Prediction of Heart Disease Using Multilayer Perceptron Neural Network

Jayshril S. Sonawane
P. G. Student
Department of Computer Engineering
S.E.S's R.C.Patel Institute of Technology Shirpur,
Maharashtra, India
Email: jayshri.sonawane@gmail.com

D. R. Patil
Assistant Professor
Department of Computer Engineering
S.E.S's R.C.Patel Institute of Technology Shirpur,
Maharashtra, India
Email: dharmaraj.rcpit@gmail.com

***Abstract*—In medical field the diagnosis of heart disease is most difficult task. It depends on the careful analysis of different clinical and pathological data of the patient by medical experts, which is complicated process. Due to advancement in machine learning and information technology, the researchers and medical practitioners in large extent are interested in the development of automated system for the prediction of heart disease that is highly accurate, effective and helpful in early diagnosis. In this paper we present a prediction system for heart disease using multilayer perceptron neural network. The neural network in this system accepts 13 clinical features as input and it is trained using back-propagation algorithm to predict that there is a presence or absence of heart disease in the patient with highest accuracy of 98% comparative to other systems. The accuracy thus obtained with this system shows that it is better and efficient than other systems.**

Keywords*— *heart disease, machine learning, Cleveland heart disease database, multilayer perceptron, back-propagation.

I. INTRODUCTION

The heart is the organ that pumps blood over blood vessels to different body parts, with adequate proportion of oxygen and other essential nutritional components that are required. The life of any organism is totally dependent of the proper functioning of the heart and if there is some problem in the pumping action of the heart, the main organs of the body like the brain and kidneys are adversely affected. If the working of the heart stops then the death of the person occurs within few minutes [1].

The term heart disease means different problems that affect the normal functioning of circulatory system, which consists of heart and blood vessels. There are different categories of heart diseases like cardiovascular disease in which the heart and blood vessels are affected and as a result of which the blood is not pumped and circulated properly throughout the body parts. In coronary heart disease the heart does not get sufficient blood that it requires because of cholesterol and fat that is deposited inside the wall of the arteries that supply the blood to heart. In myocardial infarctions which is also known as a heart attacks in which the path in the coronary artery is blocked due to the clotting of blood on the wall of the artery that supply the blood to the heart. In angina chest pain occurs due to the supply of blood that is inadequate to the heart as a result of which it does not function properly. There are also other forms of heart disease that include coronary artery disease, valvular heart disease, stroke, high blood pressure, etc [2].

The disease diagnosis process in the medical field can be considered as a decision making process in which the diagnosis of a new and unknown case is made by medical practitioner from the information that is available from clinical data and from his/her experience in clinical field. In order to make this decision making process less costly, easy, faster, more accurate and efficient, the process can be automated.

In today's world, large number of population is suffering from different types of heart diseases and the count of patients suffering and dying from these disease is increasing day by day. So there is a need of accurate and early detection of heart disease with proper and adequate treatment which can save the life of many patients. But unfortunately, due to the complicated processes and different symptoms and pathological tests the correct diagnosis of heart diseases is a difficult task and causes delay in the proper treatment. Hence, there is a need to develop the prediction systems for heart disease which can help the medical experts in the early and accurate diagnosis of heart disease.

II. LITERATURE SURVEY

The number of systems for prediction of different diseases are proposed and implemented by using different techniques and methods. George et al. have proposed decision support system for dementia patients using support vector machines to define and detect agitation transition. In this system two new SVM architectures are presented, which were applied to the detection of agitation and agitation transition. This approach gives the accuracy of 91.4%, which is higher as compared with 90.9% for the traditional SVM [3].

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The automated recognition of obstructive sleep apnea syndrome by using SVM classifier is proposed by Haitham and Alan. In this approach, for the detection of the syndrome they computed the features from the phase and magnitude of the signals obtained from thoracic and abdominal respiratory effort and evaluated the classification of whole night normal and apneic epochs. The highest accuracy of this system is 95% [4].

A system for diagnosis of heart disease that is based on support vector machine along with sequential minimal optimization algorithm is presented. In this system the network structure of Radial Basis Function is also used and it is trained using Orthogonal Least Square algorithm and applied to the dataset based on indian patients. The result shows that the SVM is equivalently as good as compared to Radial bias function in detection of heart disease with accuracy of 86.42% [5].

Tsai and Watanabe have classified myocardial heart disease from ultrasonic images by optimizing the fuzzy membership functions by using genetic algorithm based method. In this method by using the texture features obtained from ultrasonic images, the gaussian distributed membership function is constructed and the genetic algorithm based fuzzy classifier is used in classification. In this technique 96% of classification accuracy is achieved [6].

Genetic algorithm is also used in another approach by Anbarasi et al. where number of tests that are to be conducted by patient is reduced by determining the attributes that involved in the prediction of heart disease. In this approach three classifiers were used and these classifiers were fed with reduced attributes, but the system takes more time for model construction [7].

