

CHAPTER - 1

INTRODUCTION

1.1 Scope of the work

A tremendous increase in the incidence of heart disease has taken place in recent years. Anxiety and tension, inadequate rest, over crowding population, pollution, infections, increased longevity etc. are all responsible for the increase of such incidence of heart disease.

Electrocardiogram (ECG) is an indispensable tool for analysis of different cardiac conditions and no opinion can be given on heart cases without it. It is one of the essential methods of investigations in the practice of medicine and is required in every steps of diagnosis of heart diseases as well as medical check up. The investigation is so easy and simple that it is accepted by any patient without any hesitation [18][†].

Attempts to computerize the process of the interpretation of ECG have started very early, specifically in the late 50s. Much progress has been made but still many problems remain to be solved [16,20,21,22,37,43,49,58,59,77,85,90,95,97,103]. The main reasons to computerize the ECG processing are, perhaps, the follows:

[†]The numbers within the parentheses correspond to the numbered bibliography at the end of the thesis.

- a) rapid analysis of large volume of data.
- b) on line patient monitoring.
- c) extraction of information from ECGs with high accuracy.
- d) ability to provide objective and consistent interpretation because of the identical principles in each case.
- e) opportunity to provide greater number of people at decreased cost.
- f) automatic diagnosis.
- g) opportunity to explore new approaches to ECG waveforms and diagnosis.

The interpretation of an ECG is done by the physician who applies a visual procedure which can be divided into two separate stages. In the first stage, he recognizes some characteristic features of the ECG (i.e various cardiac complexes, cardiac segments etc.) and measures their parameters (i.e. durations amplitudes etc.). In the second stage, he interprets the ECG using the results of the first stage, in connection with the established empirical diagnostic criteria [43].

Most contemporary computerized ECG processing systems used in hospital and medical offices try to imitate the cardiologist [127]. Thus these systems perform two distinct tasks. The first is a pattern recognition and a pattern parameter measurement task. The second is an interpretation task. In these systems the pattern recognition task is the hardest of all.

Three different approaches have been used for tackling the pattern recognition task: the "non-syntactic", the "syntactic" and the "hybrid" approach. The non-syntactic approach employs techniques from classical signal processing [6,26,60,76,79,82,118,121,124,125,146,147,160,161,162]. such as digital filters, threshold triggers, template correlation,

frequency domain analysis, functional approximation of waveforms etc., as well as heuristic techniques.

The syntactic approach employs techniques from the syntactic pattern recognition field. Several interesting description of syntactic pattern recognition methods can be found in [37,43,50,54,73,77,80,86,95,96,97,98,135,150]. Motivation for using a syntactic approach resides in the fact that human inspection of ECG waveforms is primarily an extraction of structural and qualitative information. Once this information has been obtained and some typical forms (like a QRS complex) have been recognised, the numerical values of the durations and amplitudes of various concerned parameters, useful for diagnosis, can be measured.

The hybrid algorithms try to combine aspects from both the syntactic and the non-syntactic ones, as well as from the field of artificial intelligence [4,74,91,92,163]. An artificial intelligence system created to solve problems in a particular domain is called an expert system. The problem of combining pattern recognition system with expert system has also been pursued [51]. The development of A.I and expert systems can be found in [2,32,133,169]. An expert system stores a large body of facts, along with rules about how these facts can be used to solve problems. This collection of knowledge is called knowledge base.

The present work is divided into two parts. The first part is concerned with the development of different algorithms for feature extraction of ECGs utilising syntactic pattern recognition approach. The algorithms have been implemented in GWBASIC language. This approach can be extended to analysis of ECG data

for rhythm diagnosis.

The second part is concerned with the diagnosis of cardiac diseases . An attempt has been made to explore the usefulness of Turbo Prolog language and dynamic knowledge base to identify the different cardiac diseases present in the patient's ECG. The complete work has been implemented on a personal computer (compatible to IBM-PC) and encouraging results have been obtained.

1.2 Synopsis of the thesis

Chapter 2 presents an introduction to electrocardiogram. In chapter 3, a brief discussion on the syntactic pattern recognition is described. Useful concepts of formal language theory including context-free grammars and parsing algorithms have also been discussed.

In Chapter 4, a brief discussion on the concept of knowledge base in the light of expert systems and artificial intelligence (A.I) has been presented. The AI language Turbo Prolog has also been described in the same chapter.

Chapter 5 provides a review of several important works on the ECG analysis. In this chapter, data reduction strategy, feature extraction strategy and classification strategy of the ECG signals have been reviewed.

Chapter 6 is primarily devoted to data reduction, feature identification and extraction and measurement part of the digitized ECG data. This chapter includes several algorithms developed as part of the work. The following algorithms are presented in sequence : (i) an algorithm for the conversion of digitized ECG data to a string like structure; (ii) a data

reduction algorithm; (iii) algorithms for the ECG-feature identification and extraction; (iv) algorithms required for the measurement of the extracted ECG-features; and v) algorithms for measurement of heart rate and electrical axis of the heart. Context-free grammars in Chomsky normal form are also developed in this chapter for the extraction of ECG features.

Chapter 7 is mainly concerned with the diagnosis of heart diseases. A dynamic database is used for the diagnosis. The method is similar to a production system used in expert systems. The diagnostic program has been discussed thoroughly in this chapter.

In chapter 8, the various steps involved in the actual execution of the different algorithms over a computing system have been suitably illustrated with the help of a practical ECG waveform. Complete documentation of the different programs are given in the appendix.