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An overview of Expert System for Heart Disease using Neural Network and Data Mining

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ABSTRACT: Heart disease is a major cause of morbidity and mortality in modern society. Medical diagnosis is extremely important but complicated task that should be performed accurately and efficiently. This paper presents the practical knowledge and use of expert system for heart disease using different techniques such as Support Vector machine, Radial Basis |function, GRNN, Feedforward Backpropagation The main aim of this case study is to understand how data should be collected and which parameters are useful to develop the any type of expert system on the basis of symptoms. Factors discussed include many types of techniques which are used in developing the expert system with technical aspects. This paper also proposed to find out the heart diseases through data mining, Support Vector Machine (SVM), Genetic Algorithm, rough set theory, association rules and Neural Networks. In this study, we briefly examined that out of the above techniques Decision tree and RBF is most effective for the heart disease. So it is observed that, the data mining could help in the identification or the prediction of high or low risk heart diseases.

KEY WORDS: Data Mining, Neural Network, Heart Disease, SVM, Radial Basis Function.

I. INTRODUCTION

A. Overview of Data Mining and Expert System

Knowledge discovery in databases is well-defined process consisting of several distinct steps. Data mining is the core step, which results in the discovery of hidden but useful knowledge from massive databases. A formal definition of Knowledge discovery in databases is given as follows: “Data mining is the non trivial extraction of implicit previously unknown and potentially useful information about data” [1]. Data mining technology provides a user-oriented approach to novel and hidden patterns in the data. The discovered knowledge can be used by the healthcare administrators to improve the quality of service. The discovered knowledge can also be used by the medical practitioners to reduce the number of adverse drug effect, to suggest less expensive therapeutically equivalent alternatives. Anticipating patient’s future behavior on the given history is one of the important applications of data mining techniques that can be used in health care management. [2]

An expert system is defined as a software that attempts to reproduce the performance of one or more human experts, most commonly in a specific problem domain. It basically uses an inference engine connected to the knowledge base. A wide variety of methods can be used to simulate the performance of the expert however common to most or all are:

• The creation of a so-called “knowledgebase” which uses some knowledge representation formalism to capture the Subject Matter Expert’s (SME) knowledge; [34]

• A process of gathering that knowledge from the SME and codifying it according to the formalism, which is called knowledge engineering.

Expert systems may or may not have learning components but a third common element is that once the system is developed it is proven by being placed in the same real world problem solving situation as the human SME, typically as an aid to human workers or a supplement to some information system.

In future we can also use big data for medical analysis as it handles the large amount of data as described in [3] What are the Big data issues, challenges, tools are important studies for the basic things to know for everyone who is related to computer science. In this paper [6] author discussed about basic properties of big data like volume, velocity, variety, complexity, value has been discussed. And what are the important sources from which big data is coming and generated. Big data has a great importance in various fields like social media, government sector, sensor data, and log

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storage and risk analysis. As we are now in 21st century we can use the SMART classroom and to explain research, technology as one of the resource for researcher. [4]

B. The Need for Expert Systems

Expert systems are necessitated by the limitations associated with conventional human decision-making processes, including:

- Human expertise is very scarce.
- Humans get tired from physical or mental workload.
- Humans forget crucial details of a problem.
- Humans are inconsistent in their day-to-day decisions.
- Humans have limited working memory.
- Humans are unable to comprehend large amounts of data quickly.
- Humans are unable to retain large amounts of data in memory.
- Humans are subject to deliberate or inadvertent bias in their actions.
- Humans can deliberately avoid decision responsibilities.
- Humans lie, hide, and die. [5]

II. BACKGROUND

A. Related work on various diseases

Up to now, various classification algorithms have been employed on Turkoglu's valvular heart disease data set and high classification accuracies have been reported in the last decade. Turkoglu's valvular heart disease data set was obtained from Firat Medical Center. A detailed description for the data set will be given in the next section. The valvular heart disease data set was firstly utilized in [6] where Turkoglu et al. fulfilled an expert diagnosis system which uses backpropagation artificial neural networks (BPANN) classifier. The performance evaluation of the realized system was evaluated by classification accuracy and the correct classification rate was about 94% for normal subjects and 95.9% for abnormal subjects. Later, Turkoglu et al.suggested an intelligent system for detection of heart valve disease based on wavelet packet neural networks (WPNN) [7].

