CHAPTER-I
INTRODUCTION

Throughout the years, the computational changes have brought growth to new technologies. Artificial Intelligence is proven to be an emerging technology to solve complex real world problems which require expertisation & decision making.

Artificial Intelligence (AI) is a human endeavor to create a non-organic machine-based entity that has the abilities like to think, to imagine, to create, to memorize, to understand, to recognize patterns, to make choices, to adapt change and to learn from experience. The two basic approaches to Artificial Intelligence are bottom-up and top-down approaches. The bottom-up approach believes the best way to achieve Artificial Intelligence to build electronic replicas of complex network neurons of the human brain, while the top-down approach attempts to mimic the brain's behavior with computer programs [PRW88][Azz04][EARR04]. One of the bottom-up approaches of Artificial Intelligence is *Artificial Neural Networks (ANNs)*.

Artificial Neural Network is an information processing paradigm that is inspired by the biological nervous system [SAA06] [NAN07]. Artificial Neural Networks allow the systems to recognize the input patterns by learning from past experiences or examples. Moreover ANNs do not require separate memory locations to store the outcome data with its associated probabilities. The major

tasks of Artificial Neural Networks are Function Approximation, Classification, Clustering, Decision Support Systems, etc,.

Decision Support System (DSS) has been identified as one of the important solution providers in the emerging field of Artificial Neural Networks [RD03][TEFK06][HYJC06]. A *Decision Support System* is an interactive, flexible and adaptable computer-based information system. The main objective of a Decision Support System is to increase the effectiveness and efficiency of the decisions and to reduce the time taken for making decisions. Decision Support Systems are gaining popularity in various domains including business, engineering, military and medicine.

Medical Decision Support System (MDSS) is an interactive Decision Support System software, which is designed to assist physicians and other health professionals in decision making tasks and to diagnose the patient disease [PIR00] [Ree04] [Sco05] [Chi09] [KLMG10]. The Medical Decision Support System reduces the diagnosis time and improves the accuracy of the diagnosis.

The *Decision Support System for Congenital Heart Septum Defect Diagnosis (DSSCHSD)* automatically predicts the Heart Septum Defect for new cases based on the previous learning. Decision Support System for Congenital Heart Septum Defect Diagnosis is built based on the Physical Evaluation and Clinical Evaluation of Congenital Heart Septum Defect by using Artificial Neural Network Techniques.

Congenital Heart Septum Defect *(CHSD)* or Cardiac Septal Defect or Hole in the Heart is a type of Congenital Heart Defect (CHD), which is present at the time of birth. The diagnosis of Congenital Heart Septum Defect is carried by two stages namely the Physical Evaluation and the Clinical Evaluation of a patient.

In the Physical Evaluation, Signs, Symptoms and Measurements of a patient are obtained. The Signs of a Heart Septum Defect are cyanosis, thrill, fainting, etc., which are noticed by the physician or others; the Symptoms are like shortness of breath, fast breathing, etc., which are sensed by the patient; the Measurements are the systolic blood pleasure, diastolic blood pleasure and hear rate, etc., which are recorded by the physician. During the Physical Evaluation if the physician suspects the disease then the patient is advised for Clinical Evaluation. But suspecting Congenital Heart Septum Defect during the Physical Evaluation is a difficult task for physicians due to unavailability of the subject specialists or lack of subjectivity or inexperience with the previous cases or even they may fail to get required information from the children because they can’t express the problem in a proper way. Therefore to increase the accuracy of the diagnosis, in the present study, a Decision Support System is developed using Neural Networks to diagnose Congenital Heart Septum Defect based on Signs, Symptoms and Measurements.

The Clinical Evaluation of Congenital Heart Septum Defect includes Electrocardiogram (ECG), Chest X-ray and Echocardiography (Ultra Sound Scan Test). Congenital Heart Septum Defect is clinically diagnosed by extracting the features from clinical tests which includes obtaining the amplitudes of P,Q,R,S,T waves and the intervals between the wave of R-R, P-R, S-T, Q-T, etc., from the ECG Signal; obtaining the heart size measurements like Transverse Diameter, Broad Diameter, Longitudinal Diameter, Thoracic Ratio, etc., from the Chest X-ray of a patient; obtaining the location, size of the Congenital Heart Septum Defect features from Echocardiography.

Manual extraction of clinical features of congenital Heart Septum Defect is a difficult task and is time consuming process due to the Image analysis. In order to extract the clinical features automatically, Digital Image Processing Techniques and Wavelet Transformation Techniques are used in the current work.

