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A PREDICTIVE EXPERT SYSTEM FOR PERSONALIZED INSULIN DOSAGE MANAGEMENT

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ABSTRACT

High blood glucose (blood sugar) levels are a hallmark of diabetes, a chronic metabolic disease. The pancreas produces the hormone insulin, which is generally used by the body to control blood sugar levels. Blood sugar levels rise with diabetes, though, because either the body does not produce enough insulin or the cells do not react to it well.

Diabetes management is keeping blood sugar levels within a desired range using a mix of diet, medication, frequent exercise, and blood sugar monitoring. Numerous consequences, such as cardiovascular disease, renal damage, nerve damage, and eye issues, can result from uncontrolled diabetes.

The Linear Regression technique is used to estimate insulin dose in diabetic patients, and the Gradient Boosting Classifier is used to predict diabetes. The UCI insulin dosage dataset will be used to estimate insulin dose, while the PIMA diabetes dataset will be used to train the models.

You have selected the UCI insulin dosage dataset for insulin dose prediction and the PIMA diabetes dataset for training the gradient boosting classifier. Verify that these datasets are available to you and that your machine learning algorithms can use them in the correct manner. The datasets may need to be pre-processed before the models are trained. This might entail separating the data into training and testing sets, addressing missing values, and normalising or standardising the features.

Train the Gradient Boosting Classifier using the PIMA diabetes dataset. In order to forecast the existence of diabetes, this algorithm will identify trends and connections in the data. You will upload a test dataset devoid of class labels after the classifier has been trained. Determine if diabetes is present in each sample in the test dataset using the trained model.

The UCI insulin dosage dataset may be used to estimate the insulin dose for samples that the Gradient Boosting Classifier identified as having diabetes. To estimate insulin dose, preprocess the information as needed and extract pertinent characteristics. A Linear Regression model was trained using the pre-processed UCI insulin dosage dataset. The link between the insulin dosage and the input characteristics will be learnt by this model.

Apply the trained Linear Regression model on the samples that the Gradient Boosting Classifier identified as

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having diabetes. Each sample's insulin dose will be predicted by the model.

Analyse how well the Linear Regression model and the Gradient Boosting Classifier perform. Metrics like mean squared error (MSE), recall, accuracy, and precision can be used to evaluate the models' performance.

I. INTRODUCTION

1.1 Introduction

High blood glucose levels brought on by abnormalities in insulin production, action, or both define a class of metabolic illnesses known as diabetes mellitus, or simply diabetes. The prevalence of diabetes has been increasing more swiftly in central and low-income countries. The number of persons with diabetes has grown from 108 million in 1980 to 422 million in 2014.

Either an inadequate response to insulin or a shortage of insulin itself might cause diabetes symptoms. Diabetics must take their insulin dosage as directed in order to maintain controlled blood glucose levels. Additionally, the patient's expert must estimate the required amount of insulin based on historical dosage data and the patient's continuously measured blood glucose level.

Three primary types of diabetes exist: It is believed that an autoimmune reaction—the body mistakenly fighting itself—causes type 1 diabetes, which encompasses type 1, type 2, and gestational diabetes. This response stops the manufacturing of insulin. Five to ten percent of people with diabetes have type 1 diabetes. Type 1 diabetes side effects often worsen quickly. It is often diagnosed in children, adolescents, and young adults. If you have type 1 diabetes, you must take insulin daily to stay alive. As of right present, type 1 diabetes cannot be prevented.

Type 2 Diabetes: In type 2, your body is unable to maintain normal blood sugar levels due to poor insulin utilisation. Ninety-five percent of people with diabetes have type 2 diabetes. It mostly affects adults, but with time, it also impacts kids, teenagers, and young adults more and more. Even if you don't have any symptoms, it is imperative that you have your blood sugar checked if you are at risk. Type 2 diabetes can be avoided or postponed by adopting a healthier lifestyle, which includes:

- Getting in shape.
- Consuming nutritious food
- Being involved.