In this paper [8] the author has collected the dataset of the present study consists of 215 subjects, both male and female, which have been numbered from P1 to P215. The dataset contains subjects that are in the first stage of diabetes, that is, prediabetes (PD), who are not suffering from diabetes (NODB) and who are suffering from diabetes mellitus-2 (DM2). They used a type of Bayes classification. The NaiveBayesMultinominalText was selected as it is applied only on string. If any other input attributes are present other than string, then they are ignored but accepted during the training as well as classification. The study therefore concludes that NaiveBayesMultinominalText classification can be trusted for classification only 48.357%.

To diagnose the heart failure cause different popular methods used are MRI, Doppler and Expert System. MRI can provide clear three dimensional images of the heart. Doppler technique has gained much more interest since Satomura first demonstrated the application of the Doppler Effect to the measurement of blood velocity in 1959[11]. However the factor such as calcified disease or obesity often results in a diagnostically unsatisfactory. Doppler techniques assessment and therefore, it is sometimes necessary to assess the spectrogram of the Doppler Shift signals to elucidate m the degree of the disease [12]. Many studies have been implemented the classify Doppler signals in the pattern recognition field [13-14].

In this paper [15] the doctors do have a need of an automated system to detect diabetes disorder by which their time for writing down the prescription will be minimized. The automated detection of the disorder will help doctors to reduce the time spent on the test also it will be helpful for patient to take precautions much early if in case a subject is suffering from the disorder. The present analysis concludes that PD, NODB or DM2 is classified 100% using the simple decision tree classification technique.

Diabetes Mellitus (DM), commonly referred as diabetes is a disorder that most of the people suffer from and which also leads to death many of the times. n. The present study [16] mainly deals with the relation of Regular insulin and NPH insulin using the statistical feature on the insulin dependent diabetes mellitus dataset. The outcome of this study is regular insulin and NPH insulin are regularly taken by the patient suffering from Type 1 diabetes mellitus. From the statistical classification it has been found that the blood glucose level reading obtained after giving the Regular insulin

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doses not affect the blood glucose level reading obtained after giving the NPH insulin dose. It is totally independent of each other.

Heart disease is the Noteworthy reason for short life. Large population of people depends on the healthcare system so that they can get accurate result in less time. The main aim of this paper [17] is to apply machine learning algorithm our on dataset which collect data by the healthcare organization and KVK research Lab on the daily basis. This paper proposes to prediction of heart disease and classification of unique attribute extraction method to increase the accuracy of classification. This kind of system is very helpful in reducing the risk of death.

The brain is the anterior most part of the central nervous system. Brain tumor is one of the major causes of death among people. It is evident that the chances of survival can be increased if the tumor is detected and classified correctly at its early stage. Magnetic resonance (MR) imaging is currently an indispensable diagnostic imaging technique in the study of the human brain. Computer aided diagnosis systems for detecting Brain tumor for medical purpose have been investigated using several techniques. In this Review paper, it is intended to summarize and compare the methods of automatic detection of brain tumor through Magnetic Resonance Image (MRI) used in different stages of Computer Aided Detection System (CAD). Various segmentation approaches are reviewed with an emphasis placed on revealing the benefits and drawbacks of these methods for medical imaging applications.[18]

B. Some Early Signs of the Heart Trouble

It has been said earlier that any disturbance in the supply of blood to heart muscle leads to its functional impairment. It will be useful to discuss here such factors, which may lead to disturbances in the supply of blood to heart muscles. Certain conditions increase the strains on the heart. Among these are lack of rest, over exertion or prolonged hard labor which create an excessive body demand for oxygen that the heart, muscle must supply through pumping more blood. If the blood vessels are inelastic on account of arteriosclerosis fibrous thickening or narrowing of passage (atherosclerosis) additional work on the part of the heart will be needed to push blood through these vessels. Other indirect factors that may result in causing disturbance in blood supply are indigestion of food, anger and other emotional excitements.[19]

III NEURAL NETWORK TECHNIQUES USED FOR HEART DISEASE

A. A Feed-forward algorithm:-

A feed-forward neural network is similar to the types of neural networks that we have already examined. Just like many other types of neural networks, the feed-forward neural network begins with an input layer. The input layer may be connected to a hidden layer or directly to the output layer. If it is connected to a hidden layer, the hidden layer can then be connected to another hidden layer or directly to the output layer. There can be any number of hidden layers, as long as there is at least one hidden layer or output layer provided. In common use, most neural networks will have one hidden layer, and it is very rare for a neural network to have more than two hidden layers.

