CHAPTER 15
An Improved System for Heart Disease Prediction Using Artificial Neural Networks

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ABSTRACT

Heart disease is one of the most hazardous diseases to human which shows the way to death all over the world since 15 years. Many researchers have been done with the techniques of knowledge discovery in various fields for Heart Disease prediction and have shown the acceptable levels of accuracy. By investigating the survey of those accuracy levels, this research paper is proposed to help doctors not only to diagnose and predict the heart disease by achieving accuracy levels but also helps to prescribe the medicine successfully according to the predicted disease. In this paper assessment is done by two methodologies, Artificial Neural Network (ANN) by testing the datasets, Case Based Reasoning (CBR) image similarity search by mapping the similarities of images of old patients that are stored in database for heart disease prediction. The result of the evaluation of CBR is also implemented for prescribing medicine from the history of old patients with GRNN and RBF successfully.

Keywords— *Artificial neural network (ANN), Case Based Reasoning (CBR), Generalized Regression Neural network (GRNN) and Radial basis function (RBF).*

INTRODUCTION

Cardiovascular disease has become the major challenge for health care unit (doctors, medical centers, hospitals). Cardiovascular disease is a disease class which involves heart and blood vessels [21]. The American heart association has estimated that 17.3 million people are losing their life because of cardiovascular disease per year, particularly heart attacks, strokes, coronary heart disease, pulmonary heart disease etc. [22]. This global cause of death can increase the number to grow more than 23.6 million

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by 2030. The population in low and Middle-income countries (LIMC) is the most affected by heart diseases. 80% of death by heart disease especially to younger people occurs usually at LIMC when compared to higher income countries [21].

To prevent the cause of death in LIMC and reduce in number, diagnosis and prediction is very important, but it has never been an easy task for accurate diagnosis of heart diseases. Lots of research is being done for diagnosis of heart disease but still the complications in various factors are causing delay in diagnosis of heart disease and deciding the accuracy. Like for instance the symptoms from clinic, the practical and pathological symptoms of heart diseases are linked with the human organs including heart, which shows signs of different diseases in human body. Perhaps these signs have similar symptoms of heart diseases as well. Researchers are facing difficulties to find accuracy not only in diagnosis but also in prescribing the correct medicine for the particular symptom of heart diseases.

From the survey of different researchers, various techniques have been used for diagnosis. Recently integrated clustering of more than one data mining techniques can improve performance in the heart disease diagnosis [17]. For the diagnosis of congenital heart disease. Reategui et al. proposed a model by integrating case-based reasoning with neural network [14]. Fuzzy reasoning optimized by genetic algorithm was used for the classification of my cardial heart disease [21]. All the above different techniques are used to diagnose the heart disease to a certain extent either for one specific heart disease or for some common heart diseases. But no research has been done which identifies the heart disease with utmost accuracy and also a technique which helps the doctors to provide the suitable treatment with the right prescription of medicine.

The proposed methodology is separated with two schemes one is neural network method which is integrated with Case Based Reasoning (CBR) data mining techniques with similarity search algorithm to diagnose the heart disease with accuracy. And the second is integrating CBR data mining technique with generalized regression neural network (GRNN) and radial basis function to prescribe the medicine. This paper is structured as following, in section 2, the brief explanation about ANN and CBR technique is illustrated. In section 3, the proposed methodology,

First scheme, evaluates the output of the neural networks and the output of the CBR similarity search technique.

Section 4, Second scheme, the diagnosed disease from the first scheme is used to prescribe the medicine with GRNN and radial basis function by the data's of different patients in the database, the medicine from the CBR technique is compared with the medicines given by RBF technique and the original medicine.

In Section 5, Experimental analysis of both the scheme is implemented. This paper is concluded in Section 6.

LITERATURE SURVEY

The survey shows that, several researchers are using various techniques like data mining and neural networks etc, to identify the risk factors associated with heart disease. Statistical scrutiny has identified the risk factors related to heart disease to be age, blood pressure, cholesterol [11], smoking [10], diabetes [19], high blood pressure with cholesterol levels, family history of heart disease [15], obesity, physical inactivity [16], high stress, poor hygiene.

Sufficient information about the risk factors related to heart diseases helps health care professionals to identify patients at high risk of having heart disease. Hospitals, doctors, health care systems and health care professionals store considerable data about the patients and it is necessary to analyze these datasets to extract useful knowledge.

Different techniques have been implemented to analyze this datasets and diagnose heart disease.

