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Application of Artificial Neural Networks to Predict Type II Diabetes Blood Glucose Levels Accurately.

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ABSTRACT

In diabetes, the body produces insufficient or no insulin, does not properly utilize the insulin it produces, or shows a combination of both. As a result of any of these conditions, the body cannot absorb sugar from the blood into the cells, causing high blood sugar levels. Diabetic blood glucose levels are elevated either because of inadequate insulin release (type I diabetes) or because of impeded insulin action (type II diabetes). Health problems such as this can cause physical disability and even death in some cases. Diabetes has affected over 246 million people worldwide as indicated by the World Health Organization (WHO) report, and this number is predicted to ascend to more than 592 million in 2035. Unlike the western world, India has a different type of diabetes - Type I diabetes is relatively rare, while Type II diabetes affects more than 90% of the population. Forecasting and early prediction of Type II diabetes have become increasingly important due to the high incidence of the disease in recent years.

An artificial neural network (ANN) is a network of artificial neurons, similar to those found in the human brain, which is used to solve artificial intelligence problems such as image recognition, pattern recognition, classification, prediction, data compression and optimization. Diabetes has been predicted and classified using ANN techniques. The purpose of

this study is to identify a technique among various artificial neural network techniques that can accurately predict the blood sugar levels of people with Type II diabetes based on a review of various literature papers. Keywords: Artificial neural network (ANN), Type II Diabetes, Back Propagation Neural (BPN) Networking.

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INTRODUCTION

Artificial Intelligence (AI) is now a day's gaining immense importance and is becoming a key technology in many fields ranging from banking industry, to travel industry, to communication industry and robotic industry.

Artificial Neural Network (ANN) is an artificial Intelligence system closely modeled on the human brain. Diagnostic systems, biochemical analysis, image analysis and drug development are the various areas in medicine where artificial neural network is used successfully.

A simple statistical technique cannot be a enhanced way to diagnose Diabetes. To avert complications in diabetes, patients have to know the future value of blood glucose so they can take precaution and be normal as possible. ANN has mathematically implemented technique and is easy to use as compared to other statistical techniques.

As we analyze recent works to use ANN techniques to help in the management of diabetes, along with the related challenges. We analyze the literature from 2010 to 2020 yielded 24 relevant articles. We obtained evidence of an acceleration of research activity aimed at developing ANN-powered techniques for prediction and prevention of complications associated with diabetes. In this study, we found that there are several ANN techniques used for an accurate blood sugar level prediction of Type II Diabetes.

LITERATURE REVIEW

Suitability and appropriateness of artificial neural network for prediction of Diabetes disease by past recorded data has identified from a broad literature review. Wherein, research contributions from 2010 to 2020 have been reviewed. It is found that various techniques of Artificial Neural Network (ANN) such as Back Propagation Neural (BPN) Network, Support Vector Machine (SVM), Form-Feed Neural (FFN) Network, Multi Layer Perception (MLP), and Recurrent

Neural Network (RNN) are found appropriate and sufficiently suitable for prediction of Type-II diabetes.

Tarik A. Rashid et al. [1] designed an intelligent based classification, prediction, and description model to provide comprehensive knowledge that required by Diabetes Mellitus patients .

Manaswini Pradhan and Dr. Ranjit Kumar Sahu [2] suggested an Artificial Neural Network based classification model as one of the powerful method for classifying diabetic patients.

Aishwarya Mujumdar and Dr. Vaidehi V [3] proposed a diabetes prediction technique for better classification of diabetes which includes some external factors responsible for diabetes like Glucose, BMI, Age, Insulin, etc. Where Shiva Borzouei and Ali Reza Soltanian [4] found waist circumference and age were the most important predictors of type II diabetes mellitus using logistic regression analysis.

Sareh Mortajez and Amir Jamshidinezhad [6] proposed a hybrid neural network that had performed better than neural network, fuzzy model and artificial immune system to diagnose type II diabetic patients.

Tejas N. Joshi and Prof. Pramila M. Chawan [8] developed a system which perform early prediction of diabetes for a patient with a higher accuracy by combining the results of different machine learning techniques.

