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Enhancing Diabetes Management through Ensemble Models and Cloud-Based Big Data Analytics for Personalized Detection and Diet Planning

Dr. P. Rama Koteswara Rao[1*], Y. Shiva Kumar[1], K. Shanmuhk[1], S. Sneha Reddy[1], B. Mamatha[1]

[1]Department of Computer Science and Engineering (AI & ML), Sree Dattha Institute of Engineering and Science, Hyderabad, Telangana, India

[*]Corresponding E-mail: prkr74@gmail.com

Abstract

Millions of people suffer from chronic diabetes. It needs constant monitoring and control to avoid problems. Technology has shifted healthcare toward data-driven disease detection, monitoring, and individualized treatment methods. Big Data analytics, especially in healthcare clouds, can analyze massive patient data to improve diabetes control. Traditional diabetes detection and diet planning use rule-based algorithms or rudimentary machine learning models. These systems may not capture complex data linkages or respond to patient health changes. They may not completely utilize cloud-based large-scale healthcare data. However, present diabetes detection and diet planning systems frequently lack the sophistication to manage patient data complexity and unpredictability. The sheer volume of healthcare data in cloud systems makes processing and extracting relevant information difficult. A more advanced approach is needed to improve diabetes care accuracy, efficiency, and customisation. Modern analytics and machine learning are needed to improve diabetes detection and provide personalized food recommendations for each patient. Therefore, this effort intends to construct a user interface and cloud model using an ensemble architecture for diabetes detection and diet planning, which will revolutionize healthcare analytics. Ensemble frameworks capture detailed data patterns better than individual models, improving diabetes prediction and diet planning. Ensemble models excel at healthcare large data clouds' dynamic and diverse nature due to their robustness and adaptability. Ensemble frameworks scale to process vast amounts of healthcare data efficiently, enabling real-time analytics and decision-making. The transformative potential to improve diabetes management precision, adaptability, and efficiency improves patient care and outcomes.

Keywords: Ensemble Model, Diabetes Detection, Diet Plan Suggestion, Healthcare, Internet of Medical Things

1. Introduction

Diabetes has been a persistent health concern throughout human history, with records dating back to ancient civilizations. Early medical texts, such as those from ancient Egypt and Greece, describe symptoms resembling diabetes and propose treatments involving dietary modifications and herbal remedies. However, it was not until the 20th century that significant advancements were made in understanding the physiology and treatment of diabetes. The discovery of insulin in the 1920s marked a turning point in diabetes management, allowing individuals with diabetes to regulate their blood sugar levels effectively. Over the decades, medical research and technological innovation have continued to shape the landscape of diabetes care. The advent of glucometers in the mid-20th century revolutionized blood glucose monitoring, providing patients with a means to track their blood sugar levels at home. Subsequent developments in pharmaceuticals, such as oral hypoglycemic agents and insulin analogs, have further improved diabetes management and control.

In recent years, the proliferation of digital health technologies and the rise of big data analytics have ushered in a new era of diabetes care. Electronic health records (EHRs), wearable devices, and mobile health applications have enabled the collection of vast amounts of patient data, offering unprecedented insights into disease patterns and treatment outcomes. Additionally, advances in machine learning and artificial intelligence have opened up new possibilities for leveraging healthcare data to optimize disease detection, management, and personalized treatment strategies.

The motivation behind the development of an ensemble framework-based diabetes detection and diet plan suggestion system stems from several key factors. Firstly, the rising prevalence of diabetes globally underscores the need for innovative approaches to disease detection and management. With millions of individuals affected by diabetes, there is a growing imperative to harness the power of technology and data analytics to improve patient outcomes and quality of life. Furthermore, the limitations of existing diabetes detection and diet planning methods highlight the need for more sophisticated and personalized approaches. Rule-based systems and simple machine learning models may not adequately capture the complexity of diabetes data or adapt to individual patient needs. As such, there is a compelling motivation to explore advanced analytics techniques, such as ensemble frameworks, to enhance the accuracy and efficacy of diabetes management strategies.

Moreover, the emergence of healthcare big data clouds presents a unique opportunity to leverage vast amounts of patient data for disease detection and personalized treatment planning. By harnessing the scalability and computational power of cloud computing, healthcare providers can analyze large datasets in real-time and derive actionable insights to inform clinical decision-making.

2. Literature Survey

Kaur et al. have introduced a cloud IoT-based framework named CI-PDF for diabetes prediction considering accuracy, sensitivity, and specificity as evaluative parameters on the PIDD dataset and claimed to have achieved 94.5% of prediction accuracy by combining neural network (NN) and DT approaches [1]. Barik et al. have introduced FogLearn, a fog computing-based framework for the application of -means clustering in Ganga River Basin Management and real-world feature data for detecting diabetes patients suffering from diabetes mellitus and found that fog computing holds a lot of promise for medical and geospatial big data analysis [2].

Gia et al. have developed a fog-based structure for remote health monitoring and fall detection. The system provides numerous progressive amenities such as ECG feature extraction, security, and locally distributed storage. In addition, the system operates accurately, and the wearable sensor node is energy efficient [3]. Devarajan et al. proposed an energy-efficient fog-assisted healthcare system that manages glucose levels based on evaluative measures such as energy efficiency, prediction accuracy, computational complexity, and latency on two datasets from the UCI repository diabetes dataset and the Physical Activity Monitoring Dataset (PAMAP2). The experimental results show that fog over cloud computing has increased bandwidth efficiency, reduced latency, and enhanced accuracy [4]. Abdel-Basset et al. have suggested a novel framework based on computer-propped diagnosis and IoT to detect and observe type 2 diabetes patients and indicated the validity and robustness of the proposed algorithms considering accuracy and execution time as the performance evaluators [5].