Diabetes During pregnancy, pregnant women who have never had diabetes develop gestational diabetes. If you have gestational diabetes, your child may be more likely to have health issues. After your baby is born, gestational diabetes typically disappears. However, it makes you more likely to develop type 2 diabetes in later life. Your baby has a higher risk of becoming obese as a child or teen and later developing type 2 diabetes.

Prediabetes

In the US, 96 million grown-ups — more than 1 out of 3 — have prediabetes. Over 80% of them are unaware that they have it. Prediabetes is a condition where blood sugar levels are higher than normal but not yet in the range for a diagnosis of type 2 diabetes. It is considered a warning sign. You are more likely to get type 2 diabetes, heart disease, and stroke if you have prediabetes. However, there is good news. A lifestyle change program approved

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by the CDC can assist you in taking healthy steps to reverse prediabetes.

The forecast of glucose focuses could work with the suitable patient response in critical circumstances like hypoglycemia. As a result, advanced data-driven methods have been taken into consideration in a number of recent studies for the creation of precise predictive models of glucose metabolism.

Notwithstanding the overall rules that the patient adheres to during his regular routine, a few diabetes the board frameworks have been proposed to additional help the patient in the self-administration of the sickness. One of the fundamental parts of a diabetes the board framework concerns the prescient displaying of the glucose digestion.

Methodology

In this project we are using Gradient Boosting Classifier to predict diabetes and then using Linear Regression algorithm to predict insulin dosage in diabetic detected patients. To implement this project we are using PIMA diabetes dataset and UCI insulin dosage dataset.The objective of the PIMA dataset is to diagnostically predict whether or not a patient has diabetes, based on certain diagnostic measurements included in the dataset.The UCI Machine Learning Repository is a collection of databases, domain theories, and data generators that are used by the machine learning community for the empirical analysis of machine learning algorithms. We are training both algorithms with above mention dataset and once after training we will upload test dataset with no class label and then Gradient Boosting will predict presence of diabetes and Linear Regression will predict insulin dosage if diabetes detected by Gradient Boosting

1.2 Problem statement

Diabetes mellitus, sometimes known as diabetes, is a collection of metabolic illnesses marked by elevated blood glucose levels brought on by deficiencies in insulin secretion, action, or both. Type 1 and Type 2 diabetes are the two primary subtypes. pancreas, resulting in a complete lack of insulin. various secretions combined. A number of diabetes management systems have been presented to help patients even more with self-management in addition to the general rules that patients follow in their daily lives.

1.3 Objectives

The predictive modelling of glucose metabolism is one of the key elements of diabetes management systems. It is obvious that anticipating glucose levels helps patients respond appropriately in urgent circumstances like hypoglycemia. Therefore, a number of recent studies have investigated cutting-edge data-driven methodologies to create precise predictive models of glucose metabolism.

II. LITERATURE SURVEY

Water demand forecasting using extreme learning machines

AUTHORS: Tiwari, Mukesh, Jan Adamowski, and Kazimierz Adamowski

ABSTRACT: The provided text discusses the assessment of different modeling approaches for forecasting daily urban water demand using limited data. The focus is on extreme learning machine (ELM) modeling approaches alone or in combination with wavelet analysis (W) or bootstrap (B) methods. The performance of

these ELM-based models (ELM, ELMW, ELMB) is compared to traditional artificial neural network-based models (ANN, ANNW, ANNB).

The study utilized 3-year water demand and climate datasets for the city of Calgary, Alberta, Canada, to develop the urban water demand forecasting models.

Furthermore, the ELMW model demonstrated a significant improvement in predicting peak urban water demand compared to the ANNW or ANNB models. This suggests that the inclusion of wavelet transformation plays a crucial role in enhancing the overall performance of the urban water demand model.

It's important to note that the provided text seems to be a summary or excerpt from a larger study or research paper. The information provided gives insights into the comparison and evaluation of different modeling techniques for urban water demand forecasting.