Sharma [9] concluded that the neural network models as Back Propagation (BP), Support Vector Machine (SVM), Multi Layer Perception (MLP), and Recurrent Neural Network (RNN) were sufficiently suitable for prediction of diseases.

Md. Kowsher et al. [10] compared seven machine learning classifiers and an artificial neural network method to predict the detection and treatment of diabetes with a high accuracy at an early age. They found that ANN outperforms with 95.14% accuracy among all other tested machine learning classifiers.

Verma M. [11] used Feed-Forward Back Propagation Neural Network Model in disease diagnosis.Yinghui Zhang et al. [12] proposed a model based on feed-forward artificial neural network for the early prediction of diabetes using the PIMA Indian Diabetes dataset implemented in MATLAB with 82% accuracy.

Laman R.Sultan [13] devaloped a model for diagnosis of type II diabetes using Feed-forward Neural Network technique and implemented in MATLAB taking Pima Indians Diabetes Dataset as an input and got 88.8% accuracy.

Fayrouz Allam et al. [14] compared a recurrent neural network with a feed forward neural network prediction model on data obtained from continuous glucose monitoring device. They found that the recurrent neural network was better than the feed forward neural network to predict the future values of the glucose concentration for the relatively long prediction horizons (PH) of 15, 30, 45, 60 minutes.

Shahabeddin Abhari et al. [15] suggested that among all machine learning applications the Support vector machine and Naive Bayesian might achieve better performance than other applications due to the type of variables and targets in diabetes-related outcomes classification.

Deepti Sisodia and, Dilip Singh Sisodia [16] used three machine learning classification algorithms named Decision Tree, SVM and Naïve Bayes in their experiment to detect diabetes at an early stage and they found Naive Bayes outperforms with the highest accuracy of 76.30% comparatively other algorithms.

Zahed Soltani and Ahmad Jafarian [17] used probabilistic artificial neural networks to implement in MATAB for diagnosing diabetes type II disease in training and testing the Pima Indians Diabetes dataset. They concluded that training accuracy and testing accuracy of the probabilistic artificial neural networks was 89.56% and 81.49%, respectively.

Dr. Garima Verma and Dr. Hemraj Verma [18] proposed a machine learning model based on Multilayer Perception Neural Network to identify diabetes patients in the early stage and their experiment results of the model showed 82% accuracy in prediction using Pima Indians Diabetes Data Set.

Muhammad Azeem Sarwar et al. [19] Compared the six different machine learning techniques namely K-Nearest Neighbours (KNN), Naive Bayes (NB), Support Vector Machine (SVM), Decision Tree (DT), Logistic Regression (LR) and Random Forest (RF) on PIMA Indian dataset. They found SVM and KNN gives highest (77%) accuracy for predicting diabetes.

M.Durairaj and G.Kalaiselvi [20] obtained the classification accuracy of Back Propagation Network (BPN) with Levenberg–Marquardt (LM) was better than those get by other studies for prediction.

Maan [21] proposed a technique using Back Propagation to derive relationship among the attributes of the complex dataset for better analysis of clustered data. They used a partitioning based technique of k-method to cluster the dataset.

V. Ashok et al.[22] presented a supervised Back Propagation Neural (BPN) network for the determination of blood glucose in diabetic patients. They got BPN network performs better with 99.69% accuracy.

Gavin Robertson et al. [23] were used Elman recurrent artificial neural networks to predicate blood glucose level.

P. Moksha Sri Sai et al. [24] analysed different types of algorithms to avoid risk factor of type 2 diabetes.

METHADOLOGY

There are many types of Artificial Neural Network techniques. Major ones are as follows –

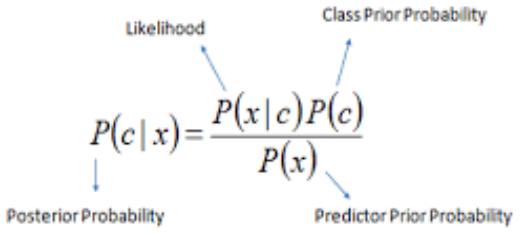
1. Naive Bayes

This supervised learning algorithm is based on Bayes theorem. It is used for solving classification problems. It is a simple and most effective classification algorithm that helps in building the fast machine learning models for quick predictions.

