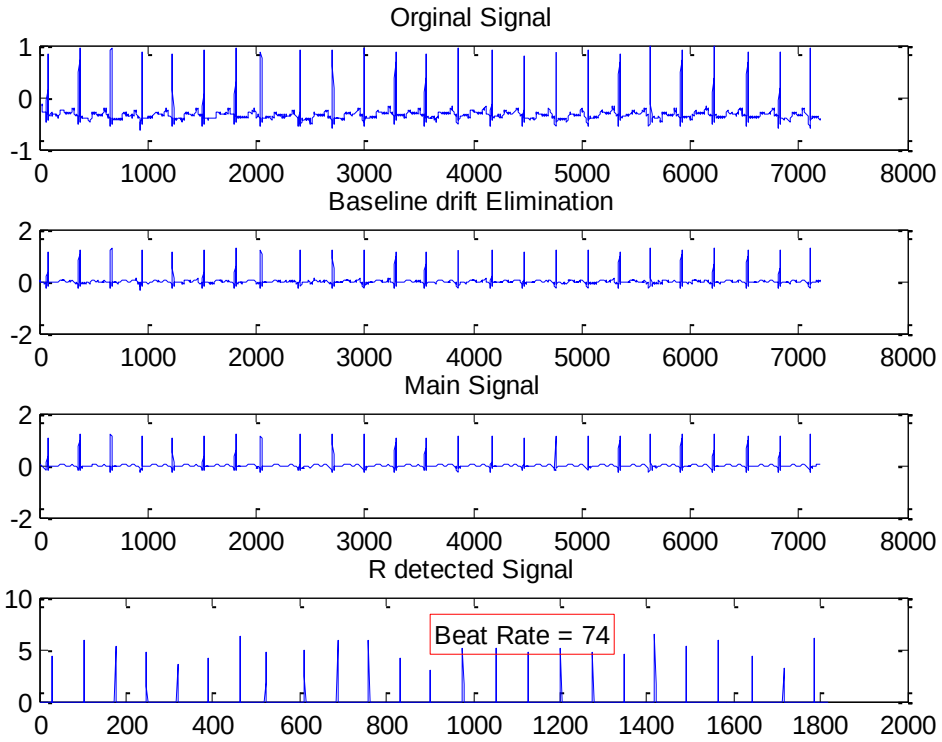

Figure 6.8: Heart rate measurement using DWT technuique

Compression of ECG signal using different transformation techniques

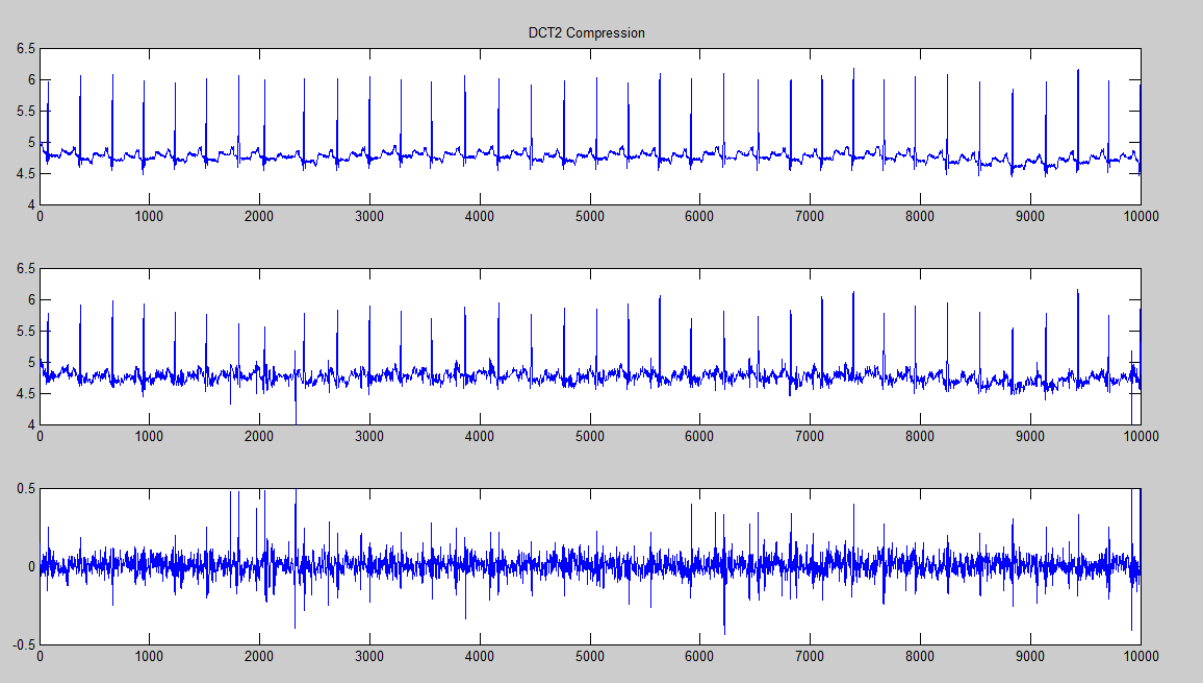

Figure 6.9: Compression of ECG signal using 2-d DCT

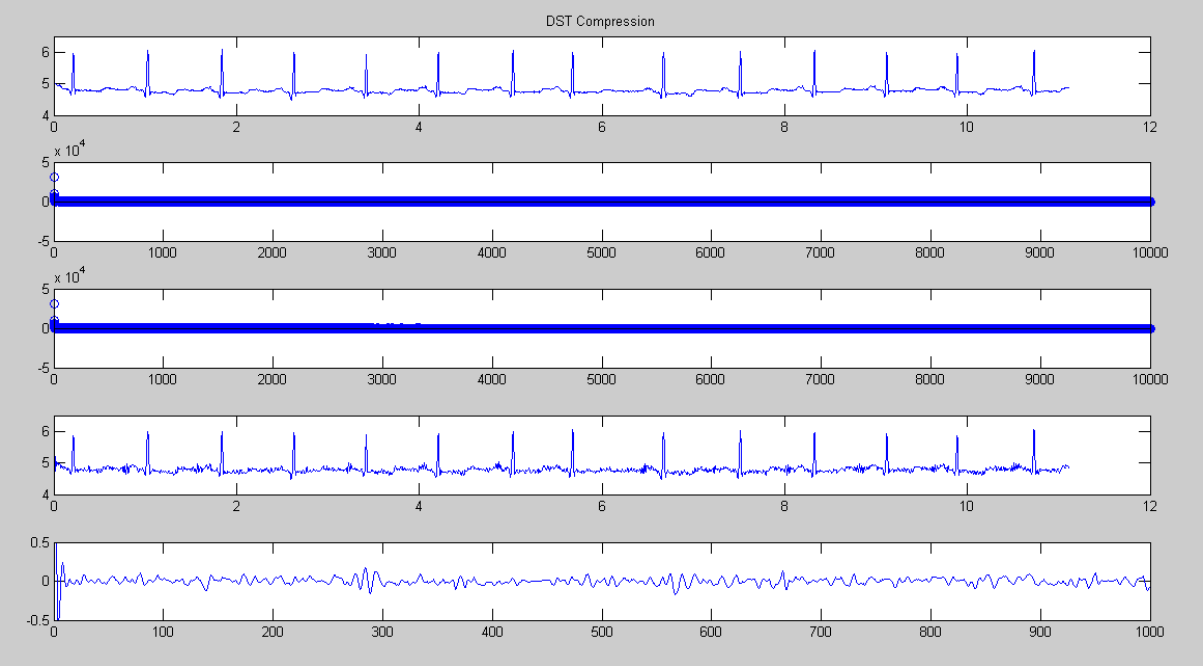

Figure 6.10: Compression of ECG signal using DST

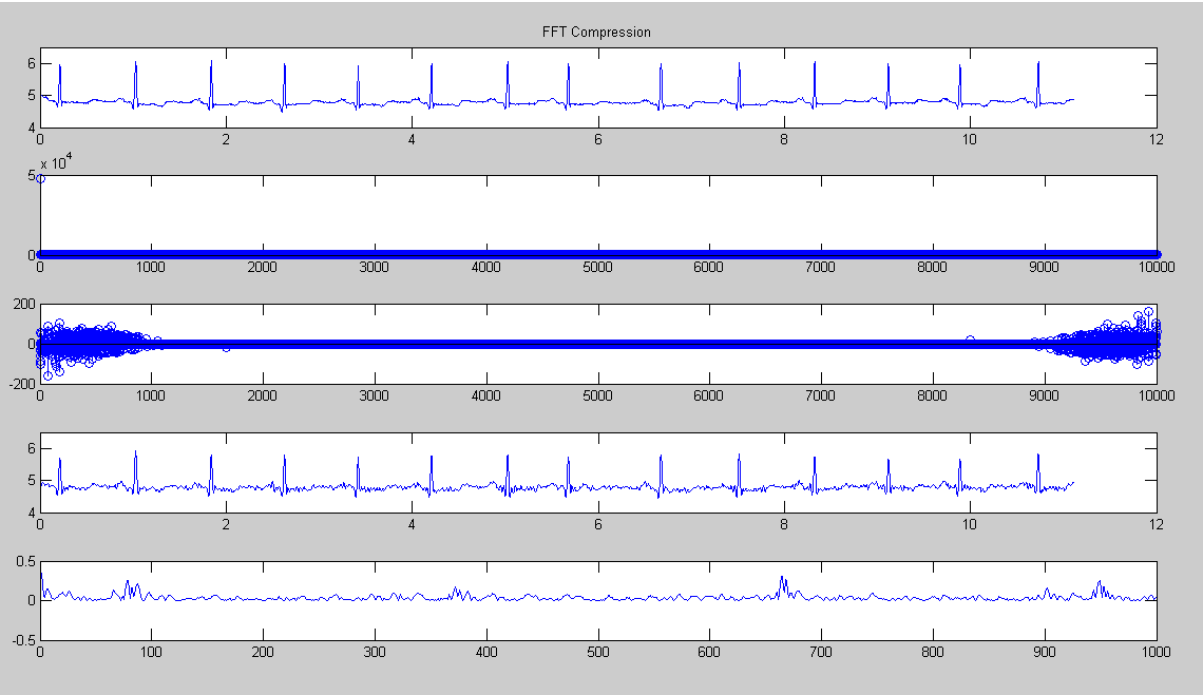

Figure 6.11: Compression of ECG signal using FFT

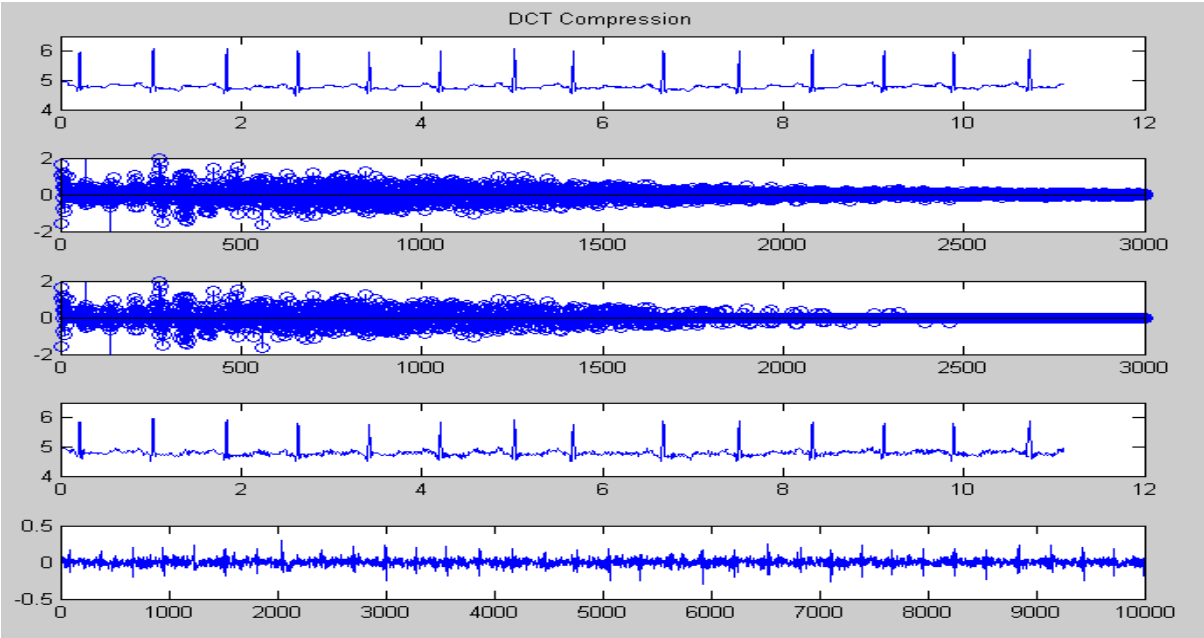

Figure 6.12: Compression of ECG signal using DCT