AUTHORS: Devi, M. Renuka, and J. Maria Shyla

ABSTRACT: Data mining approach helps to diagnose patient's diseases. Diabetes Mellitus is a chronic disease to affect various organs of the human body. Early prediction can save human life and can take control over the diseases. This paper explores the early prediction of diabetes using various data mining techniques. The dataset has taken 768 instances from PIMA Indian Dataset to determine the accuracy of the data mining techniques in prediction. The analysis proves that Modified J48 Classifier provide the highest accuracy than other techniques.

Predicting Diabetes Mellitus using Data Mining Techniques

AUTHORS: J. Steffi, Dr. R. Balasubramanian, Mr. K. Aravind Kumar

ABSTRACT: Diabetes is a chronic disease caused due to the expanded level of sugar addiction in the blood. Various automated information systems were outlined utilizing various classifiers for anticipate and diagnose the diabetes. Data mining approach helps to diagnose patient's diseases. Diabetes Mellitus is a chronic disease to affect various organs of the human body. Early prediction can save human life and can take control over the diseases. Selecting legitimate classifiers clearly expands the correctness and adeptness of the system. Due to its continuously increasing rate, more and more families are unfair by diabetes mellitus. Most diabetics know little about their risk factor they face prior to diagnosis. This paper explores the early prediction of diabetes using data mining techniques. The dataset has taken 768 instances from PIMA Indian Diabetes Dataset to determine the accuracy of the data mining techniques in prediction. Then we developed five predictive models using 9 input variables and one output variable from the Dataset information; we evaluated the five models in terms of their accuracy, precision, sensitivity, specificity and F1 Score measures. The purpose of this study is to compare the performance analysis of Naïve Bayes, Logistic Regression, Artificial neural networks (ANNs), C5.0 Decision Tree and Support Vector Machine (SVM) models for predicting diabetes using common risk factors. The decision tree model (C5.0) had given the best classification accuracy,

followed by the logistic regression model, Naïve Bayes, ANN and the SVM gave the lowest accuracy IndexTerms—Data mining, Prediction, Naïve Bayes, Logistic Regression, C5.0 Decision Tree, Artificial Neural Networks (ANN) and Support Vector Machine (SVM).

Comparison Data Mining Techniques To Prediction Diabetes Mellitus

AUTHORS: Aswan Supriyadi Sunge

ABSTRACT: Diabetes is one of the chronic diseases caused by excess sugar in the blood. Various methods of automated algorithms in various to anticipate and diagnose diabetes. One approach to data mining method can help diagnose the patient's disease. In the presence of predictions can save human life and begin prevention before the disease attacks the patient. Choosing a legitimate classification clearly expands the truth and accuracy of the system as levels continue to increase. Most diabetics know little about the risk factors they face before the diagnosis. This method uses developing five predictive models using 9 input variables and one output variable from the dataset information. The purpose of this study was to compare performance analysis of Naive Bayes, Decision Tree, SVM, K-NN and ANN models to predict diabetes mellitus.

III. SYSTEM ANALYSIS & SYSTEM DESIGN

Existing System

Data mining approaches such as k-means is used to create a system for predicting diabetes. The use of data mining aids in the disease diagnosis of patients. In this particular investigation, the researchers utilized a dataset called the PIMA Indian Dataset, which consists of 768 instances. They employed several data mining approaches to predict diabetes early.

The goal was to assess the effectiveness of these approaches in terms of prediction accuracy. The high accuracy achieved by the Modified J48 Classifier suggests its potential as a useful tool for early prediction of diabetes in patients. However, it's important to note that the study's findings are specific to the PIMA Indian Dataset and may not necessarily apply universally to all datasets or populations. Further research and validation using different datasets and populations would be beneficial to confirm the efficacy of the Modified J48 Classifier for diabetes prediction.

Insulin dosage prediction plays a crucial role in the management of diabetes mellitus. In this study, an expert system is developed to predict optimal insulin dosages using the K-Means clustering algorithm. The system leverages patient characteristics, blood glucose levels, and previous insulin dosages to generate personalized recommendations.

