

ANALYSIS OF NEURAL NETWORKS BASED HEART DISEASE PREDICTION SYSTEM

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Abstract- Heart disease is one of the major reason for increase in the death rate. Healthcare is one amongst the most important beneficiaries of huge knowledge & analytics. Extracting medical data is progressively becoming more and more necessary for prediction and treatment of high death rate due to heart attack. Terabytes of data are produced every day. Quality services are needed to avoid poor clinical decisions that lead to disastrous consequences. The Hospitals can make use of appropriate decision support systems thus minimizing the cost of clinical tests. Now-a-day hospitals employ hospital information systems to manage the patient data. Enormous amount of data generated by health care industry is not effectively used. Some new approach is necessary to decrease the expense and to predict the heart disease in an easy. The objective of this paper is to analyze various research works done on heart diseases prediction and classification using various machine learning and deep learning techniques and to conclude which techniques are effective and accurate. (*Keywords-Heart disease prediction, Data mining, Machine Learning, Neural Network, Deep Learning*)

I. INTRODUCTION

Mortal rate in India increases due to the Non-communicable diseases. Data from various health organizations like World Health Organization and Global Burden of Disease (GBD) reported that cardiovascular diseases account for death and disability in most cases.

Based on the latest statistics done by World Health Organization (WHO), over 37% of world deaths are caused by cardiovascular disease. In this twentieth century, cardiovascular diseases cause more than 10% of all deaths throughout the world. The predictions results show that by 2030, cardiovascular diseases will increase the death rate in the world [1]. With advancement in technology, huge amount of medical is generated. This could be considered as the leading cause for rising inclination towards the usage of data mining in this research field.

Health care research is tremendously increasing to identify the ways to reduce the death rates. There are numerous diseases which are the major reason for high death rates; one among them is the heart disease which is caused due to various reasons. The proposed system aims to predict heart disease accurately than other systems. The treatment for heart diseases are lagging due to several silent symptoms. Monitoring the health condition using the data collected from various resources supports to predict the health condition of the patients and to take appropriate measures. Health care is facing the issue of predicting and diagnosing the disease. Disease diagnosis is an extensive task, which needs more accurate results. Hence its automation would be highly beneficial [2].

The major issue is information overloading. Data mining technique is adapted to predict heart disease and helps the doctors to take appropriate decisions and treat the disease. Predicting heart disease by applying data mining algorithms such as Artificial Neural Network (ANN), regression, clustering and classification are widely used. The mining should be more accurate with the redundant, incomplete and multi attribution of data. Data mining is a process to extract the data patterns using intelligent methods from the large amount of data. The medical data available in the repository turned into meaningful information by applying data mining approaches. The gained information in medical data set is used to predict the chance of heart disease. As a result, data mining helps to achieve the natural evolution in the medical field. Most popularly used techniques such as machine learning, neural network and deep learning for diagnosis of heart diseases are briefly described in the subsequent section.

A. Machine Learning

Due to the drastic boom in the computing technology machine learning has become a current buzz. Analytical models are automated with the method of machine learning. A machine learns and adapts from learning.

Machine learning helps computers to learn and act accordingly without explicit program. It helps the computer to learn the complex model and to predict the data as shown in Fig.2. Machine learning has the ability to calculate complex mathematics on big data. The independent adaption to new data is achieved through an iterative aspect of machine learning [3]. Machine learning helps to analyze huge complex data accurately. The machine learning based heart disease predicting systems will be precise and will reduce the unknown risk. The machine learning technique will stick on to different approaches to build different models relying upon the sort of information concerned.

The value of machine learning technology is recognized well in Health care industry which has a large pool of data. It helps medical experts to predict the disease and lead to improvise the treatment.

B. Artificial Neural Network

It is a multi-layer network containing input, hidden and output neurons as mentioned in the Fig.1. It is a computing system that performs the task similar to the working of brain. ANN solves the problem as like a human brain. The collection of nodes connected in a network transmits a signal and process the artificial neurons [4]. The activation node contains weight values. A neural network is trained to teach the problem solving technique to the network using training data.