Performance evaluation

To evaluate the performance of compression techniques two parameters are used, i.e PRD and CR.

$$PRD = \sqrt{\frac{\sum_{n=1}^{N}\left(x[n]-\hat{x}[n]\right)^2}{\sum_{n=1}^{N}\left(x[n]\right)^2}} \times 100$$

$x[n]$ is the original signal, $\hat{x}[n]$ is the reconstructed signal, N is the length

$$CR = \frac{N_{bits}^{Original}}{N_{bits}^{Compressed}}$$

Table 6.1: Performance comparison of different compression techniques

Transformation	Compression ratio	PRD
DCT	90.43	0.9382
FFT	89.57	1.16
DST	85.18	1.25
DCT2	95.77	1.33

The compression ratio of DCT2 is better than all the transformations mentioned above in the table. Therefore DCT2 is considered as the suitable transformation method for bio medical signal processing.

Table 6.2 and 6.3 shows the disease related to ECG signal based on interval and amplitude of QRS complex of ECG signal.

Table 6.2: Disease detection based on Interval of Peaks

INTERVALS	NORMAL SINUS RHYTHM(NRS) in sec	<NRS Diseases	>NRS Diseases
P-R	0.12-0.2	Reduce FMD;	Blockage Of AV Node; Atherosclerotic disease
Q-R-S	0.09	Hypercalemia	-
Q-T	0.35-0.44	-	-
S-T	0.05-0.15	-	-
P-P	0.11	-	-
R-R	0.80-0.85	Tachycardia (Fast Heart)	Bradycardia (Slow Heart)

Table 6.3: Disease detection based on Amplitude of Peaks

AMPLITUDE	NORMAL SINUS RHYTHM(NRS) in mV	<NRS Diseases	>NRS Diseases
P	0.25	Dextrocardia (Inverted P wave)	-
Q	25% of R wave	-	-
R	1.60	-	-
S	-	-	-
T	0.1-0.5	Myocardial ischemia (Inverted T wave)	Hyperkalemia (Tall T wave and absence of P wave)

