International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-11 Issue-1, October 2021

Deep Convolutional Neural Network Feed-Forward and Back Propagation (DCNN-FBP) Algorithm for Predicting Heart Disease using Internet of Things

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Abstract: ***In recent years, due to the increasing amounts of data gathered from the medical area, the Internet of Things are majorly developed. But the data gathered are of high volume, velocity, and variety. In the proposed work the heart disease is predicted using wearable devices. To analyze the data efficiently and effectively, Deep Canonical Neural Network Feed-Forward and Back Propagation (DCNN-FBP) algorithm is used. The data are gathered from wearable gadgets and preprocessed by employing normalization. The processed features are analyzed using a deep convolutional neural network. The DCNN-FBP algorithm is exercised by applying forward and backward propagation algorithm. Batch size, epochs, learning rate, activation function, and optimizer are the parameters used in DCNN-FBP. The datasets are taken from the UCI machine learning repository. The performance measures such as accuracy, specificity, sensitivity, and precision are used to validate the performance. From the results, the model attains 89% accuracy. Finally, the outcomes are juxtaposed with the traditional machine learning algorithms to illustrate that the DCNN-FBP model attained higher accuracy.***

Keywords : Deep Convolutional Neural Network, Internet of Things (IoT), Wearable devices, Heart disease.

I. INTRODUCTION

One of the major health risks faced by humans is heart disease and among the chronic diseases, it is considered as the most universal [11,13]. Meenakshi Mission Hospital and Research Centre reported that past 25 years India has seen a 50% rise in heart disease accounted for 28.1% of all deaths and globally accounting for 31% of deaths. Nowadays, in India people move on to a lifestyle close to the western lifestyles, creating a breach in health.

In cities, people engaged in a diet consisting of high-calorie and low-nutrient foods. This results in many chronic diseases like cardiovascular disease and cancer. In addition to the diet, tobacco, and alcohol usage is also one of the risk factors.

Any factor that influences the normal functioning of heart disease is called heart disease [18]. Symptoms of heart disease are chest discomfort, nausea, heartburn, pain in arms, dizziness, light-headedness, pain in the throat or jaw, easily exhausting, snoring, sweating, continuous coughing, swollen legs, feet, or ankles, irregular heartbeat. They are caused mainly by the blood vessels and the narrowed, blocked, or stiffened blood vessels prevent the supply of blood to the heart and any parts of the body [25]. To diagnose heart disease physicians used angiography, which is the most common method [6]. Therefore, it is necessary to analyze the cardiovascular disease parameters and consult doctors.

To identify the severity of heart disease and to diagnose it earlier screening process is needed. During the screening process, various tests like ECG or EKG, blood glucose level test, Echocardiography, blood pressure, CT scan, MRI, stress test, etc., are conducted by doctors. But this process is labor-intensive and time-consuming. Thus, automated systems are required to identify heart disease naturally. Several researchers had developed many techniques such as data mining, machine learning, deep learning, and Artificial Intelligence (AI) techniques to diagnose heart disease [34]. However, those methods didn't work well with large amounts and streams of data. These systems fail to analyze big data and leading to complex systems and leads to a loss of efficiency. So, in this proposed work, to handle massive amounts of data deep learning methods are used.

Because of the large development in wireless sensor computing, the Internet of Things is broadly utilized in numerous areas. IoT technologies provide versatile and less expensive sensor devices to reach the objectives. In health care applications, it plays a crucial role. In this work, to collect the patients' vital signs IoT devices are used. Sensors such as a temperature sensor, blood pressure sensor, heartbeat sensor, etc., are used. These sensors produce massive amounts of data. The characteristics of these data are high volume, velocity, and variety. Hence innovative computing models are needed for effective mining of huge information from these data.

II. RELATED WORK

Various approaches are proposed by many researchers in recent years using IoT technologies in medical areas. Many efforts have been proposed to monitor the patients remotely and predict the diseases at the right time. In [35] probabilistic data collection mechanism is proposed. The collected data are analyzed using correlation analysis.

Manuscript received on October 18, 2021.
Revised Manuscript received on October 27, 2021.
Manuscript published on October 30, 2021.

