

Ensemble based Model for Diabetes Prediction and COVID-19 Mortality Risk Assessment in Diabetic Patients

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Abstract: - Millions of individuals worldwide suffer from a chronic ailment known as diabetes, which can harm several organs, including the kidneys, eyes, and heart arteries. Diabetes patients are those who are most impacted by COVID-19. This study explores machine learning techniques for predicting diabetes and assessing COVID-19 mortality risks for diabetic patients. The study was conducted on diabetes and covid 19 datasets containing patients' demographic and clinical features. The machine learning techniques Support Vector Machine, Random Forest, Multilayer Perceptron, Naive Bayes, and Logistic Regression are used on both datasets. Additionally, their combination is employed to improve the performances of the models. These algorithms' accuracy, precision, recall, and F1-score were evaluated to determine their performance in predicting diabetes and COVID-19. By making this enhancement, healthcare services could use less time, labor, and resources while also making decisions with more reliability. The study results showed that the ensemble model had the highest accuracy in predicting diabetes and covid 19. The study also found that older age, higher HbA1c levels, and comorbidities significantly predict mortality risk in diabetic patients with COVID-19. The study concludes that machine learning techniques can help predict diabetes and assess COVID-19 mortality risks in diabetic patients. These findings could aid in developing effective prevention and treatment strategies for diabetes and COVID-19.

Keywords: Accuracy, Covid 19, Diabetes, Ensemble technique, Machine learning.

1. Introduction

Across the world, millions of individuals suffer with diabetes, a chronic metabolic illness. Due to the body's inability to make or use insulin properly, it is characterised by high blood sugar (glucose) levels. Diabetes increases the risk of developing various complications such as cardiovascular diseases, kidney problems, nerve damage, and eye problems. The COVID-19 pandemic caused by the novel coronavirus (SARS-CoV-2) has become a global health crisis, affecting millions of people worldwide. People

with underlying health conditions such as diabetes are at increased risk of severe illness and death from COVID-19. COVID-19 infection in people with diabetes can cause more severe symptoms, including respiratory distress, acute respiratory distress syndrome, and multi-organ failure. The interaction between diabetes and COVID-19 is complex and not yet fully understood. Emerging findings reveals that people with diabetes may be more susceptible to severe COVID-19 infection and mortality. This risk may be due to several factors, including impaired immune function,

chronic inflammation, and underlying cardiovascular disease.

In this experiment, we examine how diabetes affects COVID-19 consequences, risk factors for severe COVID-19 illness in patients with diabetes, and possible mechanisms underlying the link between diabetes and COVID-19 infection. We will also discuss the management of diabetes in the context of COVID-19, including the impact of COVID-19 on diabetes management and the importance of maintaining good glycemic control in diabetic patients during the pandemic. Overall, understanding the relationship between diabetes and COVID-19 is crucial in developing effective strategies to prevent severe illness and death in diabetic patients infected with COVID-19. This research can help inform public health policies and clinical practice guidelines to better manage the health of diabetic patients during the ongoing pandemic.

A growing number of healthcare institutions are utilizing machine learning techniques, including predictive modeling, to advance healthcare. Sophisticated algorithms are employed to detect hidden patterns and processes beyond human perception. These techniques aid in the discovery of novel treatments and drugs. Predictive modeling, which utilizes data mining, machine learning, and statistical methods, identifies patterns in data and assesses the likelihood of future outcomes. In this paper, we propose a diabetes prediction system for early diagnosis and Covid 19 prediction of diabetes patients.

Our work focuses on the following points:

(1) To make an effective decision about the diagnosis of diabetes, it is essential to establish a system architecture for diabetes prediction based on ML algorithms. It is also necessary to evaluate distinct ML models in order to find the optimal model.

(2) Results of the best ensemble model have been contrasted to those of other well-known ML classifiers, including LR, SVM, NB, MLP, KNN, and RF.

(3) Additionally, we contrast our suggested method with leading-edge approaches that made use of the same experimental protocol, and performance assessments.