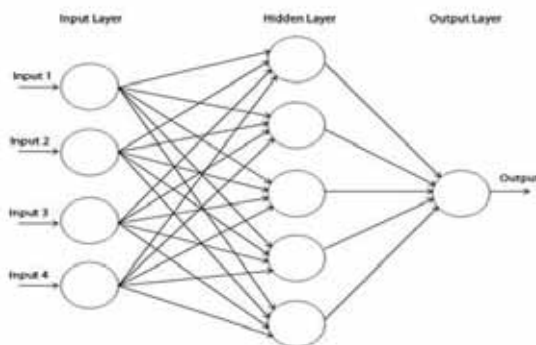


Fig. 1. Artificial Neural Network

During training the neural network is validated to stop when it is over fitting in the network and to check the performance of the ne

C. Deep Learning

System that makes its own decision based on intelligence is highly needed in today's life. The breakthrough is one of the biggest defeats in an artificial neural network which becomes a major reason for arise of the new approach called deep learning. The new approach arises from machine learning to meet the inner goals of Artificial intelligence [3].The world needs a deep learning system which thinks like a neo-cortex. Various types of patterns are learned by the system from the training samples are used for prediction and classification in accordance with the real sense. To train large neural network,

deep learning is the best situated approach. Deep learning approach gives better performance than any other approach when considering the massive amount data. The advantage of deep learning is that it allows automatic feature extraction and makes the feature learning easier. This approach helps to discover the structure in the data. The problem in unsupervised and supervised learning is tackled with the help of deep learning algorithm.

II. OVERVIEW OF HEART DISEASE

Health care researcher's addresses that the risk of heart disease is high and it changes the life of the patients all of a sudden. There are various causes for heart disease and some of them are due to change in lifestyle, gene, and smoking. Numerous variations of genetic will increase the heart disease risk. The heart disease treatment such as cholesterol-lowering drugs ,insulin and blood pressure medications are started once the accurate prediction of heart disease is made. Predicting a disease is not an easier task. The accurate prediction of heart attack needs a constant follow up of cholesterol and blood pressure for lifetime. A foundation of plaques that cause heart attack need to be identified which is much more sensitive to the patient. The health care industry investigates various researches in the detection of heart disease.

TABLE I. HEART DISEASE FACTORS WITH SYMPTOMS

Heart Disease -Risk Factors	Heart Disease- Symptoms
Age	Discomfort, pressure or heaviness,
Sex	Pain in the chest or arm, or below the breastbone.
Family History	Discomfort burning to the back, jaw, throat, or arm.
Smoking	Fullness, indigestion, or choking feeling.
Poor Diet	Sweating, nausea, vomiting, or dizziness.
High Blood Pressure	Extreme weakness, anxiety, or shortness of breath.
High blood cholesterol level	Rapid or irregular heartbeats
Diabetes	
Obesity	
Physical inactivity	
Stress	
Poor hygiene	

TABLE II. HEART DISEASES TYPES

Heart Disease Types	Description
Coronary heart disease	Block in the coronary blood vessels, which leads to the reduction in supply of blood and oxygen to heart.
Angina pectoris	Chest pain will occur due to the insufficient supply of blood to heart.
Congestive heart failure	Heart is not able to pump enough blood.
Cardiomyopathy	Weakening or a change in the heart muscle.
Congenital heart disease	Defect in the structure of the heart or its functioning, leading to abnormal formation of heart.
Arrhythmias	Disorder in the rhythmic movement of the heartbeat.
Myocarditis	Inflammation of heart muscle by viral, fungal, and bacterial infections affecting the heart

The problem in functioning of heart, due to various conditions is termed as a heart disease. Some of the common heart disease are Cardiac arrest, Arrhythmia, Stroke, Congestive heart failure, Coronary artery disease and Congenital heart disease [5]. The symptoms to predict a heart disease depends upon the types of heart disease. Each type will have its own symptoms. Example, chest pain is one of the symptoms for coronary artery, but all people would not have the same symptom. Some may have a different symptom like indigestion. The doctor confirms the heart disease with the diagnosed report of the patient and various other parameters. Some of the most common heart disease symptoms and its types are listed in the Table I and Table II.

III. DATA SOURCE

The publicly available Cleveland [6] and Statlog [7] heart disease databases from UCI Repository are used. They consists of 303 records and 270 records respectively.