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The most correlated patient's future health conditions are foreseen using a stochastic prediction model. Analysis times are reduced because of excessive utilization of bandwidth. Ed-daoudy et al [44] applied machine learning, particularly decision tree to predict the health status of the patients. In [4] KNN is used to diagnose a heart condition, [5] used SVM to classify the data. M. Baig [50] used clustering techniques to monitor the vital signs of elder people using wearable medical sensors. The author proposed a fuzzy logic, but it takes more time to process. Applying multiple algorithms is used by many researchers to increase accuracy. In [37] the author applied a rotation forest ensemble classifier. In this paper, feature extraction is done by using correlation-based feature selection. Austin et al., [12] applied the random forest technique with high sensitivity. Santhanam et al [42] proposed a genetic-fuzzy model with an accuracy of 86%. Orthogonal Local Preserving Projection (OLPP) and Gravitational Search Algorithm (GSA) with Levenberg-Marquardt are developed in [43] In optimization problems, when there is a large search space, searching optima is very hard. Tingxi et al [20] compared various clustering approaches analyzing their time complexities depending on swarm intelligence. PSO and Bat approach works faster than others. In [40] PSO techniques and randomly generated rules with some encoding techniques are proposed. For feature selection, Binary Cuckoo Optimization Algorithm is used in [38], and for classification, the SVM algorithm is used. Using Data mining techniques in health care areas took more processing time with less accuracy. Therefore, Neural Networks are used, and it is considered as one of the best tools for the prediction of chronic disease. In [44] Multi-Layer Perceptron with Back Propagation algorithm is used. In this paper, for feature selection information gain is used. Soni et al., in [45] Weighted Associative Classifier (WAC) technique is proposed to predict heart disease and the results showed that WAC outperforms other classifiers like CMAR, CBA, and CPAR. ANN is used in [48] and in [15] for feature selection they used Principal Component Analysis and regression techniques with feed-forward neural network classifier. Ajam [46] proposed Artificial Neural Network with Feed-forward back propagation neural network for classifying heart disease. A Cascaded Correlation neural network is proposed in [47].The proposed work on [41] Deep Belief Neural Network (DBNN) is proposed for predicting heart disease and the work is compared with convolutional neural network (CNN). Results show that DBNN yields higher accuracy than CNN. [39] used Artificial Neural Network to train the classifier by calculating objective function with an arithmetic mean of randomly created neural networks and the Entropy Ensemble of Neural Networks are applied to classify the heart disease.

III. METHODOLOGY

A. Deep Convolutional Neural Network Feed-Forward and Back Propagation Algorithm (DCNN-FBP):

Past few decades, researchers developed an interest in neural networks and used them in various areas like medical, engineering, marketing, retail and sales, banking, and finance, etc. Neural Network is a model or system that consists of various functionality, and it works like a human brain. It is a non-linear and adaptive system that performs certain functionality, i.e., mapping input to output by learning from the data. Various neural networks are used in medical decision-making. Convolutional neural networks are effective because they discover the important features instantly without any human interception. It also performs parameter sharing and enables CNN to run on any device. It works well on a relatively large dataset. Convolutional neural networks are a class of deep learning which widely used in applications such as image and video analytics, medical data analysis, natural language processing, etc., And it is supervised learning where the networks are trained with a dataset to produce the desired response. CNN is a computational model comprising multiple nodes that perform complex functions effectively. These nodes are arranged in layers and each layer performs some operations. Generally, the CNN network consists of a convolutional layer, pooling layer, fully connected layer. In the convolutional layer, for the given input data, the output can be calculated by computing linear convolution operation. The Pooling layer is used to decrease the dimensions of the input layer. The fully connected layer calculates the final output. The overview of DCNN-FBP is shown in Figure 1.

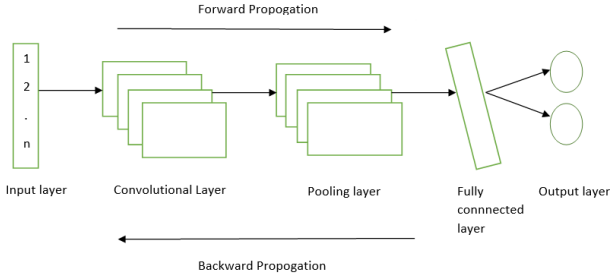

Fig. 1.Overview of dcnn-fbp

The feed-forward computation algorithm consists of two steps. In the first step, the values from the input layer are pushed to the nodes in the hidden layer. In the hidden layer, the values are multiplied by the weights and the bias. Various functions are proposed like sigmoid, tanh function, etc., After the hidden layer values are calculated, the values are propagated to the output layer. And the Back Propagation algorithm is worked as follows: After the computation of the feed-forward network, the algorithm is propagated to the output layer and then to the hidden layer. Then weight updating is performed. The algorithm stops when the error function values become sufficiently small.