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Artificial neural networks and data mining techniques are the key techniques used by health care professionals in the diagnosis of heart disease and also to predict the medicine for heart disease.

Recently GRNN and RBF are used for the function of heart disease diagnosis and the medicine data is prescribed. Experimental analysis was made for first five patients [21]. Data mining can play an important role in the diagnosis of heart disease patients.

Table 1:A Sample of Different Neural Network concepts and Data Mining Techniques used on Diagnosis of Heart Disease.

Author	Year	Technique	Accuracy
Polat et al.,Sahan., S.Gunes	2007	Fuzzy-AIRS-K-nearest neighbour	87%
Das,et al.,Turkoglu.A., Sengur	2009	Neural network ensembles	89.01%
Shaikhabdulhannan., R.R.Manza., R.J.Ramkete	2010	GRNN and RBF for Heart Disease Diagnosis	93% of medicine prediction
Mohd Khalid Awang and FadzilahSiraj	2013	ANN	84%
Mai shouman,TimTurner,Rob Stocker	2013	2 Cluster Inlier K=19 Nearest Neighbour	85.7%

Clustering techniques were implemented in data mining techniques presently for the diagnosis of heart disease [17].

Mohd Khalid Awang used an Artificial neural network in the prediction of Heart Disease particularly angina in patients [17]. QeetharaKadhim Al-shayea used Artificial Neural network in Medical Diagnosis [22].

Polat K. et al.[12] analyzed Automatic detection of heart disease using an artificial immune recognition system (AIRS) with fuzzy resource allocation mechanism and k-nearest neighbour for heart disease. Das R. et al[9]. Ensembleseffective diagnosis of heart disease through neural network.

Researchers used various Artificial Neural Network and Data Mining Techniques for heart disease diagnosis and prediction as explained above.

Table 1 illustrates the sample of those techniques in the heart disease diagnosis and prediction with their level of accuracy.

All these investigations cannot be compared because they have used different datasets, unique techniques for the diagnosis and have shown the accuracies. But with this datasets and techniques accuracy levels can be improved.

The above results of researches have produced very good results in the heart disease diagnosis.

But further investigations are necessary to improve the diagnosis of heart disease and prediction to help the health care professionals.

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The proposed methodology is used to increase the level of research accuracy in diagnosis of heart disease and prediction of medicine comparatively.

The next part of the paper explains about the techniques.

PROPOSED METHODOLOGY

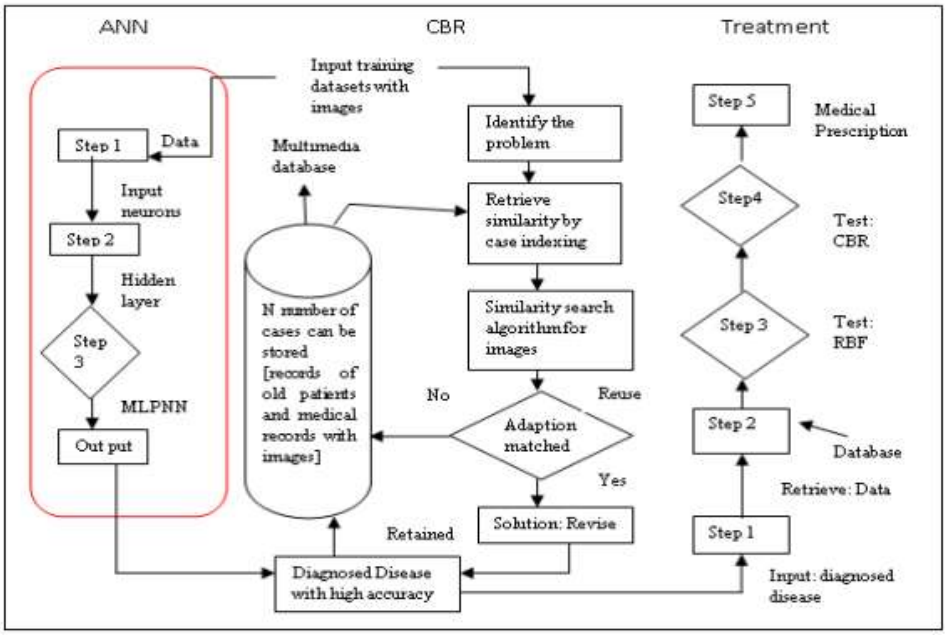

Figure: 1 Proposed Approach

NEURAL NETWORK IMPLEMENTATION

An artificial neural network is a computational network model (neurons) that are massively interconnected, operate in parallel. These elements are inspired by biological nervous system. The associations between elements to a great extent decide the system work. Therapeutic Determination utilizing artificial neural networks are at present an exceptionally dynamic research territory in prescription and it is trusted that it will be all the more generally utilized as a part of biomedical frameworks.