Disadvantages System

- Missing and unavailable data owing to technical issues play a major role in affecting the performance of this model.
- It also has the disadvantage of relatively higher time consumption when scanning and sorting the datasets.
- However, early prediction of diabetes is quite a challenging task for medical practitioners due to

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complex interdependence on various factors.

Proposed System

Using the PIMA diabetes dataset and UCI insulin dosage dataset, you're training two different algorithms: Gradient Boosting for predicting the presence of diabetes and Linear Regression for predicting insulin dosage if diabetes is detected by Gradient Boosting.

- Dataset selection: You have chosen the PIMA diabetes dataset and UCI insulin dosage dataset for your project.
- Training phase:
- a. Using the PIMA diabetes dataset, you train a Gradient Boosting algorithm to predict the presence of diabetes.
  b. Additionally, you train a Linear Regression model on the UCI insulin dosage dataset to predict insulin dosage if diabetes is detected.
- Test phase:
- a. You upload a test dataset that does not have class labels (diabetes presence) to evaluate the performance of your trained models.
  b. Using the trained Gradient Boosting model, you predict the presence of diabetes for each instance in the test dataset.
  c. If diabetes is detected by Gradient Boosting, you use the trained Linear Regression model to predict the insulin dosage.

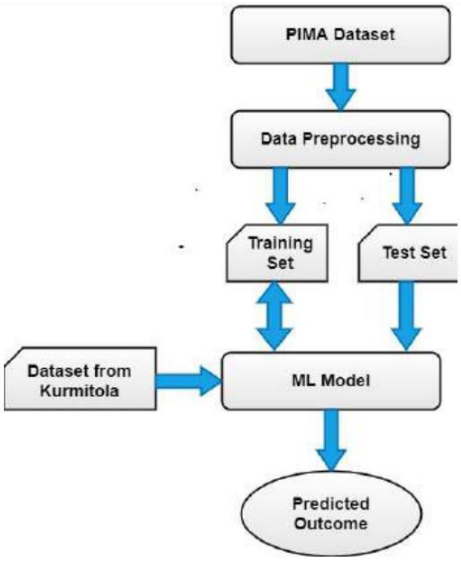
By combining these two algorithms, you aim to predict the presence of diabetes and estimate the insulin dosage if diabetes is detected. Gradient Boosting provides the initial diabetes prediction, and Linear Regression helps in estimating the insulin dosage based on that prediction.

Advantages System

- Individual blood glucose level and insulin dosing are highly erratic and precise prediction of them is likely impractical.
- Average blood glucose level over 24 hours can be more reliably predicted and determining whether the patient's glucose level is going to be high is a more feasible task.
- It helps diabetic patients to get proper amount of insulin dosage.
- When insulin is taken in right time the body can function properly and it can save the life of the person.

IV. SYSTEM DESIGN

SYSTEM ARCHITECTURE:



V. SYSTEM IMPLEMENTATION

MODULES

In this project, we have used many modules and every module has its own functionality.

Upload Diabetes Insulin Disease: In this, we upload the user dataset which was Pima Indian diabetes dataset and UCI Insulin dosage dataset.

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Execute Gradient Boosting Algorithm: We train the dataset which we uploaded by using Gradient Boosting Algorithm.

Execute Linear Regression Algorithm: After the dataset trained by the Gradient Boosting Algorithm then we train the dataset with Linear Regression Algorithm to predict insulin dosage amount.

Predict Diabetes & Insulin Dosage: After the datasets are trained then it predicts the diabetes by the Gradient Boosting Algorithm and the amount of insulin dosage by the Linear Regression Algorithm.

Performance Graph: Now in this module it shows the performance graph i.e how much accuracy both the algorithms are giving it shows in the form of graph.