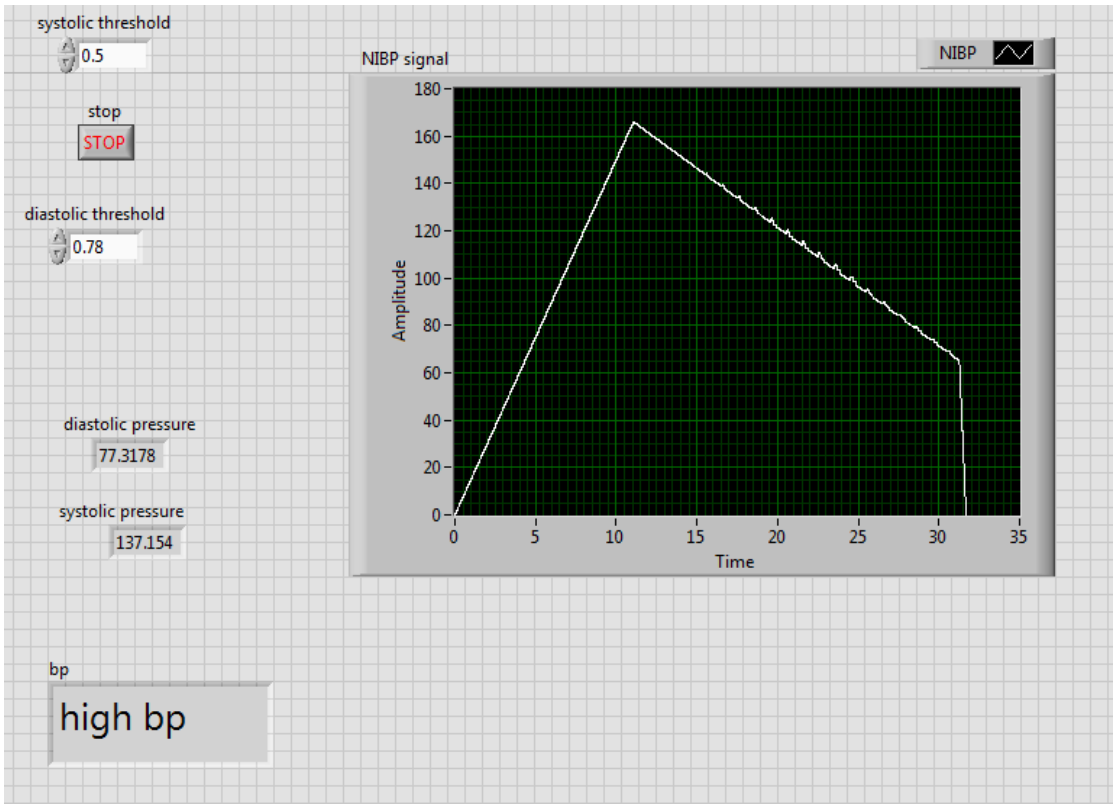

Figure 6.13: Disease detection using blood pressure signal

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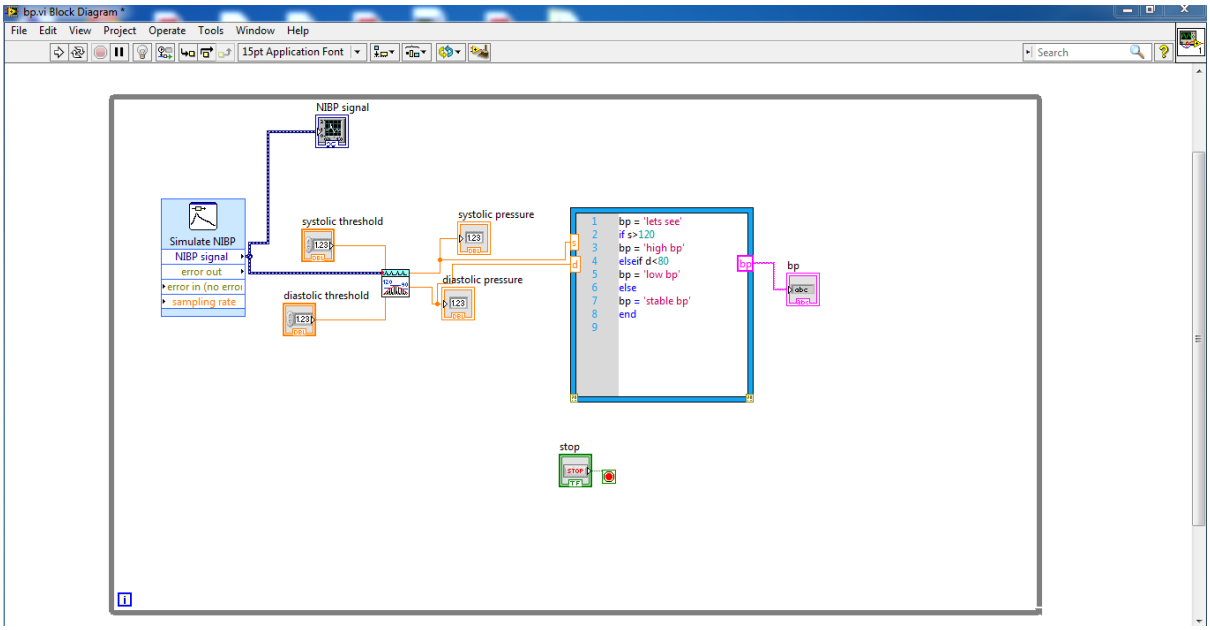