This algorithm is for binary class and multi-class classification problems. This technique is easy to understand when depicted using binary or definite input values.

It is called naive Bayes since the calculation of the probabilities for each hypothesis is easy to make their calculation well-mannered. A list of probabilities is stored in a file to learn naive Bayes model. It includes:

- Class Probabilities - The probabilities of each class in the training dataset.
- Conditional Probabilities - The probabilities of each input value given each class value.



$$P(c|X) = P(x_1|c)\times P(x_2|c)\times\cdots\times P(x_n|c)\times P(c)$$

Applications - It is applicable in text classification, social media analysis, Spam filtering, Multi-class Prediction, Real-time Prediction etc.

2. Support vector machines

Support Vector Machines (SVM) is a powerful flexible supervised machine learning algorithm which is used for both classification and regression.

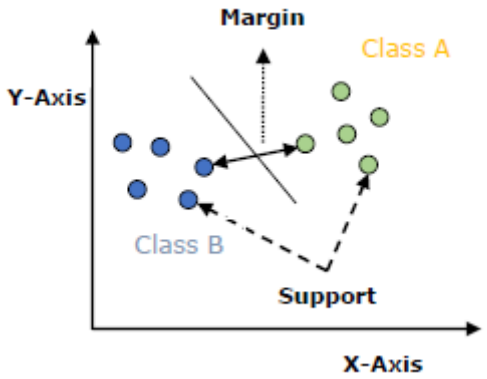


Fig. 1 Support Vector Machines

The concepts in SVM −

- **Support Vectors** − Data points that are nearby the hyperplane is called support vectors. Separating line is distinct with the help of these data points.
- **Hyperplane** − as shown in the above diagram, it is a decision plane or space which is divided among a set of objects having different classes.
- **Margin** − It is the gap between two lines on the closet data points of different classes. It can be calculated as the perpendicular distance from the line to the support vectors. Large margin is assumed as a good margin and small margin is assumed as a bad margin.

The aim of SVM is to separate the datasets into classes to locate a maximum marginal hyperplane. This can be done in the following two steps –

First, SVM will generate hyperplanes iteratively that separates the classes in best way. Then, it will decide the hyperplane that separates the classes correctly.

Applications - SVMs are applicable in face detection, handwriting recognition, image classification, Bioinformatics etc.

3. Feed-forward Neural Network

The feed-forward neural network was the first and simple type of network, where the input data goes one way. The data pass through the input nodes and exit from the output nodes. Feed-forward neural network may have the hidden layers. There are no loops in the network.

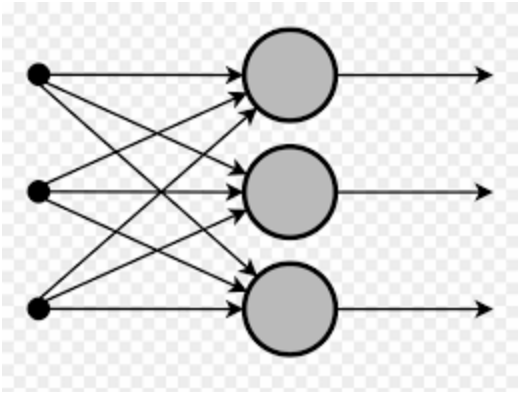


Fig. 2 Feed-forward neural network

Applications - This network is appropriate for signature confirmation, speech recognition and image processing.

4. Probabilistic neural network

A probabilistic neural network (PNN) is broadly used in classification and pattern recognition problems. In the PNN algorithm, the operations are organized into a multilayered feed-forward network. If an input is there, the first layer calculates the distance from the input vector to the training input vectors. The second layer adds the inputs of each class and produces its net output as a vector of probabilities. Lastly, the output of the second layer selects the maximum of these probabilities and produces 1 (positive identification) for that class or 0 (negative identification) for non-targeted classes.