IV. PROPOSED SYSTEM

Sensor nodes are positioned on the human body as small patches and these kinds of sensors are called wearable sensors. These sensors are embedded under the skin to measure vital signs and operate within the wireless communication network. Vital signs such as blood pressure, temperature, sugar level, humidity, and heart activity are captured and transmitted. Thereupon the collected data is directly communicated through Bluetooth to the personal server. The architecture of the proposed system is shown in Figure 2.

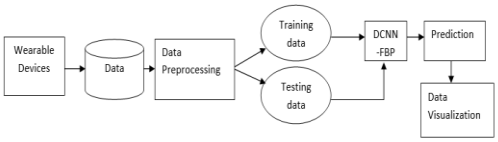

Fig. 2.Proposed System Architecture

In this model, UCI machine learning datasets are used. Initially, the data are normalized.

$$x_{norm} = \frac{x-\bar{x}}{\sigma} \quad (1)$$

where x is the input, $\bar{x}$ is the mean and σ is the standard deviation After the data are normalized, the data are given to the convolutional layer. The convolutional layer applies filters and large input is convolved into the small matrix. In this model, kernel size is used as a filter and the size is 16. The results are given to the pooling layer. The max-pooling layer is proposed where the highest values are collected from each of the matrices and a small matrix is created. The result is given to the fully connected layer. Here the activation function is proposed to classify heart disease. SoftMax is used as an activation function and it can be calculated as,

$$y = \frac{e^{z}j}{\sum_{k} e^{z}k} \quad (2)$$

A. Training the networks

The data set is divided into 70% training set and 30% testing set. The deep convolutional neural network can be trained by using Feed-Forward and Back Propagation algorithms as follows:

B. Feed-Forward Neural Networks

The typical neural network consists of an input layer, a hidden layer, and an output layer. Each layer consists of nodes associated with it. These nodes are connected to the nodes present in adjacent layers. Each node is associated with weight. In our proposed model, 1 input layer, 2 convolutional layers, 2 pooling layers, 1 fully connected layer, and an output layer are used. Random numbers in the range of (-0.5-0.5) are assigned as weights so that the weights (w) are easily adjusted back. For every data in the training set, the output can be calculated as,

$$Op = \sum_{i=1}^{n} y.w + b \quad (3)$$

where n is the number of layers and b is the bias

C. Back Propagation Neural Networks

Back propagation neural networks are applied to minimize the error between actual and observed outputs. For that difference between the actual output and observed output is calculated.

$$Error = Ap\text{-}Op \quad (4)$$

If the error value is varied high, then the observed output value should be reduced. This can be accomplished by altering the weights by

$$w = w+lr\times x\times Error \quad (5)$$

where lr is the learning rate and it's a constant value range between 0 and 1 and the computation continues for all the elements in the training set.And the updated weight is propagated back to the layers. It propagated to the 1st layer and feed-forward propagation takes place. The feed-forward and the backward processes are repeated until the error values are minimized.

V. EXPERIMENTS AND RESULTS

A. Dataset

UCI Machine Learning Repository datasets are used for training and testing the model. Initially, data preprocessing on the data set is carried out to handle the missing values. Missing values are replaced with the value -1 to reduce the impact on the algorithm. It consists of 75 attributes total of 303 patients. Optimal features are selected to predict heart disease and they are described in Table 1

TABLE I. OPTIMAL FEATURES USED FOR THE PROPOSED MODEL

S. No	Clinical Features	Description	Values
1	Age	Patients Age	In years
2	Sex	Patients Sex	1 -> Male 2-> Female
3	Cp	Chest Pain Type	1-> Typical type1 Angina 2-> Typical type Angina 3-> Non-Angina Pain 4->Asymptotatic
4	Trestbps	Resting blood pressure	Mm hg
5	Chol	Serum cholesterol	Mg/dl
6	Fbs	Fasting blood sugar	1->greater than 20 2->less than 20
7	Restecg	Resting cardiograph results	0->normal 1->abnormal(ST-T wave) 2->left ventricular hypertrophy
8	Thalach	Maximum heart rate achieved	Number
9	Exang	Exercise-induced angina	1->yes 0->no
10	Oldpeak	ST depression induced by exercise relative to rest	-
11	Slope	The slope of the peak exercise ST segment	1->unsloping 2->flat 3->down sloping
12	Ca	Number of major vessels colored by fluoroscopy	0-3
13	Thal		3->normal 6->fixed defect 7->reversible defect
14	Result	Predicted value	1->no heart disease 0->heart disease

B. Parameters

All the parameters in DCNN-FBP algorithms are initialized randomly and they are updated iteratively according to the feed-forward and back propagation processes. Parameters used in DCNN-FBP are shown in Table 2.