VI. SCREEN SHOTS

Dataset :

The PIMA Indian Diabetes Dataset, originally from the National Institute of Diabetes and Digestive and Kidney Diseases, contains information of 768 women from a population near Phoenix, Arizona, USA. The outcome tested was Diabetes, 258 tested positive and 500 tested negative. Therefore, there is one target (dependent) variable and the 8 attributes (TYNECKI, 2018): pregnancies, OGTT(Oral Glucose Tolerance Test), blood pressure, skin thickness, insulin, BMI(Body Mass Index), age, pedigree diabetes function. The Pima population has been under study by the National Institute of Diabetes and Digestive and Kidney Diseases at intervals of 2 years since 1965. As epidemiological evidence indicates that T2DM results from interaction of genetic and environmental factors, the Pima Indians Diabetes Dataset includes information about attributes that could and should be related to the onset of diabetes and its future complications.

Machine learning Models for diagnosis of the diabetic patient and predicting insulin dosage.

In this project we are using Gradient Boosting Classifier to predict diabetes and then using Linear Regression algorithm to predict insulin dosage in diabetic detected patients. To implement this project we are using PIMA diabetes dataset and UCI insulin dosage dataset.

We are training both algorithms with above mention dataset and once after training we will upload test dataset with no class label and then Gradient Boosting will predict presence of diabetes and Linear Regression will predict insulin dosage if diabetes detected by Gradient Boosting.

Both dataset available inside Dataset folder and below screen is showing dataset details

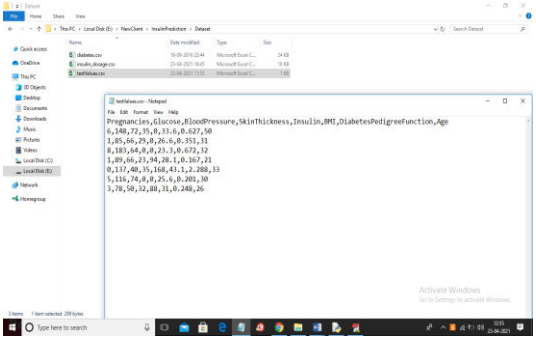

Fig.1. dataset

In above screen folder we can see both datasets available and in testValues.csv file we have no class label for diabetes as 0 or 1 where 0 means no diabetes detected and 1 means diabetes detected. When we apply Gradient Boosting algorithm on above test values then Gradient Boosting will predict class label and linear regression will predict insulin dosage.

Run Code

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To run project double click on 'run.bat' file to get below screen.

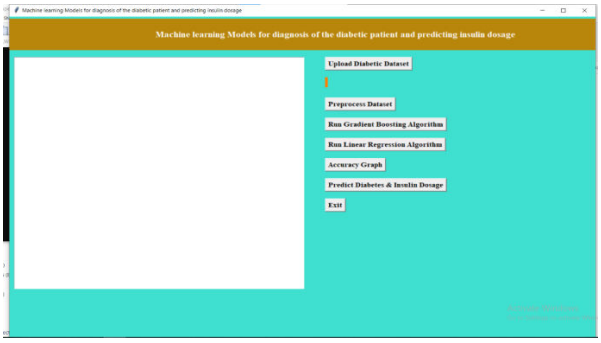

Fig. 2.Run Code

Upload Diabetic Dataset

In above screen click on 'Upload Diabetic Dataset' button to upload dataset which is available on the dataset folder the dataset is collected from the PIMA diabetes dataset and UCI Insulin Dosage Dataset which have the parameters like pregnancies, glucose, blood pressure , etc. selecting and uploading entire 'Dataset' folder to load both diabetes and insulin dataset and then click on 'Select Folder' button then we get the diabetes dataset and insulin dosage dataset.

