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Diagnosis of Diabetes Using Convolutional Neural Network

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Abstract— Modern society because of their life style is always prone to imbalanced metabolism disease called diabetes. Early diagnosis of diabetes is major challenge in real life since people don't check their blood glucose level very often. But if the diabetes remains unattended or is detected at late stage, may lead to severe problem. So, what is important is to predict the diabetes at earliest. For the same reason various researchers are taking efforts by using various data mining techniques for the early prediction of diabetes. The automated prediction system is just one of the outcomes of the efforts taken by the researchers. The proposed system uses convolutional neural network for this kind of classification.

Keywords— diabetes, Prediction of diabetes, convolution neural network, classification

I. INTRODUCTION

Diabetes Mellitus also called as diabetes is most commonly found diseases, which is a heterogeneous condition caused by metabolism imbalance [1]. Such disorder results into variety of complications and can be identified by increased glucose levels in blood. Diabetes is long term disease causing micro vascular complications that may affect to kidney, nerves, eyes and heart [2]. So, diabetes itself is dangerous, but its complications are even costlier. Based on etiology, the diabetes patients may fall into either type1 or type2 category [3] [4].

Use of Data mining techniques is not a new thing. There are various algorithms which have been used successfully to predict the diabetes at its early stage. Artificial Neural Network (ANN) is a paradigm which tries to mimic the biological neurons system to process information. ANN is composed of number of processing element called neurons. Each neuron is fully connected with rest of the neurons in such a way that they answer the given problem in black box manner [5]. Deep neural networks are simply the networks with multiple non-hidden layers which allows the data to be represented with multiple levels of abstraction [6]. Convolutional Neural Network (CNN) is a branch of deep learning and has wide application domain medical image analysis and its interpretations [7]. Convolutional neural network is feed forward neural network. Whenever the dataset is high dimensional and large scaled data, convolutional neural network is the best mechanism to find out the patterns. Convolution Neural Network is having an alternate sequence of convolution and pooling. To extract the features of the data, the convolution layer is used whereas the pooling layer is responsible for reduction of size [8]. In CNN, the filters are applied to entire layer by replicating the filter with sharing of same weights and bias which is called feature map. The filters applied are independent of the input size and the patterns can be generated irrespective of its spatial location [9]. To get the feature map a matrix of 3 *3 with random values in it also called kernel is rotated along the data. For the pooling step one has to reduce down the number of trainable parameters. The pooling can be of different types like Max, Average, and Sum etc. by which the data can be down sampled.

The next session 2 shows the related work done in this field; section 3 shows the proposed architecture. The information about the data set used, its various attribute and other features are discussed in section 4 whereas, the experimental results are given in section 5; section 6 gives a brief about the research conclusion.

II. RELATED WORK

We know artificial neural network as prediction tool and the prediction of diabetes is often seen as an application of artificial neural network; the literature shows how widely it is spread. There is lot of related work that could be cited for the same. The survey shows that neural network has even been combined with other techniques to form hybrid method. The following is the brief review of ANN in diabetic prediction:

Ebenezer Obaloluwa Olaniyi [10] has used multilayer back propagation neural network for the prediction of diabetes. The architecture used here, consist of 8 neurons in the input layer, and 6 neurons were used for constructing hidden layer, whereas the output layer was designed with 2 neurons. The activation function was sigmoidal function for both that is hidden layer and output layer. With the learning rate of 0.33, the accuracy rate obtained was 82%.

P. Venkatesan [11], in his research, collected the data from a private hospital with total of 1200 records. The researchers have used radial bias function for the prediction. The results were promising and shows the accuracy of 98% when the number of centers in Radial bias function neural network is considered to be 10.

Amongst the different models of artificial neural network, Zahed Soltani [12] worked on probabilistic neural network for the detection of diabetes. The researcher was relying on pima Indian diabetes data. Gaussian function was used in the hidden layer. The implementation was in MATLAB and the accuracy for test data set was 81%.

Madhavi Pradhan [13] proposed the use of neural network and fuzzy K nearest neighbor algorithm. She designed a classifier that could predict the diabetes well in time. The accuracy, the researchers claimed using WEKA implementation was 72.82 with 10-fold CV.

In a search of increasing accuracy, Rahmat Zolfaghari [14] has experimented a design of classifier, where he worked on getting together 2 different algorithms, back propagation neural network and support vector machine. The architecture consist of 3 layers and the accuracy was summed up to 88.04%.