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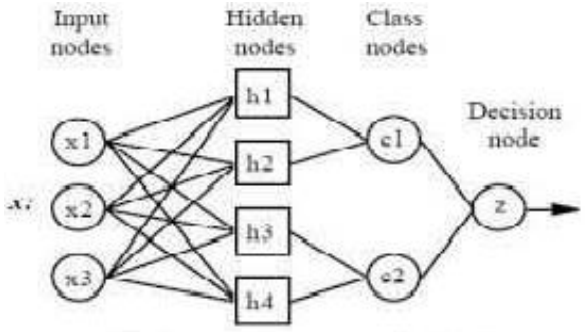


Fig. 3 probabilistic neural network

Applications - This network is applicable in Pattern Classification, Prediction of Leukemia and Embryonal Tumor, Ship Identification, character recognizing and Remote-sensing Image Classification

5. Perceptron Neural Network

A perceptron neural network (PNN) does definite calculations to perceive features of business intelligence in the input data. PNN was first introduced by Frank Rosenblatt in 1957. He proposed a Perceptron learning rule based on the original MCP (McCulloch-Pitts) neuron.

A Perceptron is a supervised learning algorithm for binary classifiers. This algorithm empowers neurons to learn and measures components in the preparation set once at a time.

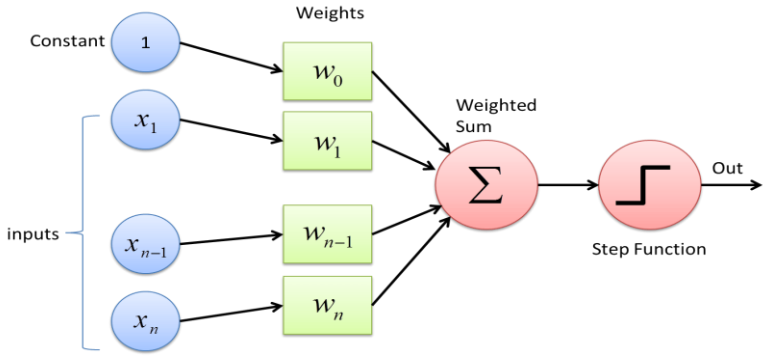


Fig. 4 Perceptron neural network

There are two types of Perceptron- Single layer and Multilayer Perceptron.

[1] Single layer Perceptron can learn immediately straight detachable patterns.

[2] Multilayer Perceptron has two or more layers with the better processing power.

The Perceptron algorithm find out the weights for the input signals in order to draw a linear decision limit. This empowers us to differentiate between the two linear divisible classes +1 and -1.

Applications – This Network is applicable in fault detection system.

6. Back-propagation Neural Network

A neural network has a variety of connected input-output units in which every association has a weight related with its computer programs. It assists to frame predictive models from large database.

Back-propagation is the technique of calibrating the weights of a neural network depends on the error rate got from the previous iteration. Proper tuning of the weights allows us to decrease error rate and create the reliable model. This technique helps us to calculate the function with all the weights within the network.

Consider the following diagram -

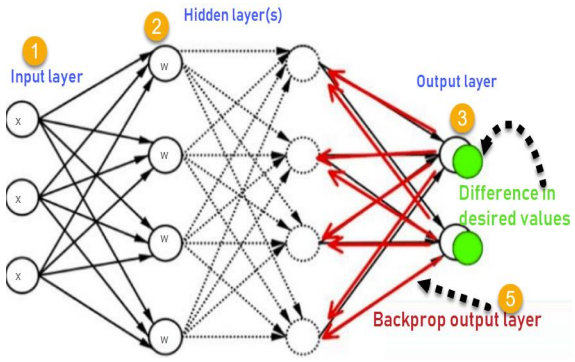


Fig. 5 Back-propagation neural network

1. Input X, overcome the preconnected way.
2. Input X is shown using real weight W. The weights are randomly chosen.
3. Compute the output for each neuron from the input layer to the hidden layers and output layer.
4. Compute the mistake in the outputs as