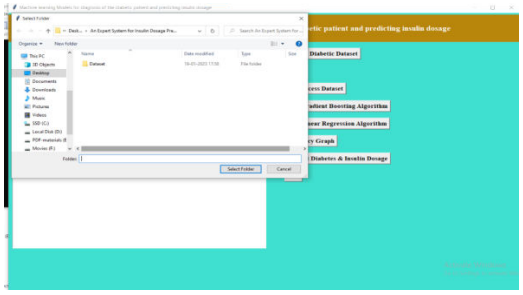

Fig.3 diabetic dataset

Dataset Loaded

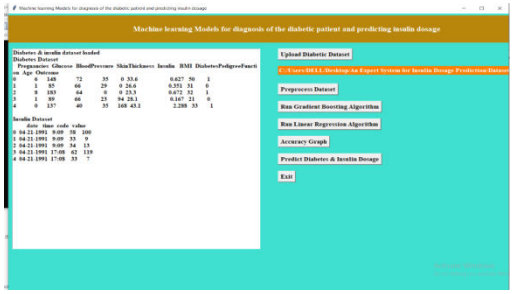

Fig. 4 dataset loaded

In above screen we can see both datasets loaded and we can see some records from each dataset and will get below graph also

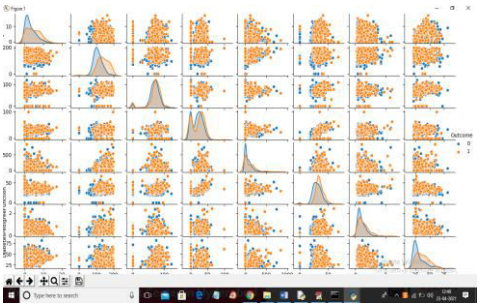

Fig.5. graph

In above graph we can see diabetes for each column where red colour dots indicate presence of diabetes and blue represents no diabetes detected.

We are plotting graph for each column value to show with which value diabetes is present and with which value diabetes is not present for example in above graph in first column we are plotting graph for 'number of Pregnancies' with 'presence or no presence of diabetes' and now close above graph and then click on 'Preprocess Dataset' button to remove missing values and to split dataset into train and test.

Pre process Dataset

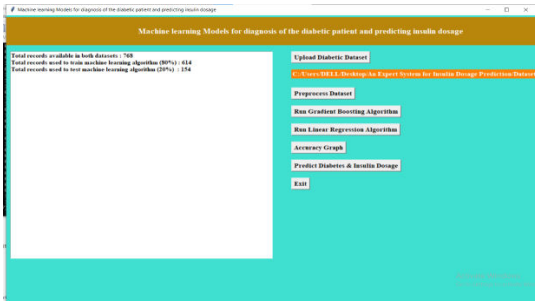

Fig.6. Pre-process Dataset

Next step is to preprocess the dataset. By clicking on the Preprocess Dataset button we get the screen like the above that how many records available in both datasets and how many records used to train the dataset using Machine Learning Algorithm and also how

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many records used to test the dataset using Machine Learning Algorithm.

In above screen we can see dataset contains total 768 records and application using 80% records for training and 20% records to test ML accuracy and now dataset is ready as we already trained and tested the dataset. So, now we can use the dataset for further process that is nothing but next step is the run the dataset using Gradient Boosting Algorithm to predict the diabetes in the patients.

Gradient Boosting Algorithm

Now click on 'Run Gradient Boosting Algorithm' button to train gradient boosting with above dataset to predict the diabetes in the patients.

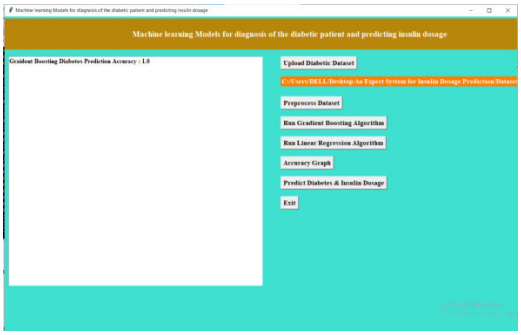

Fig .7. Gradient Boosting Algorithm

In above screen we got gradient boosting accuracy as 100% the Gradient Boosting Algorithm predicts the diabetes and gives the accuracy as 100% where it can predict that the patient has diabetes or not. If the diabetes detected then we use Linear Regression Algorithm to predict the insulin dosage amount for the diabetic detected patients detected by the Gradient Boosting Algorithm.