FLANN architecture consists of single layer feed forward neural network. Manaswini Pradhan [15] in her experiment tried to implement this architecture so that diabetes could be detected. As there is no hidden layer, this technique is easy to implement and the number of neurons in the input layer depends upon number of attribute present. Function approximation was main theme of this method. The average accuracy was found to be 59.76 when the model was simulated with 30 epochs.

Kamer Kayaer[16] tried to investigate how general regression neural network could be used for timely detection of diabetes. The researcher also tries to compare the performance with multi-layer perceptron and radial basis function. When simulated all three algorithms on MATLAB, the results shows the general regression neural network gives maximum accuracy in comparison to other two algorithms. The accuracy was 80.21%.

Rohollah Ramezani [17] suggested a hybrid approach where he tried to combine logistic regression with adaptive network based fuzzy inference system. He named it as LANFIS Logistic Adaptive Network-based Fuzzy Inference System. The accuracy with this algorithm is quite high that is 88.05%. In a hybrid approach Dilip Kumar Choubey [18], uses two techniques. The researcher uses genetic algorithm for selection of attribute and radial bias function neural network for classification purpose. When genetic algorithm used, it has selected only 4 attributes from pima Indian dataset amongst the 8 attributes available. And the accuracy reached up to 84.80% using this approach.

A novelistic approach suggested by Swapana G. [19]. In her paper the researcher uses heart rate to detect the diabetes. Here a CNN and LSTM is used to study the heart rate variance shown in the ECG. The researchers has gone through two sets of experiments, in the first one they have used CNN with 5 fold cross validation with accuracy rate of 93.6%, but when the same CNN is combined with CNN-LSTM, the accuracy is found to be significantly increased up to 95.1%

Piyush Samant [20], in his paper applied various machine learning techniques for medical image classification to be particular the researcher has used iris image for classification of diabetes and non-diabetes patients. His results show that RF classifier has given the maximum accuracy of 83.63%. whereas the best classification accuracy is achieved by applying the t-test for feature selection. For feature selection the author has used six different methods.

But from the above study, the survey shows that most of the times the convolutional neural network is only used for image processing. It detects the diabetes but on the basis of various medical images analysis. But here the author tries to apply a CNN for a normal dataset and not an image set.

III. MATHEMATICAL MODEL OF SYSTEM

Convolutional Neural Network (CNN) uses tensors for internal processing. Tensor of order 0 are scalar values, order 1 are vectors and order 2 are two dimensional matrices, so on. Modern CNNs can also process higher order tensors. When a higher order tensor is received as input, they are converted into order 1 tensor or feature vectors internally. So, any input tensor is treated as a feature vector as shown in equation 1.

$$T\ n \times n \Rightarrow fv\ 1 \times n2 \quad (1)$$

In a forward pass, CNN processes input with given weight matrix of the layer. Then output of one layer is treated as input for the next layer. In the training environment, this sequence is followed till the last layer which is back error propagation layer. Here the optimization function finds the

error between the proposed output and actual output. This error is reflected to previous layers for correction. The weights of each layer are then adjusted to optimize the result. This is shown in equation 2. After training is completed then weights of each are finalized and remain unchanged later.

$$\text{In} \Rightarrow \text{WHL1} \Leftrightarrow \text{WHL2} \Leftrightarrow \text{EP} \qquad (2)$$

In testing or application environment CNN only has forward pass with finalized weights of each layer. Also the last layer is output layer as compared to error propagation layer in training.

$$\text{In} \Rightarrow \text{WfHL1} \Rightarrow \text{WfHL2} \Rightarrow \text{OP} \qquad (3)$$

In each layer, the number of neurons used may vary. The number of neurons required for each of the layer depends on the application and processing power available to choose the number of neurons in each layer. As the number of neurons and layers increases, so the deeper patterns can be mapped even from very huge dataset. As a consequence, it increases the time and memory required for the processing. Also, as the number of neurons and layers increase, so does probability of overfitting on a small dataset. So, higher number of neurons and layers demand higher number of training records for deeper pattern analysis.

IV. DATASET

The most important step involved in construction of neural network is data acquisition. Here the dataset used is free dataset. This dataset is available on the UCI Repository of Machine Learning Databases [21]. The dataset records binary output, if it says 1, it means the patient is positive for diabetes and 0 means normal that is no traces of diabetes. Amongst all the 768 records the diabetes recorded responses are 34.9% (268) and remaining 65.1% (500) entries are classified as class 0 that is the normal persons (no diabetes).

