

Diagnosing Diabetes Using Artificial Neural Networks

Joy Oyinye Orukwo, and Ledisi G. Kabari

Abstract—Diabetes has always been a silent killer and the number of people suffering from it has increased tremendously in the last few decades. More often than not, people continue with their normal lifestyle, unaware that their health is at severe risk and with each passing day diabetes goes undetected. Artificial Neural Networks have become extensively useful in medical diagnosis as it provides a powerful tool to help analyse, model and make sense of complex clinical data. This study developed a diabetes diagnosis system using feed-forward neural network with supervised learning algorithm. The neural network is systematically trained and tested and a success rate of 90% was achieved.

Index Terms—Diabetes Mellitus, Neural Network, Feed Forward, Supervised Learning.

I. INTRODUCTION

Diabetes is the condition in which the body does not properly process food for use as energy. It is a disease in which the body cannot regulate the amount of sugar in the blood (glucose), which gives energy to perform daily activities and is responsible for the whole metabolism of the body. A greater proportion of the food we eat is turned into glucose or sugar, for our bodies to use as energy. The pancreas, an organ that lies near the stomach, makes a hormone called insulin to help glucose get into the cells of our bodies. When a person has diabetes, it is either the body isn't making enough insulin or can't use the insulin its making as it should. This causing sugars to build up in the blood. This is why many people refer to diabetes as "sugar." Diabetes can cause serious health complication including heart disease, blindness, kidney failure, and lower-extremity amputations. The prevalence of diabetes among blacks has quadrupled during the past 30 years [1].

Diabetes is a common disease in the world and a cure has not been found for it. Based on the Diabetes Research Center reports, incidence of diabetes has doubled over the last ten years worldwide and about 200 million people have been diagnosed and there is about six percent increase in the annual prevalence of diabetes in the world. Since diabetes is a chronic disease which can lead to irreparable damage to the limbs and other vital organs in the body. The use of intelligent tools can improve detection methods and disease control and can be of great aid to the doctors. According to the Diabetes Center Research early diagnostics of patients at risk can prevent 80 percent of chronic complications of type II diabetes or delayed them. Some types of diabetes are, type

I diabetes also known as insulin dependent, type 2 diabetes called relative insulin deficiency and gestational diabetes.

Artificial Intelligence (AI) in healthcare is the use of algorithm and software to approximate human cognition in the analysis of complex medical data. They learn by training from past experience data and make generalization on unseen data. Specifically, AI is the ability for computer algorithms to approximate conclusions without direct human input. Artificial intelligence has been successfully applied in medical diagnosis. They have been used for skin disease diagnosis, eye disease diagnosis, treatment protocol development, drug development, personalized medicine, and patient monitoring and care. Artificial neural networks are artificial intelligence paradigms; they are machine learning tools which are modelled after biological neural systems.

There isn't a cure yet for diabetes, but knowing your diabetes status early, developing a healthy lifestyle habits, taking prescribed medicines, getting diabetes self-management education, etc. can greatly reduce its impact on your life. Predictive modelling has proven to be a key component of solutions to many healthcare problems. Hence knowing your diabetes status is an issue of utmost importance.

More often, people continue with their normal lifestyles unaware that their health is at severe risk with each passing day as their diabetes status goes undetected. Medical diagnosis involves several levels of uncertainty and imprecision. It is of no doubt that evaluation of data taken from patient and decisions of experts are the most important factors in diagnosis.

The use of intelligent tools can improve detection methods and disease control and can be of great aid to the doctors. Predictive modelling is a key component solution to many healthcare problems. Training an artificial neural network can assist the experts and minimize possible errors that can occur in diabetes diagnosis which makes it is necessary to use an alternative tool in predicting diabetes. Hence this paper attempts to relatively efficient solution by designing and implementing a system for predicting diabetes in a patient using neural network.

Prediction of diabetes using artificial neural network will help minimize cost and time for the patient. It can learn features from a large volume of healthcare data and then use the obtained insight to assist clinical practice. It will also bring about quick detection of diabetes at an early stage so treatment can be carried out earlier and help reduce therapeutic errors that are inevitable in the human clinical practice and boost diagnosis methods. Finally, the study will serve as a reference material for future research on this area or related areas.

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J. O. Orukwor is a post graduate student of Ignatius Ajuru University of Education, Port Harcourt, Nigeria. (e-mail: joyorukwo@gmail.com).