1.3 The Structure of a Feed-forward Neural Network

Figure 1 illustrates a typical feed-forward neural network with a single hidden layer. [20]

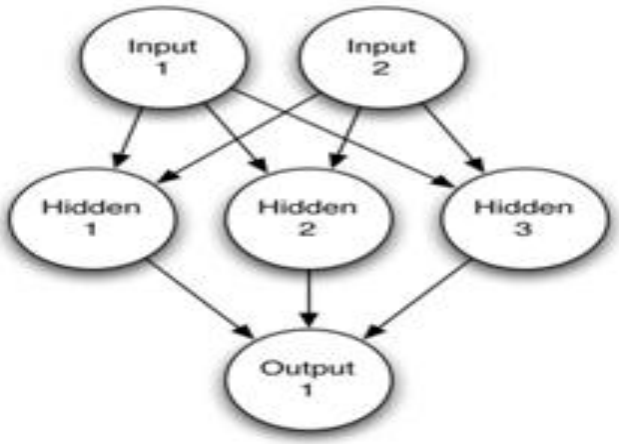

Figure 1: A typical feed-forward neural network

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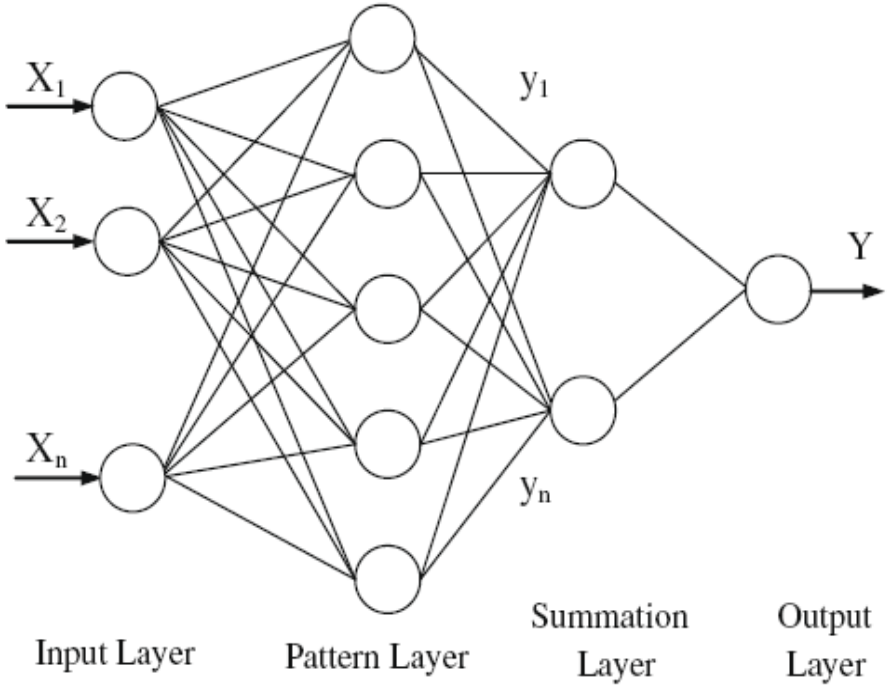
B. Generalized Regression Neural Network

A GRNN is a variation of the radial basis neural networks, which is based on kernel regression networks [20]. A GRNN does not require an iterative training procedure as back propagation networks. It approximates any arbitrary function between input and output vectors, drawing the function estimate directly from the training data. In addition, it is consistent that as the training set size becomes large, the estimation error approaches zero, with only mild restrictions on the function [21].



C. General Structure of GRNN

A GRNN consists of four layers: input layer, pattern layer, summation layer and output layer as shown in Fig. 2. The number of input units in input layer depends on the total number of the observation parameters. The first layer is connected to the pattern layer and in this layer each neuron presents a training pattern and its output. The pattern layer is connected to the summation layer. The summation layer has two different types of summation, which are a single division unit and summation units. The summation and output layer together perform a normalization of output set. In training of network, radial basis and linear activation functions are used in hidden and output layers. Each pattern layer unit is connected to the two neurons in the summation layer, S and D summation neurons. S summation neuron computes the sum of weighted responses of the pattern layer. On the other hand, D summation neuron is used to calculate unweighted outputs of pattern neurons. The output layer merely divides the output of each S-summation neuron by that of each D-summation neuron, yielding the predicted value Y0i to an unknown input vector x as [21];