The data set contains 3 different types of attributes:

- Input attributes
- Key attribute
- Predictable attribute

TABLE III. DATASET DESCRIPTION

Input Attributes	Key Attributes	Predictable Attribute
1.Age (in years)	Patient_ID: Patient's Identification Number	Diagnosis: Value 1 = < 50 % (no heart disease) Value 0 = > 50 % (heart disease)
2. Sex (value 1: Male; value 0 :Female)		
3. Chest pain type (value 1:typical type 1 angina; value 2 : typical type angina; value 3: non-angina pain; value 4 : asymptomatic)		
4. Resting blood pressure (mm Hg on admission to the hospital)		
5. Serum Cholesterol in mg/dl		
6. Fasting blood sugar (value 1: > 120 mg/dl; value 0 :< 120 mg/dl)		
7. Resting Electrocardiographic results (values 0:normal;value1: 1 having ST-T wave abnormality; value 2:showing probable or definite left ventricular hypertrophy)		
8. Maximum heart rate achieved		
9. Exercise induced angina (value 1:yes; value 0 : no)		
10. Old peak = ST depression induced by exercise relative to rest		
11. The slope of the peak exercise ST segment (value 1: unsloping; value 2 : flat; value 3 :down sloping)		
12. Number of major vessels coloured by fluoroscopy (value 0-3)		
13. Thal (value3 = normal; value 6 = fixed defect; value 7 = reversible defect)		
14.Obesity		
15.Smoking		

Most of the research papers considered above thirteen input attributes for Heart disease prediction. Additional two more significant attributes, obesity and smoking can also be included as input attributes to get more appropriate results. The Input attributes, Key attribute and Predictable attribute of the heart disease are listed in Table III.

IV. RELATED WORK

Some of the research works done on predicting the heart disease by employing data mining techniques and other Artificial Neural Network are deliberated in the following section:

A. Heart Disease Classification Using Neural Network and Feature Selection [2011]

In this work [8], classification using Multi-Layer Perceptron (MLP) with Back Propagation algorithm is proposed to predict the heart disease. To select the more relevant features from the patient dataset, Information gain is used as a feature selection technique with the biomedical test data values to diagnose heart disease with a reduced number of attributes. They used ANN without the information gain based feature selection technique. They obtained accuracy 88.46% and 80.17% for training and validation set. Then they have applied ANN with Information gain. Experimental results reveals that the accuracy is increased by 1.1 % for the training data set and 0.82% for validation data set.

B. Intelligent and Effective Heart Attack Prediction System Using Data Mining and Artificial Neural Network [2011]

Weighted Associative Classifier (WAC) [9] is propounded to predict the existence of patients heart disease.They implemented a GUI Interface to enter the patient records. They have taken 13 attributes and 303 records of data for training and testing. The author has incorporated a little modification in the dataset. They have chosen 2 class labels(0/1).If the class label is '1' then, the patient is having heart disease; else, they are not having heart disease.In this work, a new technique of WAC has been proposed to arrive at the essential rule instead of flooding with insignificant relation. From the results, it is observed that WAC surpasses other classifiers like CMAR, CBA and CPAR in average accuracy. WAC classifier obtained an accuracy of 81.51%.The support and confidence value are 25% and 80% respectively.

C. Innovative Artificial Neural Networks-Based Decision Support System for Heart Diseases Diagnosis[2013]

ANN based innovative decision support system was implemented to predict the heart disease [10]. Three types of heart diseases, such as Mitral stenosis (MS), Aortic stenosis(AS) and Ventricular septal defects (VSD) are considered. The proposed ANN based system consists of two parts such as hardware and software. Heart sound is gathered using the hardware components like stethoscope, sound cable and microphone. Fast Fourier transform is applied to extract the main sound features. The sound collected by stethoscope is of low amplitude level. Hence a microphone is inserted between the stethoscope and the PCI card which amplifies the

sound waves. The software part is implemented using Matlab and ANN toolbox. The proposed intelligent system is built using Neural networks toolbox. It makes use of many real medical data to examine the accuracy and performance. The results yields a classification accuracy of 92%. The proposed system is well suited for both valvular and non-valvular diseases. The results obtained by the work shows that the proposed system identifies MS, AS and VSD heart disease types successfully and accurately.

D. Heart Disease Classification Using PCA and Feed Forward Neural Networks [2013]

The main goal of the proposed work [5], is to extract essential information from the heart disease dataset. Principal Component Analysis(PCA) and regression techniques are used for the feature selection. From the results it is observed that the regression techniques achieved the prediction accuracy of 92.0%. Feed forward neural network classifier achieved 95.2% accuracy.

E. Diagnosis of heart disease using neural network approach [2014]

In this work [4], the diagnosis of heart disease using Multi-layer Perceptron Neural Network with Back-propagation is suggested to classify the heart disease of the patients with 13 attributes. Firstly, they have collected dataset in order to create a structured database system. Then data preprocessing is applied to clean the data. It removes the duplication features, and filling the missing values with domain value. The Experimental results shows that the proposed approach obtained 94% accuracy.