Haung and Wang have proposed a system using Support Vector Machine where feature selection and optimization of Support Vector Machine parameter is done using genetic algorithm. This system uses less number of input parameters for support vector machine and it is evaluated on 11 real world datasets with improved accuracy of 89.6% [8].

Rajkumar and Sophia have proposed the use of Data mining algorithm in diagnosis of heart disease with an accuracy of 52.33%. They have combined the ECG attributes and clinical symptoms to detect the heart disease. The algorithms used by this system are Naive Bayes algorithm, Decision list algorithm and KNN algorithm [2].

Due to the higher accuracy and learning rate the artificial neural network k(ANN) algorithms can also be used in the prediction of heart disease [9]. Kumaravel et al. have proposed automatic diagnosis system for heart diseases using neural network. In this system ECG data of the patients is used to extract features and 38 input parameters are used to classify 5 major types of heart diseases with accuracy of 63.6 - 82.9% [10].

Gudadhe et al. proposed a system to classify heart disease by using Support Vector Machine and multilayer perceptron neural network architecture. By using Support Vector Machine the database of heart disease is divided in to two classes which shows presence of heart disease or absence of heart disease with an accuracy of 80.41%, whereas the artificial neural network classifies the heart disease data into 5 with an accuracy of 97.5% [11].

III. METHODOLOGY

In the system for heart disease prediction, multilayer perceptron architecture of neural network is used. The system consists of two steps, in the first step 13 clinical attributes are accepted as input and then the training of the network is done with training data by back-propagation learning algorithm [11].

A. Multilayer Perceptron Neural Network

The multilayer perceptron neural network, as its name indicates that it is made up of multiple layers. The single layer perceptron solve only linearly separable problems but many of the complex problems are not linearly separable so to solve such problems one or more layers are added in single layer perceptron hence it is known as multilayer perceptron. Multilayer perceptron network is known as feed-forward neural network having one or more hidden layers as shown in Fig.1. They are generally used for pattern recognition, classification of input patterns, prediction based on the input information and approximation.

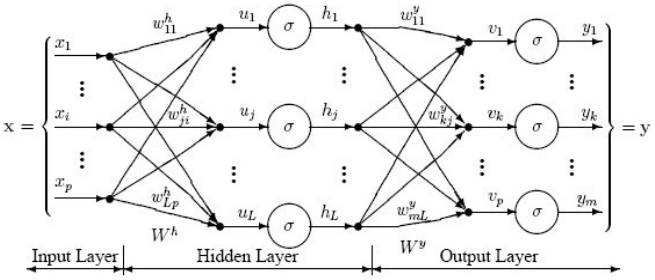

Fig. 1. Multi-layer Perceptron Neural Network Architecture [12]

It is independent of the orientation and size of the image. Color histogram is the most popular method for extracting the color information from the image. It gives the information about distribution of different colors that are present in an image. In case of digital images, histogram is the number of pixels that have colors values in each of a fixed list of color ranges that cover the image's color space. The color histogram can be built for any type of color space, but it is often used for three-dimensional spaces like RGB or HSV. In case of monochromatic images, the term intensity histogram may be used instead [1].

Above network have an input layer with three neurons, one hidden layer(in the middle) with three neurons and an output layer with three neurons [12].

- **Input Layer** - The input layer accepts the input vector (x1...xp) and standardizes the values of each variable in the range of -1 to 1. Then the distribution of these standardized values along with constant input called bias of value 1 is given to each hidden layer neurons by input layer this

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bias value is then multiplied by a weight and added to the sum that is going into the neuron.

- **Hidden Layer** - At each neuron in the hidden layer, a weight (w_{ji}) is multiplied to the value from each input neuron. Then a combined value u_j is produced by adding the resulting weighted values from each hidden layer neuron. This weighted sum (u_j) is then given to the a transfer function σ, producing the outputs of value h_j . The combined outputs obtained from the hidden layer neurons are then given to the neurons in output layer.
- **Output Layer** - At each output layer neuron weight (w_{kj}) is multiplied to the value that is obtained from each hidden layer neuron, and then a combined value v_j is produced by adding the resulting weighted values. The weighted sum (v_j) is then given to the transfer function σ , which outputs a value y_k. The y values are the outputs of the network.