L. G. Kabari is with Ken Saro-Wiwa Polytechnic, Bori, Nigeria (e-mail: ledisiogiokkabari@yahoo.com).

II. RELATED WORKS

Diabetes is a chronic (long-lasting) disease that affects how the body turns food into energy. Most of the food we eat is broken down into sugar (which is also called glucose) and released into the bloodstream. The pancreas produces a hormone known as insulin that acts like a key to let the blood sugar into your body's cells for use as energy. Absence or insufficient production of insulin, or an inability of the body to properly use insulin causes diabetes. [2].

Diabetes is a defect in the body's ability to convert glucose (sugar) into energy [3]. Glucose is simple sugar found in food. It is the main source of fuel of the body. It is an essential nutrient that provides energy for the proper functioning of the cells of the body. Mostly glucose is gotten from carbohydrates. Carbohydrates are broken down in the small intestine and then the glucose indigested food is absorbed into the bloodstream by the intestinal cells. The bloodstream carries it to all the cells in the body where it is utilized. However, glucose cannot enter the cells alone, it needs insulin to aid its transport into the cells. Hence, without insulin, the cells get starved of glucose energy notwithstanding the presence of abundant glucose in the bloodstream. In certain types of diabetes, the cells' inability to utilize glucose gives rise to the ironic situation of "starvation in the midst of plenty". Abundance or unutilized glucose is excreted in the urine. When food is digested it is changed into fats, protein, or carbohydrates. Foods that affect blood sugars are called carbohydrates. When carbohydrates are digested it changes to glucose. Examples of some carbohydrates are: bread, rice, pasta, potatoes, corn, fruit, and milk products, etc. persons with diabetes are advised to eat carbohydrates but must do so with moderation. Glucose is then transferred to the blood and is used by the cells for energy. In order for glucose to be transferred from the blood into the cells, the hormone called insulin is needed.

ANNs generated from the Neuro Solutions software package was used to make Blood Glucose Level predictions [4]. The data were acquired from 18 patients with Type-1 diabetes using a CGM to acquire blood glucose data over a period of 3–9 days. Training involved the use of datasets from 11–17 patients. One possible reason which was cited for this was that the dataset used for ANN training contained fewer examples of hypoglycaemic events than BGLs in other ranges.

In their work titled "A Neural Network Approach in Predicting the Blood Glucose Level for Diabetic Patients", they observed that Diabetes Mellitus is a chronic metabolic disorder, where the improper management of the blood glucose level in the diabetic patients will lead to the risk of heart attack, kidney disease and renal failure [5]. In the paper, they attempt to enhance the diagnostic accuracy of the advancing blood glucose levels of the diabetic patients, by combining principal component analysis and wavelet neural network. Their proposed system takes separate blood glucose prediction in the morning, afternoon, evening and night intervals with the use of dataset from one patient which covers a period of 77 days.

Neural network feed forward prediction model in conjunction with back propagation algorithm was employed and given training data set to predict whether a subject was

likely to have diabetes or not [6]. Their research was aimed at modelling neural network for a prediction scenario – diabetes and its type prediction here and to analyse the prediction results and compare the network efficiency upon changing the network parameters like the number of hidden layer nodes, type of normalization function used, prediction function used, learning rate and the initial biases for each layer. The correlation between training samples, their expected outputs and the number of iterations required to predict with RMS error below a threshold of 0.02% was also analysed. It took an average 1250 iterations to achieve the output. The maximum number of iterations was kept to 10000 so that the algorithm doesn't get stuck into an infinite loop if the prediction is not very accurate and quick. In general, we took 8 basic parameters to predict diabetes and its type in a person. The number of samples taken was not too many and so the algorithm took more than expected iterations to achieve optimum result. Initially we had assumed that 500 iterations would be more than enough for the task. Also on comparing the different prediction functions, it was found that sigmoidal function was the best and quickest to predict the result. Sigmoidal functions of two types namely: Binary and Bipolar were compared. Binary sigmoidal function gave results faster in less number of iterations. Bipolar sigmoidal gave results which were more accurate, but, in general it took about 250-300 iterations more than its counterpart. So, we have a trade-off between accuracy and the number of iterations, and in fact if we multiply both the functions and an optimization constant together and perform an optimization based on some criteria function we can improve the overall time-efficiency & accuracy of the algorithm by at least a factor of 2. The implementation of this optimization was also left as an extension to the basic version of the project. Hyperbolic tangential function was also accurate but it took too many iterations to converge to the final result. In fact, it more often than not took more than 7000 iterations to obtain the final result, and so we had to set the threshold number of iterations to 10000. Otherwise, a threshold of about 3000 was sufficient. This is mainly due to the geometrical nature of the hyperbolic curve in consideration. The rate of change of the slope of tangent to the curve was slow, and so it took long to converge to a constant stable value.