F. Heart Diseases Diagnoses Using Artificial Neural Network [2015]

The work done [11] choose Feed-forward back propagation neural network for classifying the presence and absence of heart disease in human. Neural Networks consists of 13 input layers, 20 hidden layers and 1 output layer. They have considered the data from UCI machine learning repository. The dataset is separated into two categories such as input and target. The input and target samples are splitted randomly. They have considered 60 % of training dataset, 20% of validation dataset, 20% of testing dataset. Training dataset is presented to the network and the network's weights and biases are adjusted according to its error. The presence and absence of the disease is known with the target outputs, 1 and 0 respectively. From the results, it is inferred that, the proposed work obtained 88% accuracy.

G. Heart Attack Prediction System using Cascaded Neural Network[2013]

The cascaded correlation neural network is elucidated for the prediction of heart disease [2]. The proposed work takes a total of 270 data samples among which 150 are taken for training data samples and the rest for testing data samples in order to simulate the network architecture. The proposed work has 13 input neurons and 1 output neuron. In case of ANN with back propagation algorithm, the training set accuracy is

72.6% and for testing it is 79.45%. CNN obtained 78.55% accuracy for training and 85% accuracy for testing. Experimental results proves that the accuracy of the CNN increased 5% than ANN. Based on the performance analysis, time complexity of the Cascaded Correlation Neural Network takes minimum amount of time for predicting heart diseases when compared to ANN.

H. Heart Diseases Diagnosis Using Neural Networks Arbitration[2015]

In [12], 270 samples are taken and is splitted into training and testing dataset. The division ratio is 60: 40 i.e 162 as training and 108 as testing dataset. The output of the neural network is set as (0 1)- heart disease is present,(1 0)- heart disease is not present. The Intelligent System is built using feed forward multilayer perceptron and support vector machine. For the above the results obtained are 85% and 87.5% respectively.

I. Diagnosis of heart disease based on Meta heuristics algorithms and clustering methods [2016]

In[1], UCI dataset is used to evaluate the heart attack. The dataset includes test results of 303 people. The dataset used in the proposed work contains two classes, one class for healthy people and the other for people with heart disease. In the proposed work, binary cuckoo optimization algorithm (BCOA) is used for feature selection and SVM is used for constructing the model. The final model of the work has 84.44% accuracy, 86.49% sensitivity and 81.49% specificity.

J. Deep Learning Approach for Prediction of Heart Disease Using Data mining Classification Algorithm Deep Belief Network (2017)

The proposed work [3], utilizes Deep Belief Network for predicting the likelihood percentage of heart disease in human. It has been designed in the MATLAB 8.1 development environment. The proposed work is compared with CNN. Results yields 90% of accuracy in the prediction of heart diseases whereas CNN achieves only 82% of accuracy, thus enhancing the heart disease prediction.

K. Improving the Performance of Entropy Ensembles of Neural Networks (EENNS) on Classification of Heart Disease Prediction (2017)

In [13], Entropy Ensemble of Neural Networks with Recursive Feature Elimination (EENNRFE)algorithm is used for feature extraction. They have used Cleveland dataset from UCI repository. Feature selection is prime to remove redundant and irrelevant features. Noisy and irrelevant features are identified and those features having the correlation coefficient among each pair of the remaining features less than a pre-determined threshold are eliminated. In addition the work proposes a new method for training of Artificial Neural Networks (ANNs) by measuring the computation of an objective function with arithmetic mean of an ensemble of chosen randomly created NNs, and applies the EENN classifier to the heart disease classification problem. The obtained accuracy for the training data is 85.66%.