B. *Back-Propagation Network*

The back-propagation algorithm is the popular algorithm for the training of the neural network. This algorithm is generally used to train multilayer perceptron and many other neural networks. In back-propagation algorithm, the output obtained is compared with the target or expected output and the error is computed. This computed error is then again given to the neural network (fed back or back propagated) and weights are adjusted using this error so that the resulting output will get closer to the target or expected output. This process is repeated for number of times such that at each iteration the error value gets reduced and the output gets more and more closer to the target or expected output. This process is known as ”training” of neural network. The algorithmic steps are as follows [13]:

1) Weights of each neuron are initialized to some random values.
2) From the set of training data receive the input signal and transmit it to hidden unit.
3) In the hidden unit calculate the net input by using the following equation:

$$z = v_{oj} + \sum_{i=1}^{n} x_i v_{ij} \quad (1)$$

where v is the bias on each hidden unit and x_i is the input signal.

4) Now compute the output of hidden unit by applying activation function over z and send it to output layer units.
5) For each output unit calculate the net input by using the following equation and then output signal is computed by applying the activation function:

$$y = w_{oj} + \sum_{i=1}^{n} z_i w_{jk} \quad (2)$$

where w is the bias on each output unit and z_j is the input signal.

6) Each output unit receives the target signal corresponding to input signal and then the error correction factor is computed using following equation:

$$\delta_k = (t_k - y_k) f'(y_{ink}) \quad (3)$$

where t_k and y_k is the target output and current output, fink is the net input to output layer.

7) On the basis on computed error weight and bias correction term between output and hidden layer unit is computed.
8) Compute the error term between hidden and input layer unit and also calculate change in weights and bias value.
9) Update the change in weights and bias on output unit and then hidden unit.
10) Repeat steps 2 to 9 until specified number of epochs is reached.

In this prediction system the Cleveland heart disease database is used to fed the input to neural network. The network is having three layers and feed forward neural network model. The back propagation learning algorithm with learning rate of momentum and adaptive learning is used to train the neural network. In the input layer of the network there are 13 neurons that accept the 13 values of clinical information from the heart disease database. The hidden layer neurons can be varied in order to reduce error and increase accuracy and the output layer consists of single neuron that indicates whether the heart disease is present or absent.

IV. EXPERIMENTAL RESULTS

A. *Data Source*

The performance of the system is evaluated on Cleveland heart disease database that was taken from dataset repository of UCI. This database consists of 303 records with each having 13 clinical attributes that include age, sex, type of chest pain, resting blood pressure, cholesterol, fasting blood sugar, resting ECG, maximum heart rate, exercise induced angina, old peak, slope, number of vessels coloured and thal respectively. In this database out of 303 records 164 belong to healthy category and 139 belong to heart disease [14].

B. *Performance Evaluation*

The system for prediction for heart disease using multilayer perceptron neural network is implemented in MATLAB R2012. In this system the database is divided in to two sets randomly that is training set and testing set. Out of total records 70% records are used for training and testing is done by using remaining 30% records. The evaluation of performance of the system is done by computing the percentage value of different

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parameters like Accuracy, Specificity and Sensitivity by using following equations [15]:

$$Sensitivity = \frac{TP}{TP + FN} X\ 100 \quad (4)$$

$$Specificity \frac{TN}{TN + FP} X\ 100 \quad (5)$$

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} X\ 100 \quad (6)$$

Where, TP = number of samples classifies as true while they were true.

TN = number of samples classifies as false while they were actually false

FN = number of samples classifies as false while they were actually true.

FP = number of samples classifies as true while they were actually false.

C. *Performance with Different Number of Neurons*

The performance with varying number of neurons of the system is shown in table I. Out of 303 instances the network is trained with 212 instances and remaining 91 instances are used for testing. The system gives the highest accuracy of 98.58% for 20 neurons in hidden layer with 1000 iterations. The different performance measures like TP, FP, TN and FN for different number of neurons is shown in table II.

TABLE I. PERFORMANCE OF THE SYSTEM WITH DIFFERENT NUMBER OF NEURONS

No. of Neurons	Acc	Sens.	Spec.	Error
5	92.92	92	93.75	7.07
10	95.75	95	96.42	4.24
15	96.69	96	98.21	3.30
20	98.58	98	98.21	1.41

TABLE II. DIFFERENT PERFORMANCE MEASURES OF THE SYSTEM

No. of Neurons	TP	FP	TN	FN
5	92	7	105	8
10	95	4	108	5
15	95	2	110	5
20	98	1	111	2

D. *Performance with Different Number of Training Epochs*

In order to compute the accuracy and performance of the proposed prediction system with varying number of epochs, the number on neurons in hidden layer is set to 5 and 212 samples are used for training and 91 samples are used for testing. Table III shows the system performance with varying number of Epochs with highest accuracy of 97.64%.