DATA PREPARATION

The data preparation is the important part to determine the best variables that contribute to define the optimal solution. This requires the detailed knowledge about the problem domain and the primary data's. Here the selection of this primary data is based on the doctor's suggestions and the survey of the literatures.

The data's total, 910 records with 16 medical aspects were taken from Cleveland Heart Disease database. The dataset consists of 78 raw attributes which experiments refer to 16 of them. The attributes which is used in this study is given in Table 2 with their parameters and weights.

The neural network is trained with the significant dataset or attributes as their inputs for the efficient heart disease prediction. The prediction is based on the computed major weights given in the table for each attribute. In ANN the processing element is called a layer.

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Table 2: Heart Attack Attributes their Values and Weights

Attributes	Description	Weights
Age for both male and female	Age<30 30 to 50 50 to 70 > 70	0.1 0.4 0.7 0.9
Family history	Yes No	0.5 0.1
Chest pain	Type: typical angina atypical angina non-angina pain asymptomatic	0.6 0.7 0.8 0.9
Smoking	Never Past Current	0.1 0.4 0.7
Poor diet	Yes No	0.9 0.2
Trestbps(Blood pressure)in mm Hg	Normal(130/89) Low(<119/79) High(>200/169)	0.1 0.8 0.9
Blood sugar(Fbs)	High(>120&<400) Normal(>90&<120) Low(<90)	0.6 0.1 0.4
Serum cholesterol in mg/dl	Very high>200 High 160 to 200 Normal<160	0.9 0.8 0.1
Thalach(heart rate)	High Normal Low	0.9 0.1 0.9
Exang(Exercise)	Never Regular High if age<30 High if age>50	0.7 0.1 0.1 0.8
Physical inactivity	Yes No	0.8 0.2
Obesity	Yes No	0.8 0.1
High Stress	Yes No	0.7 0.2
Poor hygiene	Yes No	0.6 0.2
Alcohol Intake	Yes No	0.7 0.2
Restecg (Resting electrocardiographic results)	Having ST-T wave abnormality- Showing probable or define left ventricular hypertrophy	0.6 0.8

The first layer is known to be the input layer and the last layer is the output layer. Between the input and the output layer the additional layers of units is called as hidden layer. A function can be performed by adjusting the values of the weights between elements.

MLPNN ALGORITHM AND PREDICTION

The figure 2 shows the structure of MLPNN with the layers were the significant inputs to heart disease prediction have been used with their weights given in the table 2.In which 0.1 refers to the lower risks and >0.1 refers to the higher risks.

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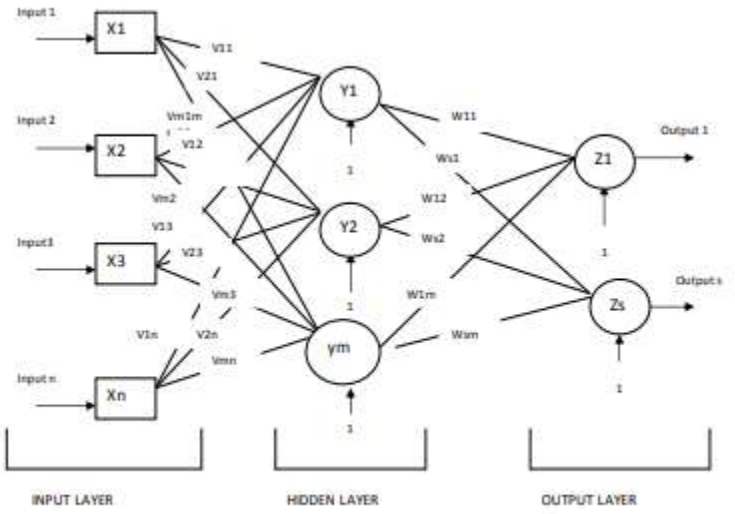

Figure 2: Multilayer Perceptron Neural Network

Here for the prediction of the heart disease the Multi-layer Perception Neural Network [MLPNN] with Back-Propagation is being used as the training algorithm. This is done in a unidirectional way. In a feed forward neural network mechanism, the input neurons of the first layer[X1, X2, X3….Xn] forward their output to the neurons of the second layer as [V11, V21…] from Which hidden layer [Y1,Y2,…Ym] evaluates the weights [W11,W22,……] and gives the output layer as [z1…]. By using this MLPNN algorithm heart disease diagnosis is done with the input attributes and the weights given in the table 2. The back propagation equation which is represented below is used for MLPNN back propagation neural network.