D. Radial Basis Function (RBF)

RBFN is an alternative to the more widely used MLP network and is less computer time consuming for network training. RBFN consists of three layers: an input layer, a hidden (kernel) layer, and an output layer. The nodes within each layer are fully connected to the previous layer. The input variables are each assigned to the nodes in the input layer and they pass directly to the hidden layer without weights. The transfer functions of the hidden nodes are RBF. An RBF is symmetrical about a given mean or centre point in a multidimensional space. In the RBFN, a number of hidden nodes with RBF activation functions are connected in a feed forward parallel architecture. The parameters

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associated with the RBFs are optimized during the network training. These parameter values are not necessarily the same throughout the network nor are they directly related to or constrained by the actual training vectors. When the training vectors are presumed to be accurate, i.e. non stochastic, and it is desirable to perform a smooth interpolation between them, then linear combinations of RBFs can be found which give no error at the training vectors. The method of fitting RBFs to data, for function approximation, is closely related to distance weighted regression. The RBF expansion for one hidden layer and a Gaussian RBF is represented by [22]

$$Y_k(X) = \sum_{i=1}^{H} W_{ki} \exp\left(-\frac{\| X - u_i \|^2}{\sigma_i^2} \right) \qquad (1)$$

E. Support Vector Machine:

Support vector machine (SVM) is a novel learning machine introduced first by Vapnik [21]. It is based on the Structural Risk Minimization principle from computational learning theory. Hearst et al. [22] positioned the S VM algorithm at the intersection of learning theory and practice:''it contains a large class of neural nets, radial basis function (RBF) nets, and polynomial classifiers as special cases. Yet it is simple enough to be analyzed mathematically, because it can be shown to correspond to a linear method in a high dimensional feature space nonlinearly related to input space.'' In this sense, support vector machines can be a good candidate for combining the strengths of more theory-driven and easy to be analyzed conventional statistical methods and more data driven
Let us define labeled training examples [xi, yi], an input vector n xi □R a class value y □ □ i l i□ □1,1 , □1,....., For the linearly separable case, the decision rules defined by an optimal hyperplane separating the binary decision classes is given as the following equation in terms of the support vectors distribution free and robust machine learning methods.

$$Y = \text{sign}\left(\sum_{i=1}^{N} y_i \alpha_i (\mathbf{x} \cdot \mathbf{x}_i) + b \right) \qquad (2)$$

Where Y is the outcome, yi is the class value of the training example xi, and represents the inner product. The vector x =(x1,x2,.,xn) corresponds to an input and the vectors xi, i=1,.,N, are the support vectors. In Eq. (1), b and I □ are parameters that determine the hyperplane.[23]

F. Feedforward Backpropagation (FFBP)

The Feedforward Backpropagation is one of the most Studied neural network by the scientific community and the most common used in many medical applications. The feedforward, back-propagation architecture was developed in the early 1970's by several independent sources (Werbor; Parker; Rumelhart, Hinton and Williams) [24]. This independent codevelopment was the result of a proliferation of articles and talks at various conferences which stimulated the entire industry. Currently, this synergistically developed back-propagation architecture is the most popular, effective, and easy to earn model for complex, multi-layered networks [25].
This network is used more than all other combined. It is used in many different types of applications. This architecture has spawned a large class of network types with many different topologies and training methods. Its greatest strength is in non-linear solutions to ill-defined problems [26, 27].
The typical back-propagation network has an input layer, an output layer, and at least one hidden layer. There is no theoretical limit on the number of hidden layers but typically there is just one or two [28]. Some work has been done

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which indicates that a minimum of four layers (three hidden layers plus an output layer) are required to solve problems of any complexity. Each layer is fully connected to the succeeding layer, as shown in Figure 1[29].