The remaining work components are listed below: Section II describes the various studies on the Covid 19 diabetes risk factors. Section III provides a comprehensive explanation of the methodology. The simulated data and an analysis are presented in Section IV. The study's conclusion is summarized in Section V.

2. Related Work

In fact, machine learning algorithms are frequently utilised in healthcare systems to make decisions based on clinical data. Numerous researchers have employed them for the diabetes diagnosis in this aspect. Numerous researchers have studied the relationships between covid 19 diabetic

patients, but they only conduct patient case studies. Here, we work on a case study and develop a prediction model for Covid 19 diabetics. [1] suggested that Deep Learning model outperform using ML techniques for diabetes prediction system. [2] In this study a standard PIMA Indian Diabetes dataset is used for evaluation. The investigation shows that LSTM improves the significant diabetes prediction with 87.26% accuracy, whereas MLP surpasses other classifiers with 86.08% accuracy. [3] To train the ANN models, the author employs a range of neurons in the hidden layer, ranging from 5 to 50., The experimental results demonstrate that the ABP-SCGNN model, which has 20 neurons, achieves 93% accuracy on the validation set, which is superior than the predictions made by the other ANNs models. [4] The classification accuracies were approximately 78% for the PID dataset after applying the ensemble technique Max Voting, and it was around 93% for Vanderbilt, which is based on a research study on rural African Americans in Virginia after employing the ensemble techniques Max Voting, and Stacking.

Following is a discussion of a few of Covid 19 mortality prediction of diabetic patient's articles. [5][6] It has been noted that COVID-19 patients with diabetes are more likely to require ICU admission and have higher mortality rates. This article displays the overall study review characteristics. The second most frequently occurring comorbidity among 1382 patients (mean age 51.5 years, 798 males) was determined to be diabetes mellitus (DM). The risk of ICU admission was remarkably greater for diabetic patients out of 471 patients (mean age 56.6 years, 294 males). Again, DM was the second most common chronic condition after arterial hypertension (HT). Patients with diabetes had a higher mortality risk as a result. [7], [8]The author concludes that out of 41 patients during one of the first short series in Wuhan, a city badly affected by the virus, 20% had diabetes, and 15% had hypertension. [9][10] Some other communities of 140 admitted to the hospital and exposed to the virus included 12%, diabetic patients. [11] In this analysis, 3% of diabetic had symptoms that persisted for more than 10 days; moreover, the small number of patients involved has been challenging to determine this prevalence. [12] Similarly, in an evaluation of 12 surveys conducted in China, out of 2018 infected patients, 10.3% were diabetes cases, comparable to the majority of diabetic patients in China in 2013, which was 10.9% for all age ranges. [13] The ratio of diabetic patients was higher among the 5700 COVID-19 patients hospitalised, Among the patients included, 34% had diabetes, 57% had hypertension, and 42% were obese in the New York City area in April (median age 63 years; 40% female). [14] A significant global explanatory analysis revealed that 14.3% of the 8910 COVID-19 patients included had diabetes mellitus. [15] [[16]The author reviewed and recommended that diabetes was related to a higher mortality rate, according to a meta-analysis (RR 2.12). [17], [18] In this study, the author

discovered that in comparison to pre-existing diabetes, newly-detected diabetes and admission hyperglycemia were more significantly linked with the COVID-19 severity outcome.

3. Methodology

The proposed Covid 19 Mortality risk prediction system and diabetes illness prediction system include a number of processes that are precisely interconnected to

provide the desired outcomes. The first phase involves preparing the data, followed by dividing the datasets into two groups: training data and testing data. In order to complete the training phase utilising the training samples with the best parameters, we next applied two separate categories (ML and their combinations). Over time, the trained models will be able to forecast the test samples. Figure 1 displays the conceptual flowchart for the suggested system.