Where x is the emitting node, z is the receiving node, y is the layer which follows z, W is weight, ais for activation, delta values with epsilon (ε)as the learning rate.

RESULTS

The result obtained from the above experiment gives the 89% to 90% accuracy of heart disease. But with this only above experiment the heart disease cannot be predicted with the high accuracy and including the type of heart disease to prescribe the medicines. So to predict the type of heart disease with the high accuracy and to prescribe medicine we integrate this with the CBR technique which is the next part of this paper.

Case Based Reasoning (CBR) with Similarity Search Algorithm A.CBR

Case-based thinking implies utilizing old encounters to comprehend and take care of new issues. In case-based reasoning, a reasoned recollects a past circumstance like the present one and utilization that to take care of the new issue. The same method here we use for heart disease prediction and to prescribe medicine.

CBR Four-Step Process

Retrieve: provided for a focus problem, recover starting with memory instances pertinent on comprehending it.

Reuse: guide the result from the past case of the focus issue.

Revise: Hosting mapped that past answer for those focus situation, test those new result for this present reality (or a simulation) and, in necessary, modify.

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Retain: after the result need been effectively adjusted of the focus problem, store those coming about background concerning illustration another event to memory.

B. Multimedia Database

The multimedia database frameworks need aid with make utilized when it may be required will administrate tremendous amounts of multimedia data objects of different types of data media. The objects for media information are: text, pictures. Graphics, heartless recordings, feature recordings, signals, etc., that are stored in digital format.

In CBR multimedia database n number of cases are collected and stored. The cases like old records of heart disease patients, medical records about the disease were stored in database. Perhaps each record consists of (patient name, patient no, symptoms, type of heart disease, doctors name, hospital name, prescriptions, and especially images of the affected heart, etc.).

C. Input Attributes

The same dataset which we had taken as symptoms in neural network approach is in use for Case based reasoning approach as well. In this CBR similarity search technique including the above symptoms we use images of heart of the patient as an input to find out the similarity with previous records and predict whether the patient is affected by the heart disease or not ,if so then what type of heart disease. The steps for CBR similarity search with multimedia database are as follows.

Step 1: Identify the Problem

First step in CBR technique is to identify the problem of the patient with the input attributes (symptoms), including the images of heart of the patient with heart disease.

Step 2: Retrieve Similarity by Case Indexing

Given a target problem, retrieve from memory cases relevant to solving it. Second step is to retrieve the similarity from the previous old patient records or medical records by case indexing with the present patient. A record is a computational information structure that can be put away in memory and sought rapidly. Case ordering includes appointing lists to cases to encourage their recovery.

Case retrieval is a procedure that recovers the most comparable cases to the present issue. Case retrieval requires a mix of hunt and coordinating. Two retrieval techniques are used by the major CBR to diagnose the similarity for heart disease prediction: nearest neighbor retrieval algorithm and inductive retrieval algorithm.

Nearest-neighbor retrieval is a straightforward approach that registers the similitude between put away cases and new information case in light of weight highlights. A run of the mill assessment work is utilized to process closest neighbor coordinating.

Where wi is the important weight of a attribute, sim is the similarity function of attribute, and fiIand fiR are the values for attributes (symptoms), i is the input and retrieved cases respectively. This retrieval is simple and slow when the case based is large.

Inductive retrieval algorithm is a system that figures out which highlights do the best occupation in segregating cases and produces a choice tree sort structure to arrange the cases in memory. This approach is extremely helpful when a solitary case perspective is required as an answer, and when that case trait is needy upon others.

This algorithm is fast retrieval process. But this process is pre-indexing which is a time-consuming and impossible to retrieve a case while case data is missing or unknown. These algorithms are used according to the type of search fast or slow.

Step 3: Similarity Search for Images

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Third step is one of the most important steps, which is used to compare and predict the similarity between the input image of the heart disease patient with the images of previous old patient and medical records. Here the images of the affected patient are taken to predict the similarity with the images in CBR by K- N Match AD similarity search algorithm.

The AD Algorithm for K-N Match Search

The k-n-match problem models similarity search as matching between the query object and the data objects in n dimensions, where n is a given integer smaller than dimensionality d and these n dimensions are determined dynamically to make the query object and the data objects returned in the answer set match best. In this paper we implement this for matching the similarity between the images of the heart patient.