Mistake=Actual Output-Desired Output

5. Travel back from the output layer to the hidden layer to coordinate the weights such that the mistake is diminished.

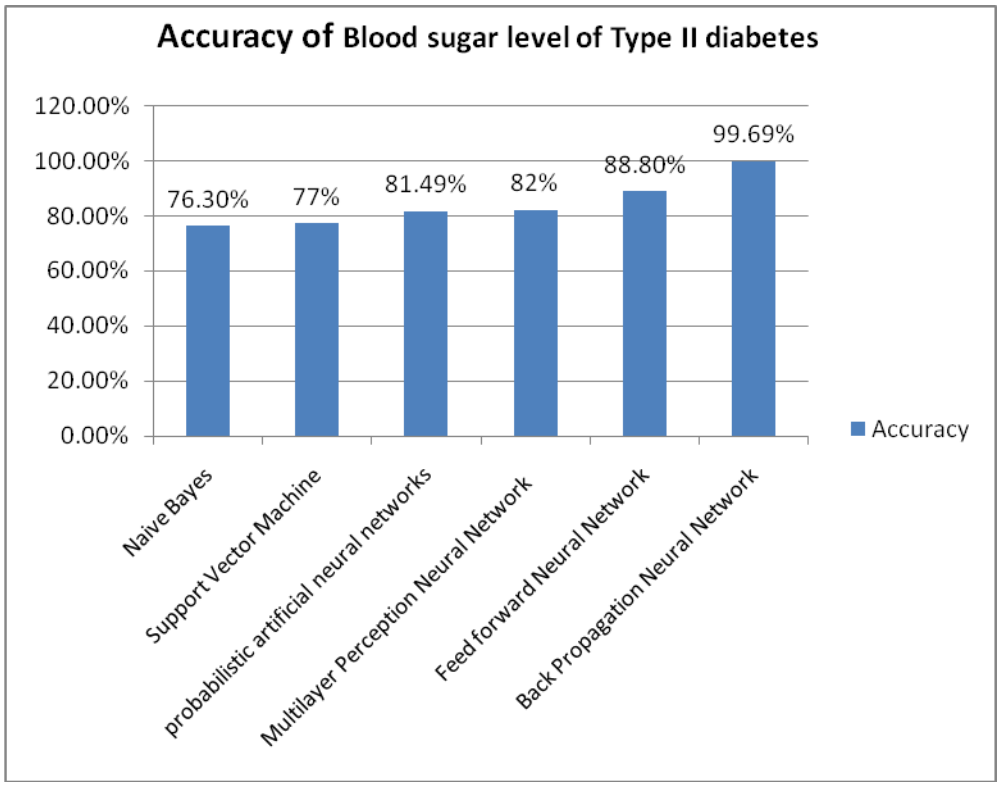
Keep repetition the method until the required output is obtained.

Applications - Back-propagation is particularly applicable for deep neural networks running on error-prone activity like various medical diagnosis, speech or image recognition, ocean tidal prediction etc.

OBSERVATION & RESULT

After reviewing the literature, we observed that several ANN techniques are used for an accurate blood glucose level prediction of Type II diabetes using Pima Indians Diabetes Data Set and found the following data -

Sno.	Name of ANN Technique	Accuracy
1	Naive Bayes	76.30%
2	Support Vector Machine	77%
3	probabilistic artificial neural networks	81.49%
4	Multilayer Perception Neural Network	82%
5	Feed forward Neural Network	88.8%
6	Back Propagation Neural Network	99.69%



To determine the best ANN algorithm for predicting the outcome, several ANN algorithms are analyzed. According to our study, Back Propagation Neural (BPN) networks can predict blood glucose levels with 99.69% accuracy in Type II Diabetes.

CONCLUSION

During the years 2010 to 2020, 24 significant contributions have been reviewed to recognize Artificial Neural Networks' applicability. This study examined the different ANN techniques applied to predict type II diabetes blood sugar levels. According to our findings, Back Propagation Neural Networking is a better technique than among ANN for predicting blood glucose levels in Type II Diabetes.

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