TABLE III. PERFORMANCE OF THE SYSTEM WITH DIFFERENT NUMBER OF EPOCHS

No. of Epochs	Acc	Sens.	Spec.	Error
1000	93.39	92	94.64	6.60
2000	94.33	93	95.53	5.66
3000	95.75	94	97.32	4.24
4000	97.64	98	97.32	2.35

V. JUSTIFICATION DIFFERENCE

The Decision support system for heart disease [11] classifies the heart disease data into 5 categories of heart disease with 97.5% accuracy using back-propagation algorithm. In this paper the prediction system gives the improved result with highest accuracy of 98.58% for 20 neurons in hidden layer with same Cleveland heart disease database. Decision support system with improved multilayer perceptron [16] have used improved algorithm by dividing its training dataset on multiple subsets with 82.8% accuracy with running time of 5.97s. The prediction system in this paper gives higher accuracy of 93.39% for 5 neurons in hidden layer with running time of 3.86s. This shows that the prediction system shows higher performance. The comparison of this system with other systems is shown in figure 2. The graph of accuracy verses number of neurons is shown in figure 3 and figure 4 shows the Roc curve.

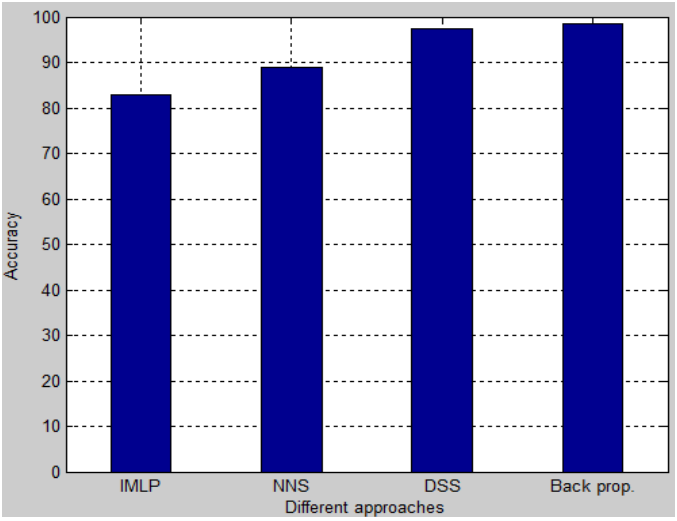

Fig. 2. Performance Comparison of Different Approaches

VI. CONCLUSIONS

In this paper a useful and accurate technique for the classification and retrieval of image by using self organizing map (SOM) is proposed and developed. In this technique the image texture is classified in two main phases, in first phase the color features are extracted and classification is done based on color features using self-organizing map. In second phase the images in each class of first phase are again classified using self-organizing map based on texture features extracted using GLCM matrix. The SOM is trained with different topology sizes and no. of iterations to improve the performance of the system. The experiments were performed on Wang's database comprising of total 1000 images including 10 categories. The experimental results show that the proposed method gives increased accuracy and improved retrieval performance for each category of the image database.

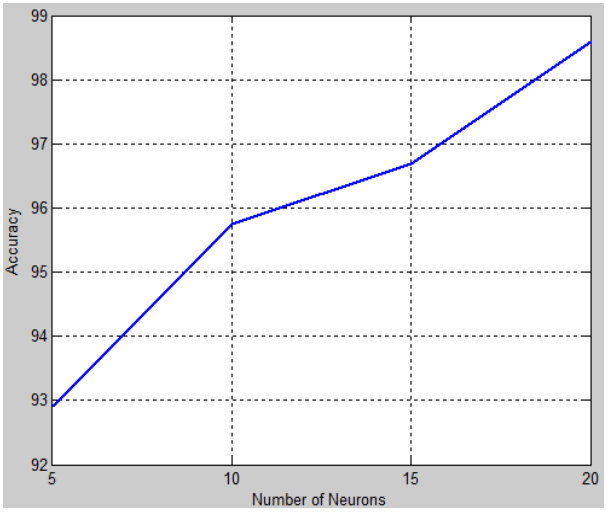

Fig. 3. Performance of System with Different Number of Neurons

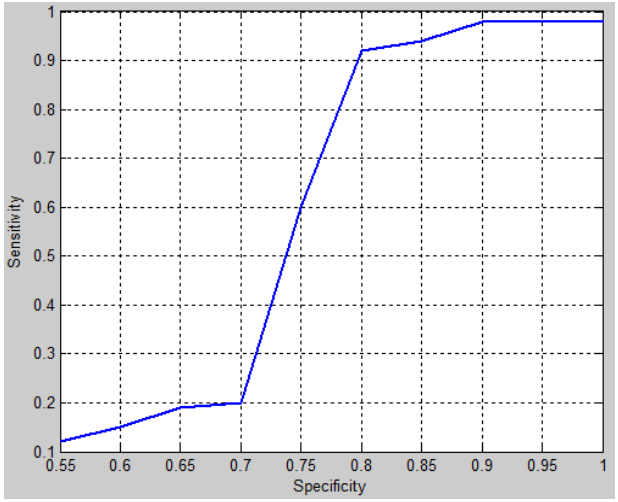

Fig. 4. ROC Curve

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