Algorithm KNMatchAD

1. Initialize appear[ ], h and S.
2. For every dimension i
3. Locate qi in dimension i.
4. Calculate the differences between qi and its closest attributes in dimension i along both directions.

Form a triple (pid; pd; dif) for each direction. Put this triple to g[pd].

5. do
6. (pid; pd; dif) = smallest(g);
7. appear[pid]++;
8. ifappear[pid] = n

9. h++;

10. S=S [pid;
11. Read next attribute from dimension pd

and form a new triple (pid; pd; dif). If end of the dimension is reached, let dif be 1. Put the triple to g[pd].

While h < k

12. returnS.

End KNMatchAD

Algm1. Algorithm KNMatchAD Step 4: Reuse: Adaption match

This step is for mapping the solution with the previous patient data's with the existing patients data's. This is involved in adapting the new solution as needed. If the adaption is matched it can be revised or else it again searches for the new solution.

Step 5: Revise

After mapping the data's of target patient, it tests the solution with the

simulation in the real world and revises it.

Step 6: Result: Retained

In this last step of CBR, disease is diagnosed and the solution is compared with the result of neural network implementation. By comparing the results the diagnosed disease perhaps gives above 97% of accuracy. The prediction is made efficient for the doctors by this methodology. Not only is the prediction

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made efficient but also the type of heart disease is diagnosed and the prescription of medicine is made easy to the doctors by CBR which is described in the next part of this paper.

Retained: After the solution has been successfully adapted to the target patient with the ANN, the resulting experience is stored as a new case in memory with multimedia database again.

Note: In the next part of the paper the diagnosed heart disease is taken as an attribute.

4. Prescription of Medicine withRBF andCBR

Radial Basis Function

RBFN radial basis function network is another option to the all the more generally utilized MLP network and is less PC tedious for network training. RBFN comprises of three layers: an input layer, a hidden (kernel) layer, and an output layer. The hubs inside each layer are completely associated with the past layer. The info factors are each allocated to the hubs in the information layer and they pass specifically to the concealed layer without weights. The exchange elements of the concealed hubs are RBF.

A RBF is symmetrical about a given mean or focus point in a multidimensional space. In the RBFN, a number of hidden nodes with RBF activation functions are associated in an encourage forward parallel design.

The parameters related with the RBFs are advanced amid the system preparing. These parameter esteems are not really the same all through the system nor they straightforwardly identified with or compelled by the real preparing vectors. At the point when the preparation vectors are attempted to be precise, i.e. non-stochastic, and it is alluring to play out a smooth addition between them, at that point direct mixes of RBFs can be discovered which give no mistake at the training vectors. The method of fitting RBFs to data, for function approximation, is closely related to distance weighted regression. An interpolation RBFN is characterized by equal number of basic functions with training points. The RBF expansion for one hidden layer and a Gaussian RBF is represented by

However, each input training point serves as a centre for the basis function. In order to ensure a smooth fit of the desired outputs, the width of each kernel has to incorporate the training points.

Preparing Data for Medical Prescription

The data’s are collected from previous old patient’s records including doctor’s examination about the patient’s symptoms, type of the heart disease affected with the prescriptions given by the doctors. N number of patient records for different diseases with medicine can be collected in database.

There are more than 13 types of heart diseases like (Angina, Congenital heart disease, Congestive heart failure, coronary heart disease etc…) which can affect human with different symptoms. At least 400 records of old patients are collected for each disease.

Database like sql, oracle is used to create tables. Individual tables are created for each disease where data’s like (Patient name, Doctors name, hospital) with coded medicines are saved. The code for the medicines is taken only under the supervision of cardiologist.

On this data some normalization, pre-processing methods, applied for the expected output. In this paper we take only 3 diseases with records of the patients and the medicines which are coded. Different medicines are used by the doctors on all patients.

In table 3, the data’s of different old patients from different hospitals particularly for congenital heart disease are collected and recorded in the database like (Patient no, Patient name, Doctor Name, Medicine prescribed) as given. So that the data’s for the particular heart disease can be retrieved for analysis to prescribe the medicine for congenital heart disease

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Table 3: Congenital Heart Disease

Patient No	Patient name	Doctor's Name	Medicine code
1	A	X	08,07,15,19,20,21,45,47
2	B	Y	07,15,19,21,45,47,08,25
3	C	Z	08,07,15,19,20,21,45,47

In table 4, the data's of different old patients from different hospitals particularly for hypertensive heart disease are collected and recorded in the database like (Patient no, Patient name, Doctor Name, Medicine prescribed) as given. So that the data's for the particular heart disease can be retrieved for analysis to prescribe the medicine for hypertensive heart disease.