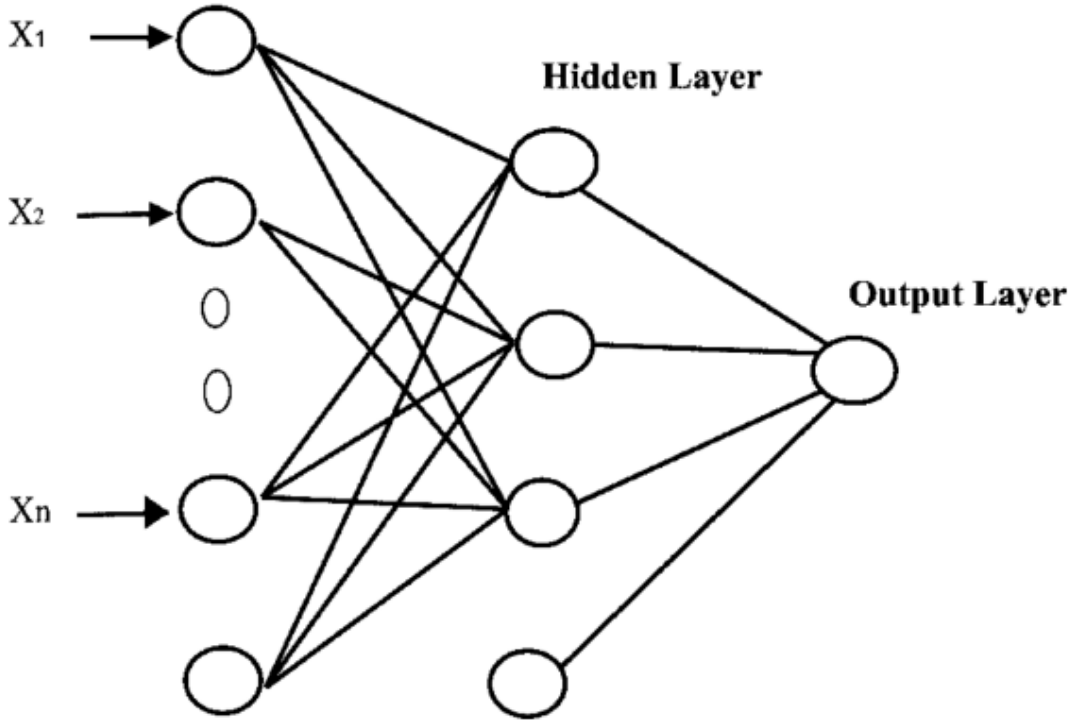

Fig. The structure of Feedforward Backpropagation Neural network [30]

IV. PREPARATION OF MEDICINE DATA

The data is collected from Sahara Hospital, Roshan Gate, and Aurangabad under supervision of Dr. Abdul Jabbar. I have visited the Hospital for OPD session daily while doctor examining the patients. The symptoms and information about patients details like Previous History, Present History, Personnel History, Physical Examination, Cardio Vascular System, Respiratory rate, Per Abdomen, Central Nervous system, ECG and Blood Investigation. The main point is ECG from which the patient can easily diagnose whether the patient is having heart problem or not.

The all 150 patient's data collected regarding heart disease and the data are prepared in different Excel Sheets which contains codes of each individual disease, history and symptoms. In one excel sheet 13 sub-sheets are taken for each field of information such as for Previous History one sub-sheet has taken and given the name is given (P1), for Present History the second sub-sheet and the name is given (P2), for Personnel History the third sheet is taken and the name is given (P3), like this total 13 different sheets for different fields. All the fields are taken under the supervision of the Cardiologist, Dr Abdul Jabbar.

The code is given to each symptoms, physical examination parameter or diseases in each sub-sheet for experimental work. On this data some pre-processing i.e. normalization, coding and decoding methods are applied for the expected output.
In one excel sub-sheet for Previous History (P1) and the diseases present in P1 are represented by Codes. The code 1 which represents Hypertension, Code 2 represents Diabetes like these 18 different diseases are found and specified 1 to 18 codes for each disease in different 150 heart patients. Some of them are as shown in Table 1.[31,32]

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Code	Name of Disease
6	Hypothyrodism
7	Old Ischaemic heart disease
8	Nil
9	Interstitial Lung disease (ILD)
10	Cerebrovascular Accident(CVA)

In next excel sub-sheet Present History (P2) and the information present in P2 are represented by Codes. The Code 1 which represents Chest Pain/Discomfort, Code 2 represents Restrosternal Pain like these 29 different symptoms are found in all patients and specified 1 to 29 codes for each symptom. Some of the symptoms are shown in table 2.