Linear Regression Algorithm

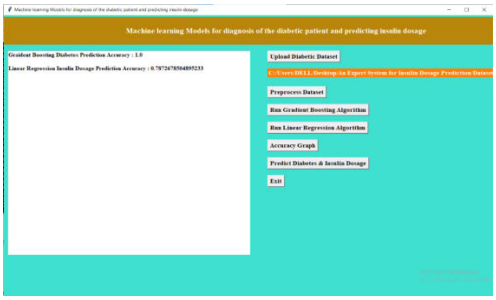

Fig.8. Linear Regression Algorithm

After the Gradient Boosting Algorithm we use the Linear Regression Algorithm to predict the insulin dosage amount for the diabetic patients which is detected by the Gradient Boosting Algorithm.

In above screen with linear regression Algorithm we got 78% accuracy compared to Gradient Boosting Algorithm the linear regression algorithm accuracy is less but it gives maximum accuracy to predict the insulin dosage amount for the diabetic patients

Accuracy Graph

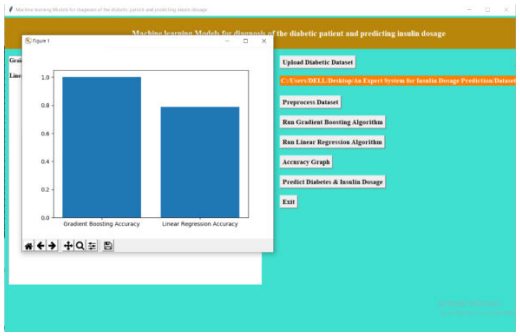

Fig .9. Accuracy graph

After we run the Linear Regression Algorithm next step is the Accuracy graph that is how much accuracy both the algorithms are giving that is shown in the form of graph. By clicking on the 'Accuracy Graph' button we can get the Accuracy graph.

Next step is to predict the diabetes and insulin dosage amount for the patients who are having diabetes.

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Predict diabetes and insulin dosage

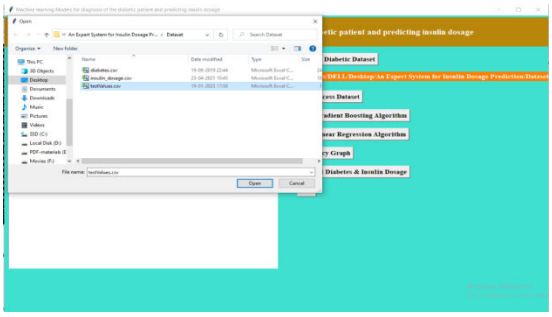
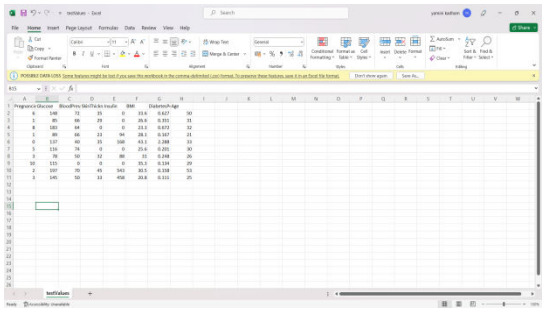


Fig.10. predict diabetes and insulin

To predict the diabetes and insulin dosage amount we have to select and upload 'testValues.csv' file and then click on 'Open' button to get the values of diabetes and insulin dosage amount. All the trained and tested data is stored in the 'testValues.csv' file.

By selecting the file and uploading it we get the final result which is diabetes and insulin dosage amount values for the patients.



In the above screen when we observe the 11th record the values are taken randomly and save it. After that upload the test values set and it will predict whether a patient is diabetic or not ,if a patient is diabetic it will predict the insulin dosage.

It predicts the patient is diabetic and also predicts the required insulin dosage for the patient.