TABLE 4: PERFORMANCE ANALYSIS OF HEART DISEASE PREDICTION USING MACHINE LEARNING AND DEEP LEARNING TECHNIQUES

Author	Techniques Used	Evaluation Metrics
Khemphila & Boonjing (2011)	Feature Selection: Information Gain Classification: Multi-Layer Perceptron (MLP) with Back-Propagation learning algorithm	Accuracy: Training:89.56% Testing:80.99%
Soni et al. (2011)	Feature Selection: Decision Tree Classification: Weighted Associative Classifier	Accuracy:81.51% Support:80% Confidence:25%
Ghwanmeh et al. (2013)	Feature Selection: Fast Fourier Transform Classification: Artificial Neural Network	Accuracy:92%
Santhanam & Ephzibah (2013)	Feature Selection: Principal Component Analysis and Regression Classification: Feed forward neural network	Accuracy : Regression: 92.0% Feed forward neural network: 95.2%
Sayad & Halkarnikar (2014)	Classification: Multi-Layer Perceptron with Back-Propagation learning algorithm	Accuracy:94%
Ajam (2015)	Classification: Feed-forward back propagation neural network	Accuracy:88%
Chitra & Seenivasagam (2013)	Classification: Artificial neural network with Back Propagation Network Cascaded Correlation Neural Network	Accuracy with ANN: Training :72.6% Testing :79.45% Accuracy with CNN: Training:78.55% Testing: 85%
Olaniyi et al. (2015)	Classification: Feed forward multilayer perceptron, Support vector machine	Accuracy: Training: 85% Testing:87.5%
Roostae & Ghaffary (2016)	Feature selection: Binary cuckoo optimization algorithm (BCOA) Classification: SVM	Accuracy:84.44%
Karthikeyan & Kanimozhi (2017)	Feature selection: Convolutional Neural Network Classification: Deep Belief Network	Accuracy:90%
SilviaPriscila & Hemalatha (2017)	Feature selection: Entropy Ensemble of Neural Networks with Recursive Feature Elimination Classification: Support Vector Machine with Recursive Feature Elimination (SVM-RFE).	Accuracy:85.66%
Kim et al. (2017)	Classification: Deep belief Network	Accuracy:83.9%

L. Statistics and Deep Belief Network-Based Cardiovascular Risk Prediction[2017]

In this paper [14], author has considered the sixth Korea National Health - Nutrition Examination Survey dataset to predict cardiovascular diseases. To extract the features, statistical analysis is used. Deep belief network is developed for the cardiovascular risk prediction. The proposed prediction model obtained 83.9% accuracy.

V. DISCUSSIONS

This paper investigates about the several research works carried out in the field of data mining, machine learning and

Deep learning techniques to predict and classify the cardiovascular diseases. Most of the research works used classification methods such as Association rule mining, Naive Bayes, Decision tree, artificial neural network and fuzzy logic for predicting heart diseases predicting system. Feature selection can significantly improve the classification accuracy. [15] Feature selection is a vigorous task because the relevant, redundant and irrelevant features may work together with other features. From the experimental results, it is inferred that the performance of the classifier is improved with the Feature subset selection. The feature selection task is still challenging due to the large search space. It increases exponentially according to the number of available features. Therefore, an extensive search is not possible in most situations. To resolve this issue, various search techniques are employed to feature

selection, such as greedy search based sequential forward selection and sequential backward selection [15] [16].

Feature subset selection suffers from local optima and high computational cost. In order to resolve the issue in feature selection an efficient global search technique is required. In recent times, apart from analyzing the commonly used data mining techniques, some of the recent research works have used evolutionary algorithms for finding optimal solutions [17] [18]. But the limitation of the technique is, the time taken to train the model is high. Furthermore, it is important in finding the relevant subset of features.

Neural Network is a training method which works similar to the human brain and it is an effective technique for predicting the relationship between both the input and output values. [19] In addition, it is a predictive model for supporting a back propagation algorithm which helps in classification, prediction, and inference sequential reasoning. Neural Network predicts cardiovascular disease at an early stage. The prediction of heart disease using Neural Networks are trained and tested with a large dataset [20]. Applying machine learning techniques on medical data helps to predict the disease accurately. Deep learning technique is necessary to process the vast and complex data in the medical field. However, cardiovascular disease risk can be predicted using various techniques such as machine learning, evolutionary algorithm and hybrid techniques. Existing techniques for predicting and classifying cardiovascular disease are time consuming. From the results it is realized that artificial neural network will provide better performance of heart disease prediction from huge amount of medical data.

VI. CONCLUSION

The recent statistics from the WHO report shows that 17.7 million people every year people die due to cardiovascular diseases, (31% of global deaths) [20] [21]. In 2017 nearly 6, 16,000 deaths have been encountered due to heart disease. Hence the need for an efficient and accurate prediction of heart disease is on high demand. This paper deals with various techniques involving the feature selection and classification of the heart diseases resulting in accurate prediction. New algorithms and techniques involving ensemble methods involve multiple learning algorithms and hybrid systems that use the combination of Artificial Intelligence methods and techniques provides better accurate results. The future is expecting the usage of the above techniques for eliminating the existing drawbacks and improving the prediction rate thus providing a way for improving the survival rate for the well-being of mankind.

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