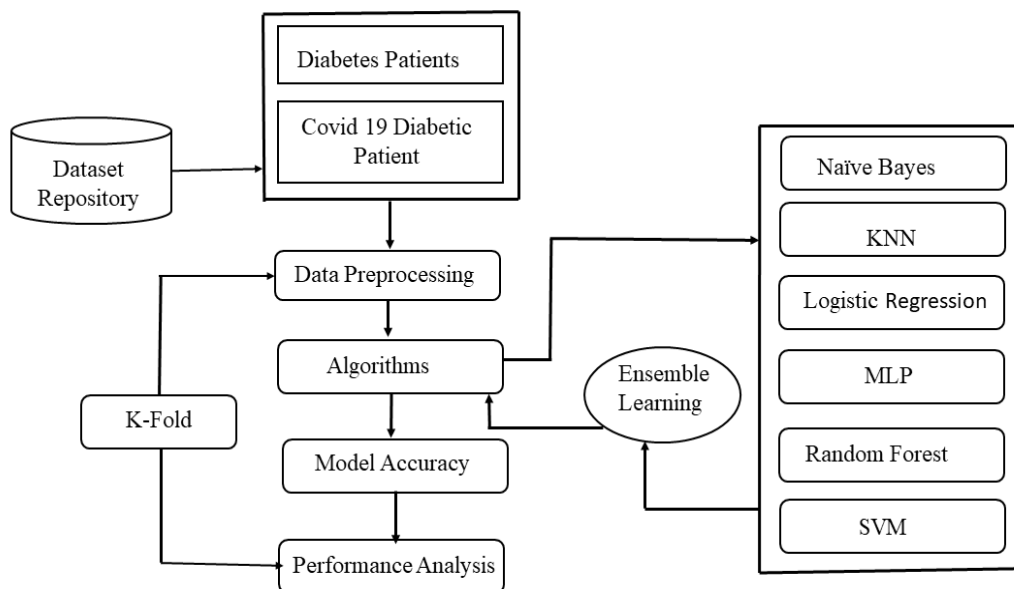


Fig. 1 Proposed Methodology system design

For this analysis, information was gathered from electronic medical records of patients who had been given confidentiality. The data is cleaned through a variety of preprocessing methods. Shapley Additive explanations

4. Results and Discussion

4.1 Clinical Data

We used the well-known diabetes dataset obtained from the Frankfurt Hospital in Germany to assess the effectiveness of this research. 2000 records with nine attributes are included in this dataset. Considering that all of the patients in this dataset are female and range in age from 21 to 81, 32.4% of the records had a value of 1, and the remaining records had a value of 0 (67.6%). We retrospectively analysed data on patients with diabetes and COVID-19 diabetics. This dataset contains an enormous number of anonymized patient-related information, including pre-conditions. The diabetes dataset contains 18 features and

methods are used to determine a feature's importance. Several machine learning classifiers are utilised for classification, and an ensemble of different techniques is employed to improve the model's performance.

520 instances. The Covid 19 diabetes dataset consists of 21 unique features and 10,48,576 unique records of the patients. Of these, 1,22,415 patients have diabetes, and 9,02,737 are non-diabetic people. The dataset has 5,13,216 female and 5,11,936 male person records.

4.2 Data Preprocessing

Data preparation is an important stage that converts the data into a useful and efficient format that can be fed into the machine learning algorithm. Data normalisation technique employed in our system for data preprocessing. The diabetes dataset contains 2000 instances and 9 attribute. The dataset contains some missing values which is filled by mean method. The Covid 19 dataset involved 10,48,576 patients. We found that individuals with diabetes were older than those without it and more likely to have hypertension,

dyslipidemia, cardiovascular disease, and chronic kidney disease. The ICU, pregnant, and imbued features have a higher percentage of missing values in the dataset. The association must also be higher to enhance the data quality; we eliminate these features. Some features contain missing values. We are imputing these values using the mean methods to improve the classifier's performance. The

correlation between the features is shown in Fig. 1. (b) We can see that Covid 19 strongly correlates with diabetes and hypertension. The target feature records are imbalanced. The data distribution concern is depicted in Fig. 1 (a). Since the dataset contains many samples, we are creating a balanced dataset using a random under-sampling technique.