Diagnosis of Diabetes Using Classification Mining Techniques focused on diabetes recorded in pregnant women was conducted. They employed Decision Tree and Naïve Bayes algorithm on a pre-existential dataset to predict whether diabetes is recorded or not in a patient.

III. MATERIALS AND METHOD

The methodology used is the object oriented analysis and design (OOAD). We employed multilayer feed forward neural network with supervised learning algorithm.

The system was designed to predicts the presence of diabetes in a patient using diabetes symptoms. The system will provide a precise approach or algorithm that would determine if an individual is diabetic or not, thereby making the person aware of his/her status and reduce the risk of undetection that can lead to further complications. The system begins from the gathering of diabetes symptoms from expert

and ends with the diagnosis of the disease using neural network. Fig. 1 depicts the internal structure of the system

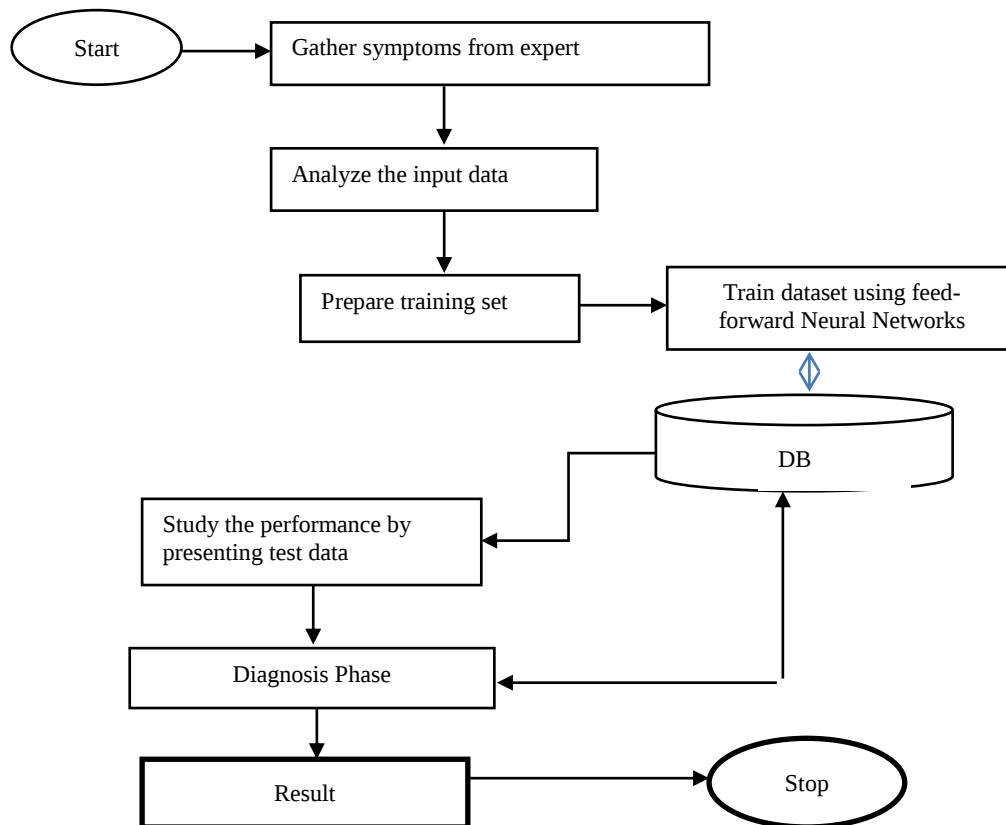


Fig. 1. Flowchart of the System Model

The neural network architectural design has 18 input variables denoting the symptoms of diabetes diagnosis, one hidden layer network and two output neurons, each for a particular diagnosis. The training process involves the following:

Steps: I. Initialize nodes and layers to the neural network.

Step II. Obtain training samples.

Step III. Train the neural network with the training samples by select the necessary symptoms and give it a tag (TYPE1 or TYPE2).