Result

In above screen as we can see in square bracket those are the test values which we have taken by various parameters and after square bracket we can see predicted result as 'No Diabetes Detected' or 'Diabetes Detected' it is by using the Gradient Boosting Algorithm and if diabetes detected then linear regression will predict insulin dosage amount that the diabetic patient have to be taken for their health.

If the diabetes are detected the it gives the proper insulin dosage amount to be taken for the patient if the diabetes is not detected it shows 'No Diabetes Detected' then it will be no problem to the patients.

VII. CONCLUSION

The study described in the publication employed a neural network model to predict the appropriate insulin dose for diabetes individuals. The particular model used in the study was based on Backpropagation (BP)-trained Gradient Boosting. For every patient, the model receives four input parameters: gender, blood sugar level, weight, and length.

Data from 180 patients was used in the study's experiments. Diabetes was predicted using the Gradient Boosting Algorithm, and the insulin dose was predicted using the

Linear Regression Algorithm if diabetes was found.

In contrast to the Linear Regression Algorithm, the Gradient Boosting Algorithm showed quick convergence and good performance, according to the data reported in the study. This implies that the Gradient Boosting model performed better at anticipating diabetes and figuring out how much insulin diabetic people should take.

REFERENCES

[1] Cho, J., Choi, Y. J., Sohn, J., Suh, M., Cho, S. K., Ha, K. H., ... & Shin, D. C. (2015). Ambient ozone concentration and emergency department visits for panic attacks. Journal of Psychiatric Research, 62, 130-135.

[2] Power, M. C., Kioumourtzoglou, M. A., Hart, J. E., Okereke, O. I., Laden, F., & Weisskopf, M. G. (2015). The relation between past exposure to fine particulate air pollution and prevalent anxiety: observational cohort study. bmj, 350.

[3] Rotko, T., Oglesby, L., Künzli, N., Carrer, P., Nieuwenhuijsen, M. J., & Jantunen, M. (2002). Determinants of perceived air pollution annoyance and association between annoyance scores and air pollution (PM2. 5, NO2) concentrations in the European EXPOLIS study. Atmospheric Environment, 36(29), 4593-4602.

[4] Llop, S., Ballester, F., Estarlich, M., Esplugues, A., Fernández-Patier, R., Ramón, R., ... & Iñiguez, C. (2008). Ambient air pollution and annoyance responses from pregnant women. Atmospheric Environment, 42(13), 2982-2992.

[5] Brook, R. D., Rajagopalan, S., Pope III, C. A., Brook, J. R., Bhatnagar, A., Diez-Roux, A. V., ... & Kaufman, J. D. (2010). Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American Heart Association. Circulation, 121(21), 2331-2378.

[6] Cho, J., Choi, Y. J., Sohn, J., Suh, M., Cho, S. K., Ha, K. H., ... & Shin, D. C. (2015). Ambient ozone concentration and emergency department visits for panic attacks. Journal of Psychiatric Research, 62, 130-135.

[7] Sass, V., Kravitz-Wirtz, N., Karceski, S. M., Hajat, A., Crowder, K., & Takeuchi, D. (2017). The effects of air pollution on individual psychological distress. Health & place, 48, 72-79.

[8] Rotko, T., Oglesby, L., Künzli, N., Carrer, P., Nieuwenhuijsen, M. J., & Jantunen, M. (2002). Determinants of perceived air pollution annoyance and association between annoyance scores and air pollution (PM2. 5, NO2) concentrations in the European EXPOLIS study. Atmospheric Environment, 36(29), 4593-4602.

[9] Xu, W., Ding, X., Zhuang, Y., Yuan, G., An, Y., Shi, Z., & Hwa Goh, P. (2020). Perceived haze, stress, and negative emotions: An ecological momentary assessment study of the affective responses to haze. Journal of health psychology, 25(4), 450-458.

[10] Lu, J. G., Lee, J. J., Gino, F., & Galinsky, A. D. (2018). Polluted morality: Air pollution predicts criminal activity and unethical behavior. Psychological science, 29(3), 340-355