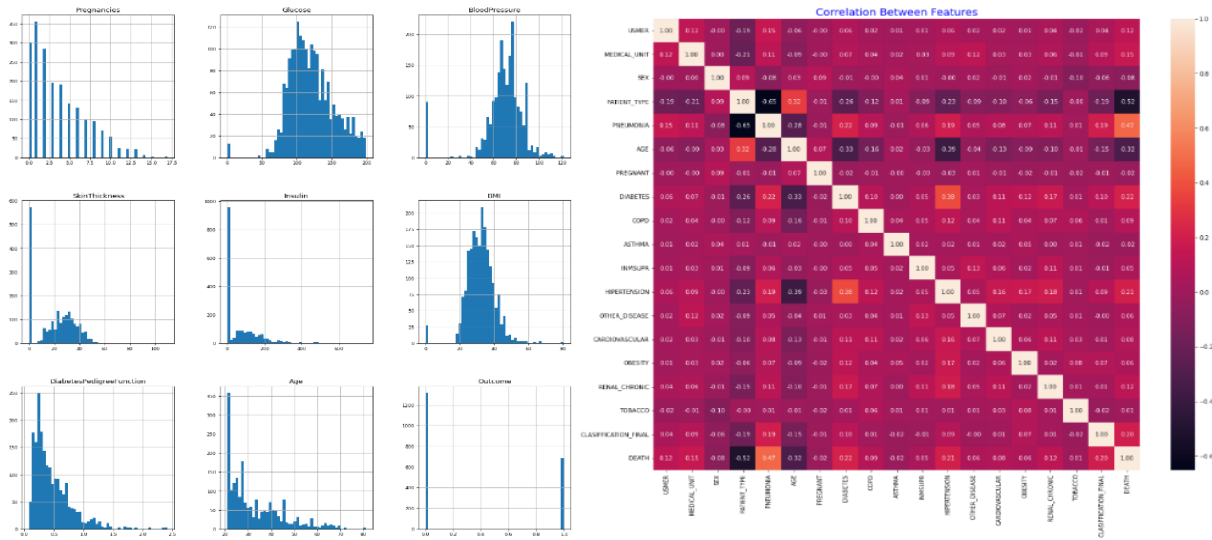


Fig. 2 Data Visualization of the features

4.3 Classifiers

4.3.1 Logistic Regression

Logistic regression [4] is a widely used machine learning algorithm that belongs to the Supervised Learning technique and is based on the probability concept. It is a classification algorithm used for predictive analysis. From a collection of independent variables, it correctly predicted the categorical dependent variable. In equation 1, the logistic regression cost function is shown, an "S"-shaped logistic function is fitted instead of a regression line, and it predicts two maximum values (0 or 1).

$$f(x) = \frac{1}{(1 + e^{(-x)})} \tag{1}$$

4.3.2 Multilayer Perceptron

(MLP) is a type of artificial neural network (ANN) [19] that is widely used in machine learning and artificial intelligence applications. It is also known as a feedforward neural network, because information flows forward through the network without any feedback connections. An MLP consists of multiple layers of interconnected nodes (neurons) arranged in a hierarchical manner. The input layer receives

the input data, which is then processed by the hidden layers, and finally the output layer produces the desired output. Each neuron in the network receives input signals from the previous layer and produces an output signal that is transmitted to the next layer. without any feedback connections.

4.3.3 Support Vector Machine

(SVM) is a machine learning algorithm [20]used for classification and regression analysis. The main idea behind SVM is to find the best decision boundary (or hyperplane) that separates the data into different classes. In classification tasks, SVM tries to find the hyperplane that maximizes the margin, i.e., the distance between the hyperplane and the closest data points of each class. These closest data points are called support vectors, hence the name Support Vector Machine. SVM can handle both linearly separable and non-linearly separable data by using different kernel functions. A kernel function transforms the input data into a higher dimensional space where it can be linearly separated.