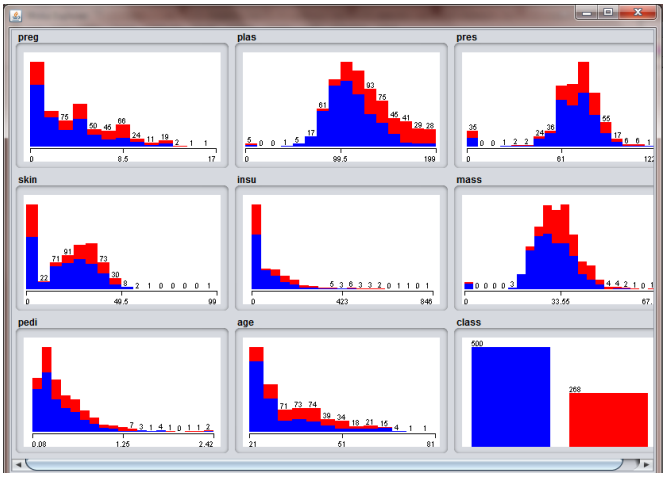

Figure 1: Distribution of data

The distribution of attribute values with respect to class attribute '0 or 1' is shown in following figure, the blue colour indicates the diabetic negative whereas the red indicates diabetic positive cases.

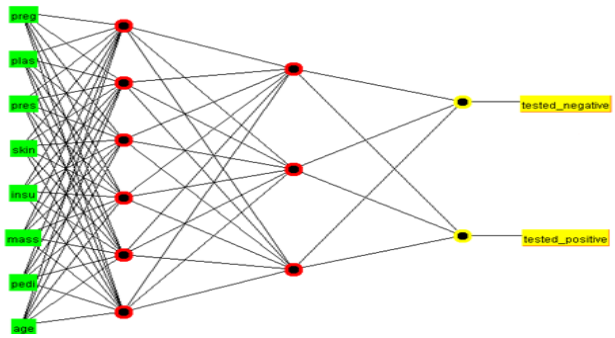

Figure 2: Proposed system architecture

V. RESULTS AND DISCUSSION

In this work, CNN with two hidden layers is used. There were two experiments conducted. In both, input layer is having 8 neurons for one to one mapping with each input feature. First hidden layer processes output from input layer, forwarding its output to the next hidden layer. Finally output layer compiles second hidden layers output in form of a class i.e. diabetic or non-diabetic. Architecture of the system used is shown in figure 2. Results show that maximum accuracy obtained in experiments is 89%. Detailed results are shown in figure 3. In higher percentage of accuracy, there are higher chances of over fitting. So, in our experiments care is taken to introduce dropout layer after hidden layers for avoiding over fitting.

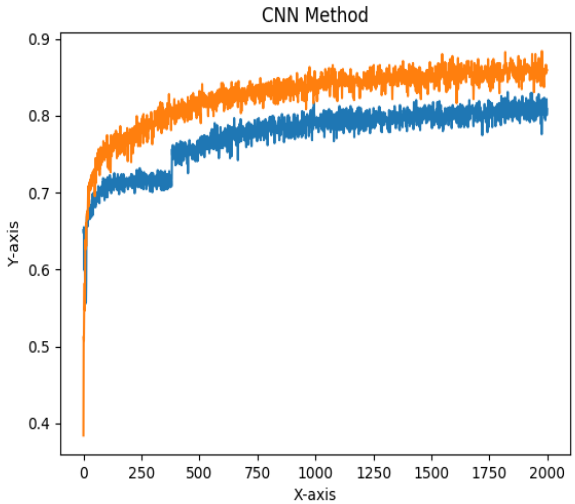

Figure 3: CNN method

VI. CONCLUSION AND FUTURE SCOPE

The problems with traditional artificial neural network like the problem of over fitting or reaching local optima etc. can be easily overcome using convolutional neural networks. The results generated here are very promising. But deep learning itself is very complex to implement, there are fair chances for enhancements and improvements. With some of more experimentations it would be very interesting to see, how the performance will change if we combine the CNN with some other techniques to form a hybrid system. So, our next task would be fuzzify the dataset and then apply the convolutional neural network. It serves two purpose, first one can understand what would be the effect of combining two techniques, will the accuracy increases? And secondly CNN is generally applied on very large data set, by fuzzification we can populate the matrix of fuzzified value for given one attribute value.

Also, the data presented here was a readymade data it is needed to check whether the model works fine if applied with some live data.

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