ABSTRACT

The advances in information and communication technology and the availability of low-cost high-performance computing technology have enhanced the role of computers in providing reliable, fast and comprehensive solutions to cardiac disease diagnosis.

Heart disease has become one of the most common diseases that affect human beings worldwide. Each year, millions of people die of heart diseases. However, early detection and timely treatment can prevent such events. Hence, the demand for quality cardiac care has thrown challenges to the field of biomedical engineering to devise reliable and faster techniques to enhance the diagnosis of heart diseases. This research work is yet another attempt in this direction.

Electrocardiogram (ECG), the recording of the electrical activity of the heart, is the primary, non-invasive tool widely used for diagnosing cardiac diseases. One cardiac cycle of the ECG signal consists of the P, Q, R, S and T waves. Any abnormal change in the shape and variation of time intervals between these characteristic waves results in an abnormal rhythm called arrhythmia. Detection of arrhythmia is a critical step in administering aid to cardiac patients. To reduce the time required for a physician in the diagnostic classification, two automatic arrhythmia classification systems have been developed. The classification is based on the features derived from intervals
between the characteristic waves and the interval time series of the R wave peaks, which are obtained from the ECG signals using Discrete Wavelet Transform (DWT).

Heart rate and heart rate variability (HRV) are important measures that reflect the state of the cardiovascular system. HRV analysis, a non-invasive technique, has gained prominence in the field of cardiology for detecting cardiac abnormalities. This analysis yields various measures that have proved to be a good aid in the classification. In this research work, the significance of linear (time and frequency domain), nonlinear and combined measures of HRV in the classification of certain cardiac diseases has been explored using heart rate variability data obtained from ECG signals. The classification results show that the combination of linear and nonlinear measures is a better indicator of heart diseases than linear or nonlinear measures alone. The classification accuracy achieved is comparable with those obtained using other techniques.

Heart auscultation is the process of interpreting sounds produced by the flow of blood into and out of the heart and the movement of mechanical structures that control this flow. This non-invasive, low-cost screening technique is used as a primary tool in the diagnosis of heart disorders. The conventional method of auscultation with a stethoscope is a subjective process which depends more on the physician’s experience and ability to differentiate between different sound patterns. To circumvent the subjective inaccuracies and support the physician in his decision making, a heart murmur classification system has been developed. DWT has been used to decompose
the heart murmur signals into subbands and the coefficients obtained in each subband are used to calculate a set of time-frequency related parameters. An artificial neural network has been developed feeding these parameters as inputs to classify heart murmurs into eight types. The classification results obtained demonstrate the fitness of the developed system as a support tool for physicians in detecting heart disorders.

In a 12-lead ECG, clinically useful information is found in the intervals, amplitudes and time durations of the characteristic waves of each ECG lead. These lead measurements extracted from the 12 ECG leads can be analysed for detecting various cardiac abnormalities. A rule-based ECG analyser which uses these lead measurements for analysis has been developed.

Most times, the knowledge of an expert is largely confined to him and is not freely available for decision making. In this research work, rule-based expert systems have been developed in consultation with experts for the following: a) Chest pain diagnosis b) ECG analysis and c) Ischemic Heart Disease diagnosis. Storing post diagnostic information of patients for future use and provision for modification and inclusion of new rules are the unique features of these systems. The diagnostic results of these expert systems were found to tally well with the diagnosis of expert cardiologists. These expert systems can hence support physicians in their diagnosis.

Telecardiology, a branch of telemedicine, benefits cardiac patients by enabling treatment from a distant place, either from home or from a rural
medical centre. The existing systems have their merits and applications. However, due to the technical support and cost involved, their implementation continues to remain difficult in small-sized rural hospitals. Most importantly, they lack the involvement of expert cardiologists in the diagnostic process. In this research work, a web based telecardiology framework that addresses these issues in providing a cost effective scalable solution for bringing quality health care to the rural sector has been proposed.

Rapid development of telecommunication networks has enhanced medical teleconsultation. In this research work, a teleconsultation framework has been proposed to provide tools for establishing meaningful communication between general practitioners in remote areas and specialists typically located in large medical centres. The current frameworks available in telemedicine allow image manipulation and voice communication. However, they do not support video consultation. The proposed system is a low-cost framework which supports both image and video based consultation, along with the advantage of voice communication facility. In addition to this, the provision of a direct connectivity to a patient with an image acquisition system through internet protocol (IP) based communication enables online consultation.

This research work shows that the effective use of technology for diagnosing cardiac diseases would assist physicians in providing quality and timely healthcare services to the society.