To extract the ECG features automatically, an algorithm is developed using Wavelet Transformation. The Daubaches Wavelet Transformation of level 8 is used for both noise removal and for Peak Detections.

To extract the Chest X-ray features automatically, an algorithm is developed using Digital Image Processing Techniques such as median filter for noise removal, threshold based segmentation to extract the contour of heart field and so on.

In order to extract the features automatically from Echocardiography, an algorithm is developed using Digital Image Processing Techniques. Here, also a median filter is used for noise removal and gray level based threshold is applied to extract the required field and some other techniques are used for efficient extraction of data.

Though the clinical features of Congenital Heart Septum Defect are extracted using the proposed algorithms, still it is difficult for a physician to manually diagnose Congenial Heart Septum Defect. Because the extracted feature values will not be constant for all the patients, instead they vary from person to person and is also a time consuming process. Therefore in the present study, to increase the accuracy of the diagnosis and to reduce the diagnosis time, respective Decision Support Systems using Neural Networks based on ECG signal features, Chest X-ray features and Echocardiography features are proposed for handling Clinical Evaluation.

Finally, a Decision Support System using Neural Networks is proposed for automatic diagnosis of Congenital Heart Septum Defect based on the resultant values of Physical Evaluation and Clinical Evaluation of a patient.

There are different models of Neural Networks for developing a Decision Support System. These models are Perceptron Neural Network, ADALINE, MADALINE, Backpropagation Neural Network, etc,. Among these models

Backpropagation Neural Network Model is the most commonly and widely used model.

For the current work, the Backpropagation Neural Network model is used to develop a Decision Support System for Congenital Heart Septum Defect Diagnosis. In addition to the diagnosis, the proposed system also stores and retrieves the resultant values for future reference.

The user friendly Decision Support Systems are designed and implemented in MATLAB 7.3 with GUI features.

1.1 Motivation and Objectives

Congenital Heart Disease (CHD) is primarily seen in neonates, infants and children although in our country it is not uncommon to see adults with uncorrected CHD [Ani05]. The burden of Congenital Heart Disease in India is likely to be enormous, due to very high birth rate. This heavy burden emphasizes the importance of this group of heart diseases. The reported incidence of CHD is 8-10/1000 live births according to various series from different parts of the world. It is believed that this incidence has remained constant world wide [Elh06][Kha09]. The studies made on CHD showed that the percentage of patients suffering with Congenital Heart Septum Defects (Cardiac Septal Defects) is more when comparing with the other types of CHD [Elh06][SKNK06][Kha09].

Rapid advances have taken place in the diagnosis and treatment of CHSD over the last 6 decades. There are diagnostic tools available today by which an accurate diagnosis of CHSD can be made even before birth. With currently available treatment modalities, over 75% of infants born with Congenital Heart Septum Defect Diagnosis (CHSD) can survive beyond the first year of life and many can lead near normal lives thereafter. However, this privilege of early diagnosis and timely management is restricted to children in developed countries only. Unfortunately majority of children born in developing countries and afflicted with CHSD do not get the necessary care, leading to high morbidity and mortality.

Pediatric cardiac care in India is still in its infancy. There are few data available on CHSD prevalence at birth or on proportional mortality from CHSD [SKNK06]. A very few specialized pediatric cardiology training programs are concentrated in certain regions of India and are often imparted through combined adult and pediatric programs. The existing number of trained personal for pediatric cardiology and pediatric cardiac surgery is inadequate. Increasing awareness of the problem amongst pediatricians through Automated Diagnosis System can be most helpful in early diagnosis and timely referral cases. Therefore in the present study, Congenital Heart Septum Defect Diagnosis is chosen as the problem domain with the objective of developing an automated Decision Support System for Congenital Heart Septum Defect Diagnosis

(DSSCHSD) that increases the accuracy of the diagnosis and decreasing the diagnosis time and cost.

Neural Networks are being applied to an increasingly large number of real world problems. Their primary advantage is that they can solve problems that are too complex for conventional technologies i.e., problems that do not have an algorithmic solution or for which an algorithmic solution is too complex to be defined. In algorithmic solution, the computer follows a set of instructions in order to solve a problem. Unless specific steps that computer needs to follow are known, the computer can't solve the problem. That restricts the problem solving capability of conventional programs, which can be solved by using Neural Networks because the Neural Networks will not depend on the instructions instead it depends on the data. By considering the successful applicability of Neural Networks in many areas, an endeavor to asses their performance for data retrieval is the basis for this research work.