Figure 6.14: Algorithm for Disease detection by blood pressure signal

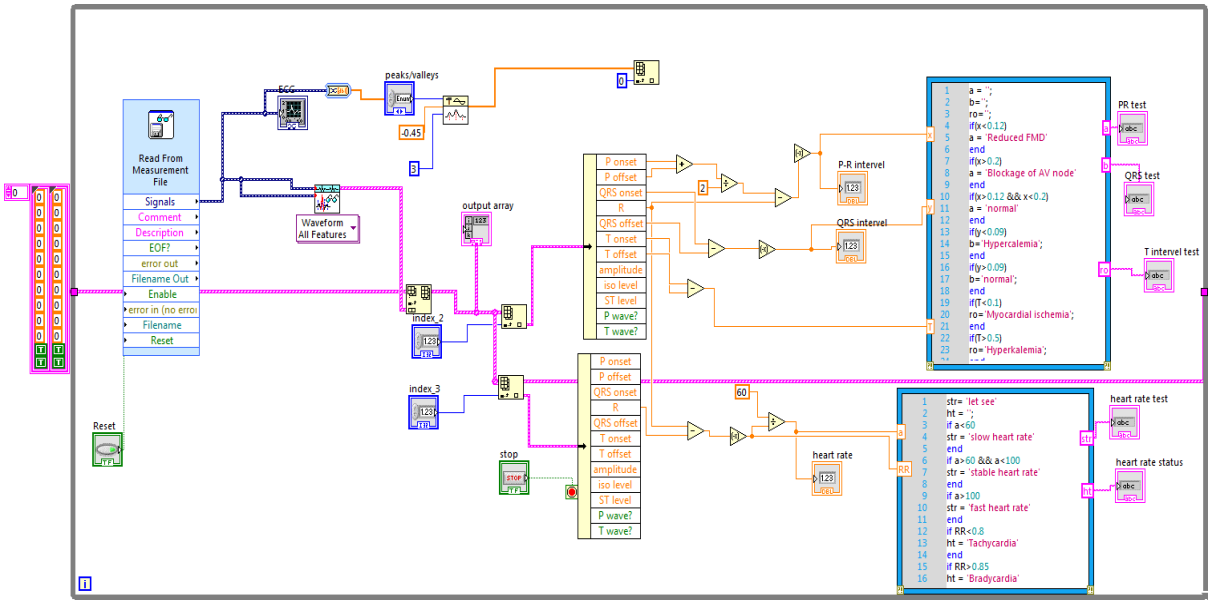

Figure 6.15: Block diagram and algorithm of disease detection by ECG signal

The fully developed LabVIEW model for ECG and BP signal processing and their corresponding output windows are shown in figure 6.14 and 6.15 respctively.

6.2 Summary

This chapter provides the detailed simulation and results of Bio medical signal acquisition, compression of Bio medical signals and disease detection using LabVIEW and MATLAB.

CHAPTER 7

CONCLUSION

In this thesis I have taken ECG and Blood Pressure sigal from MIT-BIH database and processed those signals to find the disease related to the signals using LabVIEW and MATLAB softwares. We used pick detection technique to find the feature of Blood Pressure signal. For finding feature related to ECG signal we implimented and developed the QRS detection techinues and algorithm. For ECG signal's feature detection process we used amplitude, width and slope as measuring parameters of QRS complex. In pre-processing we used band pass filter for reducing interference and noise which effects the original signal. The developed system for detecting the diseases is one of the best methods because it is capable of storing data for future. The algorithm developed for this process gives very less error in finding feature of disease. This is also very reliable and accurate in detecting the disease.

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