TABLE II. PARAMETERS USED IN DCNN-FBP

S. No	Name	Values
1	Batch-size	50
2	Epochs	200
3	Learning_rate	0.001
4	Activation function	Sigmoid
5	Optimizer	Adam

C. Performance Evaluation

Metrics like accuracy, sensitivity, specificity, and precision are measured to assess the performance of the system. Figure 3 shows the comparison between the learning rate and the accuracies achieved for various learning rate values. From the results, 0.01 learning rate achieved high accuracy.

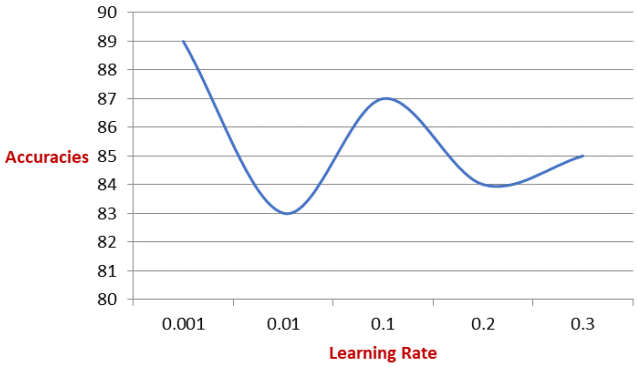

Fig. 3.Learning rate vs accuracies

Figure 4 shows the comparison of epochs with accuracy. For various numbers of epochs, accuracies are compared. From the results when the epoch numbers increase accuracies will also increase

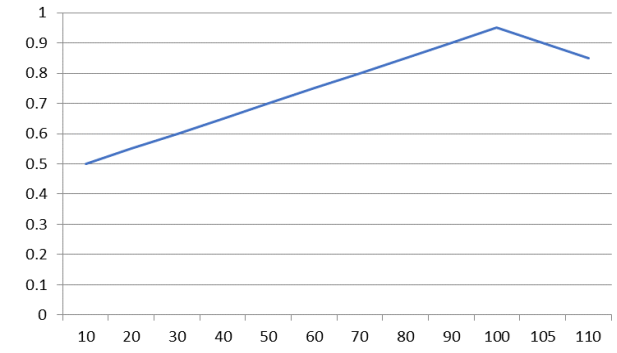

Fig. 4.Number of epochs vs accuracies

Various machine learning algorithms are compared with the proposed system. Fig 5 shows the performance comparisons of various algorithms with our proposed algorithm. From the result, it is shown that the proposed model shows higher performance

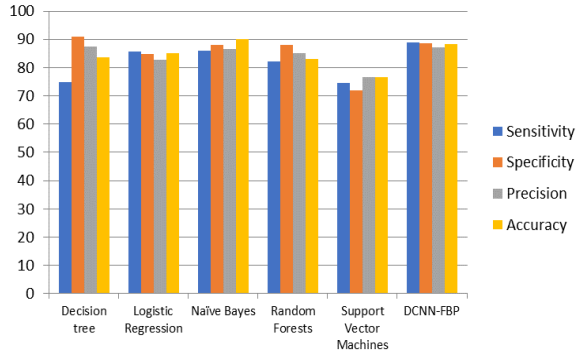

Fig. 5.Performance Comparison with other algorithms

VI. CONCLUSION AND FUTURE WORK

To generate efficient classification rules, the neural network approach is used. Medical data are classified using a neural network and it is trained by a convolution algorithm. For effective prediction Forward and Back Propagation algorithms, are introduced. Heart Disease dataset has experimented with deep convolutional neural network-Forward Back Propagation(DCNN-FBP) Algorithm. The proposed algorithm is compared with machine learning algorithms. The results insist that the DCNN-FBP algorithm achieved high accuracy compared with others.

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