The objective of the present study is to develop a Decision Support System for Congenital Heart Septum Defect Diagnosis using Neural Networks, which reduces the diagnosis costs, time and increases the accuracy of the diagnosis. The proposed system can be used by the physician to diagnose Congenital Heart Septum Defect automatically and to make the decision. The proposed system is not only used for diagnosis but can also be used to store and view the diagnosis results for future reference.

1.2 An Overview of Decision Support System for Congenital Heart Septum Defect Diagnosis Process

The proposed Decision Support System has the internal architecture of given in fig1.1. The architecture contains two main parts: one is the data and other is the Neural Network Techniques.

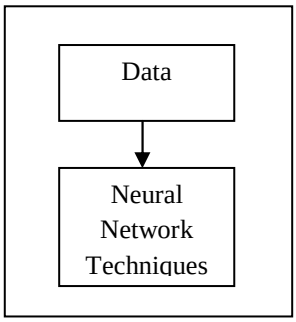

Fig 1.1: Architecture of a Decision Support System

The objective of the Decision Support System is to perform an automatic classification of the data for a new pattern (case) based on the existing data by using Neural Network Techniques. To achieve this, initially a Neural Network (Backpropagation Neural Network Model) is built by taking the input parameters from the collected data. Then the Network is trained by using the selected training method and learning rule. The Network is trained until it reaches its desired output. Once the network is trained, then it can be used to perform the classification automatically for a new pattern (case). This architecture is implemented in the proposed Decision Support System for Congenital Heart Septum Defect Diagnosis.

The proposed DSSCHSD is divided into 5 main modules based on the Congenital Heart Septum Defect Diagnosis process. The first module is the *Decision Support System for Congenital Heart Septum Defect Diagnosis based on Signs and Symptoms using Neural Networks.* The objective of this module is to obtain Signs, Symptoms and Measurements of a patient and to perform the Congenital Heart Septum Defect Diagnosis classification based on the Signs and Symptoms using Neural Networks.

In general the second, third and fourth modules occur when the resultant value of the first module is abnormal. The second module is the *Decision Support System for Congenital Heart Septum Defect Diagnosis based ECG Signal features using Neural Networks*. The functionality of this module is, to extract the features from ECG Signal of a patient using Discrete Wavelet Transformation techniques and to perform the Congenital Heart Septum Defect Diagnosis classification using Neural Networks.

The third module is the *Decision Support System for Congenital Heart Septum Defect Diagnosis based on Chest X-ray features using Neural Networks*. The aim of this module is, to extract the features from Chest X-ray of a patient using Digital Image Processing techniques and to perform the classification of Congenital Heart Septum Defect Diagnosis based on the extracted features using Neural Networks.