Table 4: Hypertensive Heart Disease

Patient No	Patient name	Doctor's Name	Medicine code
1	A	X	03,04,09,10,12,13,16,18,39,43,44
2	B	Y	03,04,09,10,12,13,16,18,39,43,44
3	C	Z	03,04,09,10,12,13,16,18,39,43,44

In table 5, the data's of different old patients from different hospitals particularly for congestive heart disease are collected and recorded in the database like (Patient no, Patient name, Doctor Name, Medicine prescribed) as given. So that the data's for the particular heart disease can be retrieved for analysis to prescribe the medicine for congestive heart disease.

Table 5: Congestive Heart Disease

Patient No	Patient name	Doctor Name	Medicine code
1	A	X	04,08,11,14,17,25,28,30,33,42,47,50
2	B	Y	04,08,11,14,17,25,28,30,33,42,47,50
3	C	Z	04,08,11,14,17,25,28,30,33,42,47,50

In table 6, all the medicine names which are prescribed for different types of heart diseases along with their code, which are prescribed by the doctors to the patients are given in the form of database, which is used to know the medicine names for different heart disease by using the code as primary key. This table contains at least 52 different medicine names which are prescribed by the doctors for different old patients.

A. Input for the Prescription of Medicine

The diagnosed disease from the first scheme is taken as the input for the prescription of the medicine. This is the first step for the prescription of medicine.

B. Retrieve from Database

When the input is given as the diagnosed diseased the data's of that particular

disease retrieved with the details about the medicine coded as given in table 6.

These records are very useful for the doctors to prescribe the medicine. Since those medicines which are coded are given to the old patients for the heart disease.

Medicine given by the expert system like GRNN and RBF are still comparatively less. So we implement this study to prescribe medicine with more than 400 patient's information for each disease in the database.

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Table 6: Medicine Names

CODE FOR MEDICINE	MEDICINE NAME
01	Danaparoid (Orgaran)
02	Enoxaparin (Lovenox)
03	Heparin (various)
04	Aspirin CA
05	Clopidogrel (Plavix®)
06	Dipyridamole
07	Diuretics ch
08	Beta blockers CA ch
09	fosinopril(Monopril)
10	hydrochlorothiazide
11	Nitroglycerin CA
12	spironolactone(Aldactone)
13	olmesartan(Benicar)
14	Angiotensin CA
15	Inotropes ch
16	quinapril(Accupril)
17	Calcium channel blockers CA
18	diltiazem(Cardizem , others...)
19	Nesiritidech
20	Digoxin ch
21	Aldosterone antagonists

Also with the outcome of CBR and the medicine prescribed by the RBF is compared. This analyzed sample data gives higher accuracy in the medicine prescription for heart disease patients.

5. Experimental Analysis

Analysis is done for both diagnosis and prescription of medicine. If a present patient is affected by the symptoms of heart disease this ANN and CBR is used to predict whether patient is affected by the heart disease with the training sets and the type of heart disease. With the type of the heart disease medicines are prescribed with high accuracy by analyzing the results. The following analysis shows the discussion of three diseases for medicine prescription.

From the analysis of prescription of medicine, RBF is not producing the appropriate result as compared with the original medicine produced by the doctors in the database and the CBR search for the different types of heart diseases. Perhaps a patient affected with more than one heart disease, the same procedure is followed to prescribe the medicine.

The analysis shows that the prescription of medicine for the heart disease patient gives 98% accuracy with the previous old patient records and CBR similarity search technique.

CONCLUSION

The principle target of this examination is to assess the utilization of artificial neural network with Multilayer perception neural network in analysis of heart diseases. The performance of back propagation neural network with the prediction accuracy is satisfactory but to increase the level of accuracy and to know the type of heart disease the CBR technique is integrated with ANN. So the accuracy of 97% is adapted by using the old patient records. In this paper CBR is not only used to increase the accuracy but

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also to predict the type of heart disease. With this output of CBR which has not only the type of heart disease but also the medicine prescribed is used to know the medicine by comparing it with the original medicine and the medicines given by the RBF (Radial Basis Function).The medicine prescribed by the above method gives 98% comparatively.

FUTURE ENHANCEMENT

In case if any old record is not matched with the present record then expert doctor advice can be taken by certain computing methods like mobile, cloud etc.

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