Code	Symptoms
6	Perspiration
7	Giddiness
8	Nausea / Vomiting
9	Epigastric Pain
10	Left Arm pain

Table 2: Present History of patients

In next excel sub-sheet Personnel History (P3) and the information present in P3 are represented by codes for different bad habits. The Code 1 which represents Smoking, Code 2 represents Tobacco like these 4 different bad habits are taken and specified by 1 to 4 codes. Some of the personnel history parameters are given below.

Code	Personnel History
1	Smoking
2	Tobacco
3	Alcohol
4	Nil

Table 3: Personnel History

In next excel sub-sheet Physical Examination (P4) and the information present in P4 are represented by codes for different physical parameters. The Code 1 which represents Consciousness, Code 2 represents Orientation like these 25 different physical parameters and specified by 1 to 25 codes for each parameter. Some are as shown below in table 4.

Code	Physical Examination
6	Normal Pulse rate
7	**High Pulse rate**
8	Low systolic Blood Pressure
9	Normal Blood Pressure
10	**High Blood Pressure**

Table 4: Physical Examination

In next excel sub-sheet Cardio Vascular System (CVS) and the information present in CVS are represented by codes for different symptoms. The Code 1 which represents Heart Sound, Code 2 represents Normal Heart Rate like this 8 different symptoms and specified by 1 to 8 codes for each symptom. Some are as shown below in table 5.

Code	Symptoms
4	Bradycardia
5	Regular Heart Rhythm
6	Irregular Heart Rhythm
7	Gallop sound
8	No Abnormality Detected (NAD)

Table 5: Cardio Vascular System

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In next excel sub-sheet Respiratory System (RS) and the information present in RS are represented by codes for different symptoms. The Code 1 which represents Breath Sound preserved, Code 2 represents Breath Sound Reduced like this 5 different symptoms are found and specified by 1 to 5 codes for each symptoms. Some are as shown below in table 6.

Code	Symptoms
1	Breath Sounds Preserved
2	Breath Sound Reduced
3	Basal Crepts
4	No Abnormality Detected (NAD)
5	Ranchi

Table 6: Respiratory System

In next excel sub-sheet Per-Abdomen (PA) and the information present in PA are represented by codes for different symptoms. The Code 1 which represents Liver (Hepatomegaly), Code 2 represents Spleen (Splenomegaly) like these 6 different symptoms have found and specified by 1 to 6 codes for each symptom. Some are as shown below in table 7.

Code	Symptoms
2	Spleen (Splenomegaly)
3	Free Fluid Present
4	Abdominal Distension
5	No Abnormality Detected (NAD)
6	Obesity

Table 7: Per Abdomen

In next excel sub-sheet Central Nervous System (CNS) and the information present in CNS are represented by codes for different symptoms. The Code 1 which represents Consciousness, Code 2 represents Orientation like this 5 different symptoms are found and specified by 1 to 5 codes for each symptom. Some are as shown below in table 8.

Code	Symptoms
1	Consciousness
2	Orientation
3	Focal Deficit
4	No Abnormality Detected (NAD)
5	Restlessness

Table 8: Central Nervous System

In next excel sub-sheet Electro Cardio Gram (ECG) and the information present in ECG are represented through codes for different finding which points to different problems of heart. The Code 1 which represents ST Elevation, Code 2 represents Anterior Wall like this 21 different heart findings are found and specified by 1 to 21 codes for each finding. Some are as shown below in table 9.

Code	ECG Point
6	Lateral
7	Septal
8	High Lateral
9	T Wave inversion
10	ST Depression

Table 9: Electro Cardio Gram (ECG)

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I next excel sub-sheet Blood Investigation (BI) and the information present in BI are represented through codes for blood investigation. The Code 1 which represents Cardiac Enzymes (High), Code 2 represents Blood Sugar Test like this 24 different investigations has found and specified by 1 to 24 codes for each investigation in all patient.

Code	Symptoms
6	Lipid Profile normal
7	Lipid Profile Abnormal
8	Complete Blood Count Normal
9	Leucocytosis
10	Anaemia

Table 10: Blood Investigation

In next excel sub-sheet all the medicines names along with their codes i.e. MID which are prescribed by the doctor to the patients. The medicine sheet contains 52 different medicines which are prescribed by the doctor in different 150 stages. Some are as shown below in table 11.