4.3.4 Random Forest

Random Forest [21] is a popular ensemble learning algorithm that is widely used in machine learning for classification, regression, and other prediction tasks. It is a type of decision tree-based algorithm that combines multiple decision trees to make more accurate and robust predictions. Random Forest works by creating a large number of decision trees (also known as base learners) that are trained on different subsets of the input data, and using their collective predictions to make a final prediction. Each tree in the forest is trained on a random subset of the input data and a random subset of the input features, making them less prone to overfitting and more capable of capturing the true underlying patterns in the data.

4.3.5 Naive Bayes

Naïve Bayes [22] is a simple yet powerful probabilistic algorithm that is widely used in machine learning for classification tasks. It is based on Bayes' theorem, which is a mathematical formula that describes the probability of an event based on prior knowledge of related conditions. The Naive Bayes algorithm assumes that the features (or input variables) in the data are independent of each other, hence the name "naive". This simplifying assumption makes it computationally efficient and easy to implement, even with large datasets. To use the Naive Bayes algorithm for classification, we first train a model on a labeled dataset. During the training phase, the algorithm estimates the probability of each class based on the frequency of its occurrence in the training data. It also computes the conditional probability of each feature given each class.

4.3.6 K-Nearest Neighbor

The supervised machine learning algorithm KNN, also known as k-nearest neighbors [23], is extensively used for classification and regression tasks. It is a non-parametric method, hence it makes no assumptions about the distribution of the data at its core. The KNN method locates the k nearest neighbours in the feature space to a given data point. Using a distance metric, such as the Euclidean distance or Manhattan distance, the distance between the data points is determined. Once the k nearest neighbors are identified, the algorithm makes a prediction by taking the majority class or mean value of the target variable among those k neighbors.

To compute the distance between data points, the Euclidean distance formula is typically used

$$distance(x, y) = \sqrt{((x_1 - y_1)^2 + (x_2 - y_2)^2 + \dots + (x_n - y_n)^2)} \quad (2)$$

Evaluation Metrics and Experimental Results

This section explores the efficiency, effectiveness, and satisfaction of the proposed method for detecting T2D and Covid 19 in diabetics. The confusion matrix (Figure 6) is an excellent tool for summarizing the results of a classification model and identifying any classification issues [24]. The classification process can result in one of four possible outcomes: True Positive (TP), False Negative (FN), True Negative (TN), and False Positive (FP) [25]. By using the confusion matrix in Figure 6, it is easy to assess the performance of the developed predictive model. The proposed model is evaluated using the following metrics [25].

In the testing phase, Accuracy (Acc.) measures the percentage of accurate predictions that a classifier has generated in comparison to the true values of the target.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} * 100\% \quad (3)$$

During the test, Sensitivity (Sens.) provides details about the percentage of True Positives that are accurately classified.

$$Sensitivity = \frac{TP}{TP + FN} * 100\% \quad (4)$$

During the test, Specificity (Spec.) provides information regarding the percentage of True Negatives that are precisely classified.

$$Specificity = \frac{TN}{TN + FP} * 100\% \quad (5)$$

Precision (Pre.) refers to the accuracy of a classifier in identifying positive instances, expressed as the percentage of instances labeled as positive out of the total predicted positives.

$$Precision = \frac{TP}{TP + FP} * 100\% \quad (6)$$

The F1-Score is a metric that measures the overall performance of a binary classification model based on both its precision and recall. It is the harmonic mean of precision and recall, and its value ranges from 0 to 1, where 1 indicates perfect precision and recall, and 0 indicates poor performance. F1-Score is calculated as:

$$F1\ Score = \frac{2 * TP}{2 * TP + FN + FP} * 100\% \quad (7)$$

Table 2. Performance evaluation for diabetes prediction and Covid 19 diabetics patients.