Step IV. Test it with the test data to confirm result accuracy. Fig. 2 depict the model

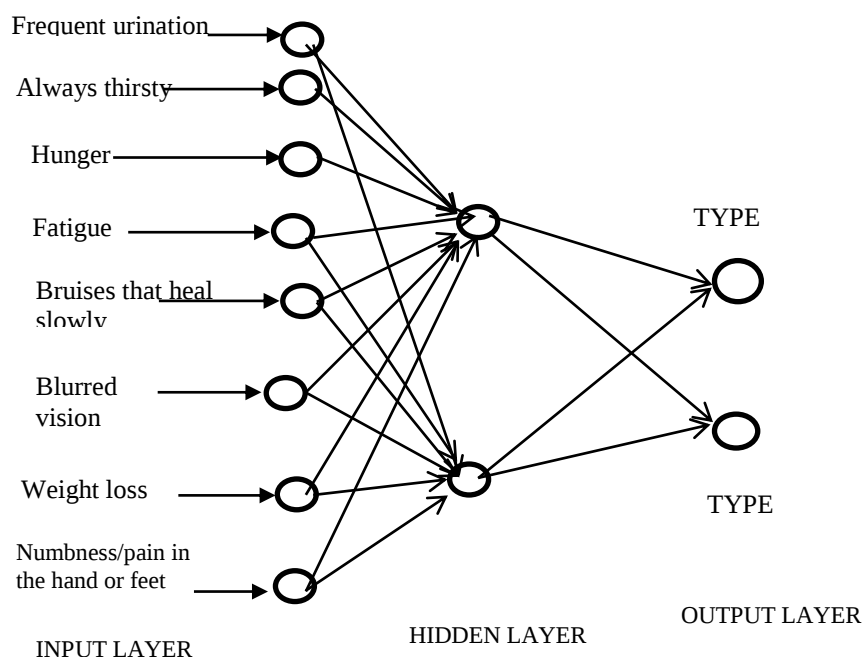


Fig. 2. Neural Network Architectural Design for the diabetes diagnosis system

Data collection consist of 100 data was collected from patients suspected to have diabetes in the survey. The symptoms that make up the data include: Family history of diabetes, Increased thirst, Blurred vision, Itchy skin, Dry skin, Frequent yawning, Obesity, Dry mouth, Frequent urine, Slow healing of wound, Patches, Extreme hunger, Sleep disorder, Have problem breathing, Weight loss, Numbness, Fatigue, Infection, Pregnancy.

IV RESULTS AND DISCUSSION

A. Data Analysis

The dataset containing the symptoms stated above were fed into the network and coded using binary numbers 0's and 1's. A feed forward neural network model using 18 neuron input and varied numbers of hidden neuron is used. The network is trained and tested in a ratio of four to one (4:1). The 80 percent of the dataset is then used for training while the one percent is used for testing the neural network.

B. Accuracy of the System

Accuracy is defined as the proportion of correctly classified results in a population. The classification accuracy, A, of an algorithm c is given as

$$A_c = t/N * 100\% \quad (1)$$

Where;

t is the number of (dataset)samples classified correctly

N is the total number of dataset (sample)

Hence;

$$A_c = t/N * 100\%$$

$$T=45 \text{ and } N=50$$

$$A_c = 45/50 * 100\% = 90\%$$

C. Discussion of Result

The result indicates that the system was indeed able to diagnose diabetes as intended. Several datasets were extensively tested to ensure the efficiency of the system. The dataset was divided into training data and testing data to ensure the systems accuracy. Various models were integrated during system testing to produce a working application for diagnosing diabetes.

The inputs of the system are designed based on the common symptoms of diabetes. The input values have been

coded with numerical values between the range of 0 and 1. From the data, it was observed from the dataset used that patient with diabetes were more. However, when a patient diagnosis reads from 60% and above, the patient is advised to go for a blood sugar test and examination to determine the level of severity. The accuracy is evaluated by splitting the data into training and testing set which gave a 90% accuracy.

IV. CONCLUSION

This study aimed at diagnosing diabetes using artificial neural network. Feed forward with supervised learning was used to diagnose the disease. The inputs of the system were designed based on the common symptoms of diabetes. The study adopted the object oriented analysis and design technique in analysing and designing the developed system. Having implemented and tested the neural network solution based on the feed forward neural network, we discovered that with ANN, it is possible to implement human intelligence for medical diagnosis. Using an adequate amount of dataset for training, the network will mimic the function being demonstrated.

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