Code	Medicine Name
6	Clopidogrel
7	Digoxin
8	Diltiazem
9	Diphenylhydantoin Sodium
10	Enalapril

Table 11: Medicine Names

In next excel sub-sheet all Patients information such as P1, P2, P3, P4, CVS, RS, PA, CNS, ECG and BI which contains all the represented codes that are present in the individual patients.

5. Experimental Analysis:

For further neural network process the proposed information coded in binary form (0 or 1). If the symptom is present in the patients at particular number at that point it is defined by one (1) and if it is absent at that location it is placed by Zero (0). Suppose for example in the field P2 (present history) there are total 29 symptoms are present and the patient one is having the symptom 1, 2, 5 and 13 so at that location it is defined by 1 (one) and all other symptoms are 0 (zero). In such a way all the fields are defined. All the parameter that we consider in medical prescription like Sr. No., ,age , P1, P2,P3,P4,CVS, RS,PA,CNS,ECG and BT that converted in binary number where this is used in neural network for train the neurons for better result.

The individual data of the patient one is define in binary form as,

Sr No Age P1
00000001 0110111 000000010000000000
P2 p3
10010000000010000000000000000 1000

P4 CVS RS
00000100010000000000000000 00000001 00010
PA CNS ECG
000010 00010 00100000000000000000
BT
01000000000000000000000;

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Symptoms and Information Coding of the patient 1.

For this system total 52 medicine are prescribed by the Doctor and if the medicine is present is defined by one (1) and if it is absent at that location it is defined by Zero (0). Similarly for patient one the prescribe medicine are defined by, 0 1 1 0 1 1 0 0 0 0 0 0 0 1 0 0 1 0 1 0 1 0 1 0 1 1 1 0 1 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0;

Medicine Coding of the patient 1.

6. Discussion of First five patients results with doctor: Original Medicines given by doctor:

A) 1,3,5,6,14.17,19,21,23,25,26,27,29,36
B) 2,3,5,6,14,16,17,21,23,25,26,27,28
C) 1,5,6,14,25
D) 3,5,7,10,11,13,14,17,19,30
E) 3,14,15,19

Medicines given by the Expert system using FFBP

A) 1,3,5,6, 14, 16, 17,21,23,25,26,27,28
B) 1,3,5,6,14,25
C) 1,3,5,6,14,25
D) 1,3,5,6,14,25
E) 1,3,5,6,14,25……[19]

Medicines given by the Expert system using GRNN

A) 1,3,5,6, 16,1718,21,23,25,26,27,28,29
B) 1,3,5,6,16,17,18,21,23,25,26,27,28,29
C) 1,3,5,6,11,14,21,22,23,24,25,26,27
D) 1,3,5,6,13,14,17,2122,23,25,26,27,28
E) 1,2,3,5,14…….[33]

Medicines given by the Expert system using SVM

A) 1,3,5,6, 16,1718,21,23,25,26,27,28,29
B) 1,3,5,6,16,17,18,21,23,25,26,27,28,29
C) 1,3,5,6,11,14,21,22,23,24,25,26,27
D) 1,3,5,6,13,14,17,2122,23,25,26,27,28
E) 1, 2,3,5,14.

Medicines given by RBF:

A) 3,5,6,14,16,17,21,23,25,26,27,28,29
B) 1,3,5,6,11,14,16,17,21,22,23,24,25,26,27,28,36
C) 1,3,5,6,14,21,25
D) 1,3,5,6,11,13,14,17,21,25,30
E) 3,5,6,14,15

VII. CONCLUSION

The analysis model by using GRNN and FFBP of ANN gives less appropriate result for medical prescription for heartdiseasepatient.The analysis model by using GRNN and FFBP of ANN gives less appropriate result for medical prescription for heart disease patient. However, there are several techniques that can improve the speed and performance of the back propagation algorithm, weight initialization, use of momentum and adaptive learning rate. It is found that the result of testing data by using GRNN and FFBP is not satisfactory as per the result verified by the doctor. The analysis model by using SVM and RBF of ANN gives better result for medical prescription for heart disease patient. However, there are several techniques that can improve the speed and performance of the back propagation algorithm, weight initialization, use of momentum and adaptive learning rate. It is found that the result of testing data by using SVM, FFBP and GRNN, is not satisfactory but the medicines prescribed by the RBF are satisfactory as per the result verified by the doctor. In future, this work may be extend using Quasi Newton's Algorithm for satisfactory result so that this expert system can be useful for the trainee as well as those who are not expert in the heart diseases.

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