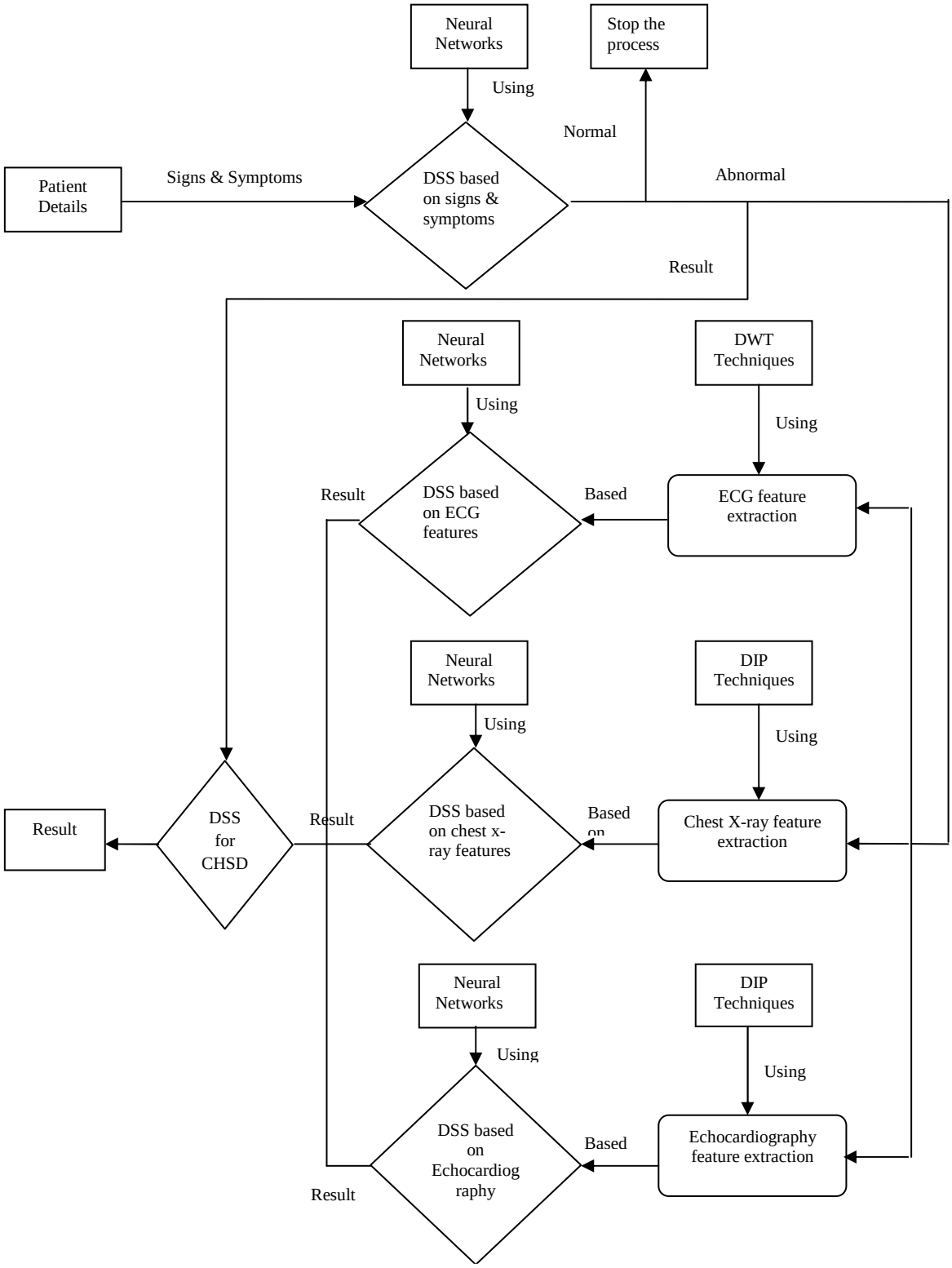

Fig 1.2: Overview of Decision Support System for Congenital Heart Septum Defect Diagnosis

The fourth module is the *Decision Support System for Congenital Heart Septum Defect Diagnosis based Echocardiography features using Neural Networks*. The objective of this module is, to extract the features from Echocardiography of a patient using Digital Image Processing techniques and to perform the Congenital Heart Septum Defect Diagnosis classification using Neural Networks.

The fifth module is the *Decision Support System for Congenital Heart Septum Defect Diagnosis using Neural Networks*. The aim of this module is to perform the Congenital Heart Septum Defect Diagnosis classification based on the resultant values of first module (if abnormal), second module, third module and the fourth module. The resultant value of this module determines whether a patient has Congenital Heart Septum Defect or not. An overview of Decision Support System for Congenital Heart Septum Defect Diagnosis process is shown in fig 1.2.

1.3 Organization of Thesis

This thesis is organized into eight chapters.

Chapter one deals with the Motivation and Objectives of the present study. An overview of Decision Support System for Congenital Heart Septum Defect Diagnosis is also presented in this chapter.

Chapter two describes the Problem Domain and Methodology used for the present work. This chapter also deals the Review of Literature for the current work.

The development of a Decision Support System for Congenital Heart Septum Defect Diagnosis based on Signs and Symptoms using Neural Networks is described in *chapter three*. The experimental results are also shown in this chapter.

Chapter four describes the development of a Decision Support System for Congenital Heart Septum Defect Diagnosis based on Electrocardiogram (ECG) Signal features using Neural Networks. The basic concepts of Wavelet Transformations and the various Wavelet Transformation Techniques implemented for extraction of features from the ECG signals are also discussed in this chapter. In this chapter, the experimental results are also shown.

In chapter five, the development of a Decision Support System for Congenital Heart Septum Defect Diagnosis based on Chest X-ray features using Neural Networks is described. This chapter introduces the basic concepts of Digital Image Processing and the various Digital Image Processing Techniques implemented for the extraction of features from Chest X-ray. The experimental results are also shown in this chapter.

Chapter six describes the development of a Decision Support System for the diagnosis of Congenital Heart Septum Defect based on Echocardiography

features using Neural Networks. The various Digital Image Processing techniques implemented for extraction of Echocardiography are presented in this chapter. This chapter also shows the experimental results.

Chapter seven describes development of a Decision Support System for the diagnosis of Congenital Heart Septum Defect based on the resultant values of Signs and Symptoms diagnosis classification, ECG signal diagnosis classification, Chest X-ray diagnosis classification and the Echocardiography diagnosis classification using Neural Networks. The experimental results are also shown in this chapter.

Conclusions and future directions are proposed in *chapter eight.*