Chapter 1

INTRODUCTION

1.1 Background

Cardiovascular diseases cause a major health care problem in the western world. According to reference with statistics, cardiovascular diseases were the primary cause amounting to 82% in Norway and India in 2012[34]. The most common cardiac diseases are related either to 1) altered load on the cardiac muscles due to pressure or volume overload or 2) depressed oxygen delivery to the muscles due to narrowed or coronary arteries. The diagnosis and prognosis of the cardiovascular diseases are based on a number of variables, including an increasing number of measures according to the rapid development of new measurement techniques. In a situation with a rapid increase in the amount of data, it is important to develop methods to extract the essential knowledge from the available data. This extraction includes quantization of diffuse measurements, classification of parameters, and model-based estimation of characteristic parameters from combinations of measures.

Mathematical models can be used to represent physiological systems. In this way it is possible to explain experimental and clinical observations. Mathematical models can also be used to estimate characteristic scalar parameters (i.e. the model parameters) from a set of measurements. This is done by fitting the model output to the measurements. A reliable estimate of the model parameters requires that the parameters are identifiable from the given measurements i.e. a unique set of parameters.

Now as the technology is advanced, real time signal processing is possible, with inbuilt smart phone sensors and using Android as an operating system for platform development. The smart phone processes the data and monitors the patient’s wellbeing, and in case of an emergency, it can automatically inform the concerned physician.

The estimated cost of direct and indirect treatment of cardiovascular diseases in the United States alone is $575.3 billion for 2012 according to American Heart Association[34]. The
estimated direct and indirect cost in India is $421.2 billion [34]. To reduce these costs and the anxiety of people with known cardiovascular problems, a portable monitoring system that monitors the heart and notifies the person or external party in case of abnormalities is proposed. The proposed monitoring system is meant for patients with a known cardiovascular disease that needs to be monitored continuously. Traditional heart monitoring solutions exist for many years such as the Holter monitor which records the patient’s ECG for 24 or 48 hours and is then analyzed afterwards by the cardiologist. The patient can wear the device and go home and resume his/her normal activities. The main drawback of such monitoring solution is the unavailability of help, if a major incident occurs during the monitoring phase. It is recorded but no immediate action is taken to help the user. Observing the records later, may not be of any use to the patient. The proposed system measures the ECG of a patient continuously on real time basis and analyses it within the mobile phone itself, and gives the patient general information about their health. This information can also be stored for further use and reference. The main objective of the present research work is that, the patient should be completely comfortable and accept the system technologies, to be used in day to day life.

The ECG monitoring device has two major components: the software component and the hardware component. Figure 1.0 illustrates the ECG analysis software component as an integral part of the ECG device, since the software performs analysis on the filtered, digitized signal, while streaming from the patient in real-time.

![Figure1.0 Architecture of Proposed System [36]](image-url)
In the proposed system, the patient is connected to the ECG sensor unit directly using a set of commercial, three-lead gel-based sensory probes. Data from sensors is collected and processed in the smart phone, for high risk cardiac patient, the ECG signal data needs to be collected continuously and should be processed on the real time basis. The focus of research is on the diagnosis of ECG signals, and ECG signal time intervals, training neural network, developing new software.

**1.2 Organization of the Thesis**

The thesis is organized in four chapters. The first chapter contains introduction and literature review including general introduction to the project, followed by a brief description of the cardiac muscle structure and function, review of previous work and system in existence.

The second chapter is experimental containing mathematical modeling and analysis using Fast Fourier series. It results in observing ECG signals according to the parameters such as heart rate, amplitudes and durations, frequency, different time intervals like P-Wave, PR-Interval, QRS-Interval, ST-Interval, T-Wave using Mat lab software and Weka version 3.7.9 as illustrated in Figure.1.1 training part of neural networks with different types of algorithms and error correction is done by perceptron learning rule, Delta learning rule and Genetic Algorithm. A software program is written in visual prolog and PHP. Precise Electro Cardio Gram (ECG) classification is used to diagnose patient’s condition.

The third chapter contains the description of a Data mining techniques implemented in WEKA (Waikato environment for knowledge analysis) software and computationally Effective solutions based on artificial neural networks (ANN) and data mining for ECG signal analysis. The entire ECG signal file is analyzed, sample by sample. The probability for the correct classification rises if only the parts of the annotations files that contain the disorder are analyzed and discerning between normal and abnormal ECG record. Clustering method has been found somewhat better than K-Means algorithm. WEKA implements decision tree C4.4 algorithm using “J48 decision tree classifier” attributes are Sinus-Bradycardia,Sinus-Tachycardia,Atrial-Tachycardia,Atrial-Flutter,Atrial-Fibrillation Heart-Block ,second-degree-Heart-Block and time intervals are p-wave,qrs-wave,st-wave ,heart-rate range(40bpm-120bpm),heart-rate-variability range(4ms-70ms).The size of tree is correctly classified instances and clearly mention in matrix.
Figure 1.1 A multi layer neural network using WEKA software.

The fourth chapter contains fuzzy analysis by decision tree and fuzzy control techniques applied in various ECG signals processing and artificial neuro fuzzy classifier fuzzy inference system based on the model of Takagi-Sugeno and uses four layers. For reasons of representation, a system with two inputs and two outputs is considered. Some more parameters are used significant to heart attack with their weight age and the priority levels are advised by the medical experts.

The thesis includes a description of the observed Heart Signals features that the proposed model arises from, a step by step description of the model development, model simulations and a qualitative evaluation of the model against measurements as illustrated in Figure 1.2.0.
Figure 1.2.0 Flowchart showing the logic of ECG signal analysis

The best fit of the model is the output from the measurements. The parameter identifiability depends on the model complexity, the relations between the parameters in the model, and the available measurements as illustrated in Figure 1.2.2 Figure 1.2.3[36].
1.3 The research contributions

The main contributions as described in this thesis can be summarized as follows:

Development of a PC-based measurement and control system for cardiac diseases and ECG signal predication by artificial intelligence techniques. A general introduction followed by a brief description of the cardiac signals and functions. Mathematical modeling and analysis using Fast Fourier series to find out ECG signals according to the parameters such as heart rate, amplitudes and durations, frequency, different time intervals like P-Wave, PR-Interval, QRS-Interval, ST-Interval, T-Wave using Mat lab software and training part of neural networks with different
types of algorithms. Error correction is done by perceptron learning rule, Delta learning rule and Genetic Algorithm. A software program is written in visual prolog and PHP. Precise Electrocardiogram (ECG) classification to diagnose patient’s condition maintained by a large database. Fuzzy analysis by decision tree and fuzzy control techniques applied in various ECG signal processing. Artificial neuro fuzzy classifier fuzzy inference system based on the model of Takagi-Sugeno and uses four layers reasons of representation, a system with two inputs and two outputs. Some more parameters significant to heart attack with their weight age and the priority levels are advised by the medical experts are also used.

Data mining techniques implemented in Weka software and cardiac muscle contraction-relaxation sequences and entire ECG signal file is analyzed sample by sample. The probability for the correct classification rises if only the parts of the annotations files that contain the disorder are analyzed and if the number of possible patient classes is reduced to two, thus discerning between normal and abnormal ECG record.