Evaluation Metrics		
	Frankful Hospital Diabetes Patients	Covid 19 Diabetics Patients

	Acc.	Pre.	Spec.	Sens.	F1-measure	Acc.	Pre.	Spec.	Sens.	F1-measure
LR	98	96	97	98	97	92	90	90	90	90
MLP	98	97	98	98	97	95	92	93	95	93
SVM	97	98	97	97	97	92.5	92	92	92	92
KNN	98.2	97	98	97.5	97	96	96	96	96	96
NB	97	97.4	97	97	97	90	92	92	92	92
RF	98.3	98	98	98	98	93	94	93.5	94	94

The accuracy and other performance metrics for prediction models are shown in Table 2 along with their respective values. In terms of predicting diabetes, the proposed machine learning model generated better results.

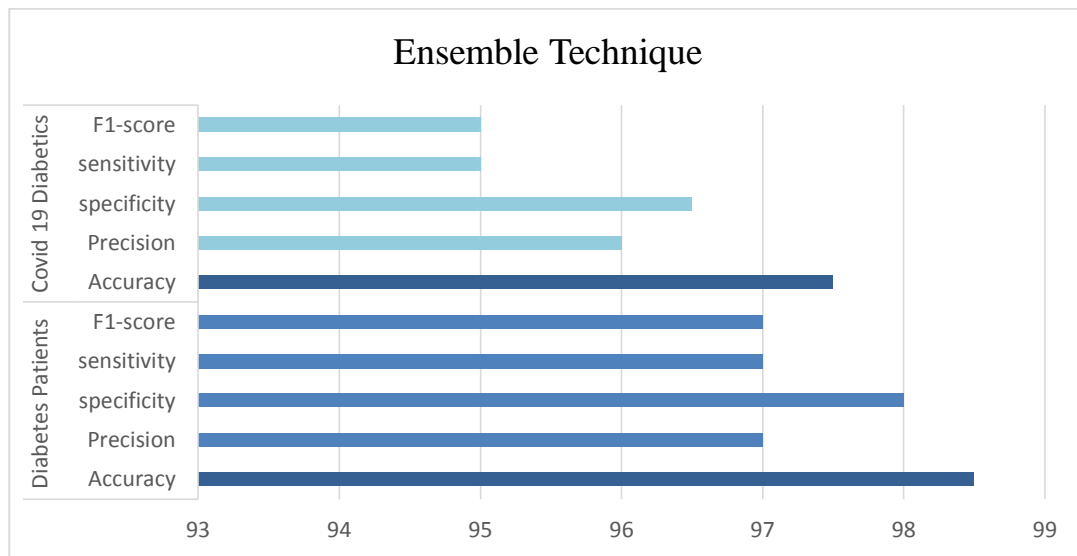


Fig. 4. Comparing performance metrics of ensemble method

Fig. 4 gives the information about the classification results of ensemble technique. The model achieves 98.5% accuracy in

case of diabetes prediction and in case of covid 19 prediction it achieves 97.5% accuracy.

5. Conclusion and Future Scope

In conclusion, this research paper demonstrated the effectiveness of machine learning techniques in predicting diabetes and assessing COVID-19 mortality risk for diabetic patients. The findings suggest that machine learning algorithms, when trained on appropriate datasets, can accurately predict the onset of diabetes and help identify high-risk patients for COVID-19 mortality. In order to forecast the development of diabetic disease, we use Naive Bayes, Logistic Regression, Random Forest, and Support Vector Machine approaches. A real dataset is taken from Kaggle and analysed using the suggested mechanism. Performance is evaluated using accuracy, precision, recall and F1- score matrices. When compared to other models, the accuracy of the ensemble model is high for both datasets.

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These techniques have the potential to aid in early diagnosis and treatment of diabetes, as well as in personalized risk assessment for COVID-19 diabetics. The research highlights the importance of leveraging technology in healthcare and encourages further exploration of machine learning techniques in diabetes prediction and risk assessment for COVID-19. Overall, this study contributes to the ongoing efforts to improve the quality of care for diabetic patients and promote better health outcomes. In the future, we'll provide a tool for medical professionals. that is incredibly beneficial for both patients and healthcare providers

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