Haq et al. have developed a filter method based on the DT-ID3 (Iterative Dichotomiser 3) model for essential feature selection in comparison to two ensemble learning algorithms, Ada Boost and RF, using prediction accuracy and computation time as evaluative measures, and found that the DT algorithm based on selected features improves the classifier’s performance [6]. Kumari et al. have proposed an ensemble voting classifier that uses the ensemble of three ML algorithms, viz., LR, NB, and RF for the classification considering the evaluative measures like accuracy, precision, recall, and -score on PIDD and claimed to have achieved comparatively enhanced results on binary classifications [7]. Geetha and Prasad have built a hybrid model named T2DDP that doctors can effectively use to treat diabetic patients by employing supervised classification algorithms such as NB and ensemble algorithms like bagging with RF and AdaBoost for DT and found that the forecast will be submitted to the patient's cell phone at an early stage to make the immediate decisions about the health risk [8]. Shynu et al. have introduced efficient blockchain-based secure healthcare services for disease prediction in fog computing, considering purity, normalized mutual information (NMI), and accuracy as performance evaluators on PIDD and Cleveland heart disease dataset (CHDD) and thereby claimed that the proposed work efficiently clusters and predicts the disease compared to other methods [9].

Singh et al. have introduced an ensemble-based framework named eDiaPredict employing XGBoost, SVM, RF, NN, and DT to predict diabetes status among patients considering performance parameters like accuracy, sensitivity, specificity, Gini Index (GI), precision, the area under the curve (AUC), the area under the convex hull (AUCH), minimum error rate (MER), and minimum weighted coefficient (MWC) on PIDD and claimed that the proposed model could provide patients with a practical and precise prediction of diabetes based on glucose concentrations [10]. Rajput et al. have proposed a reference model for assisting rural people in India who have diabetes in characterizing two diabetes victims at an early stage using KNN, LR, SVM, RF, DT, and NB classifiers, considering accuracy, misclassification rate (MCR), recall, precision, prevalence, and -score as evaluative parameters on PIDD, and claimed to have achieved improved communication and interaction between patients [11].

3. Proposed Methodology

The Ensemble Framework-based Diabetes Detection and Diet Plan Suggestion system aims to provide a user-friendly interface for individuals to monitor their health status and receive personalized diet recommendations. By leveraging machine learning algorithms and cloud computing, the system offers accurate predictions regarding the likelihood of type 2 diabetes based on user data as shown in Figure 1.

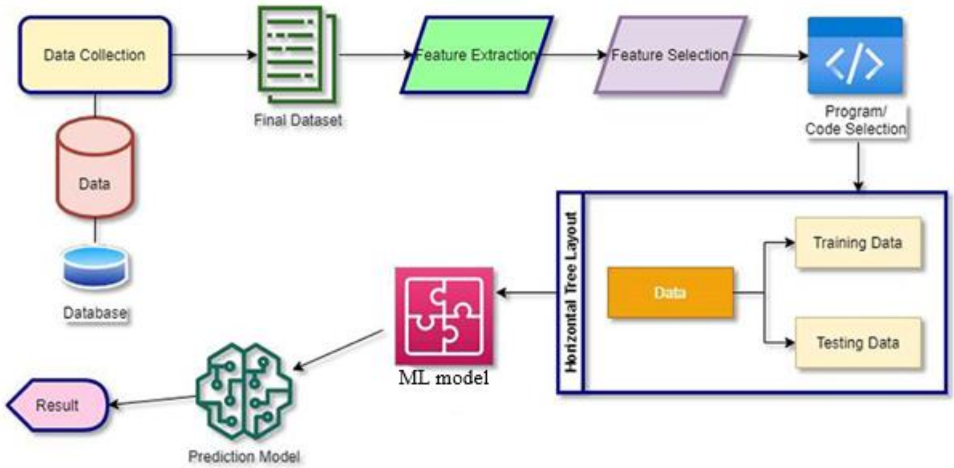

Figure 1. System architecture of proposed diabetes prediction model.

User Side

— The user side interface enables users to upload their health data files and receive real-time predictions from the cloud server. Upon selecting a file, the system reads the data and sends it to the server via a socket connection. It also retrieves a diet plan from a local file for users with abnormal health indicators.

- The interface displays the sent data and predictions received from the server, allowing users to track their health status and receive dietary recommendations if necessary. This component provides a seamless experience for users to engage with the system and take proactive measures towards improving their health.

Cloud Side

- The cloud side application serves as the backend of the system, handling data processing, model training, prediction, and communication with the user side. It offers functionalities for preprocessing datasets, training machine learning models, and evaluating their performance.
- The system supports multiple machine learning algorithms, including Decision Tree, SVM, and ANN, to analyze user data and make predictions regarding type 2 diabetes. An Ensemble Classifier model is also implemented, which combines the predictions of individual models to improve accuracy.
- The cloud side application acts as a server, listening for incoming connections from the user side. Upon receiving data, it performs predictions using the trained models and sends back the results. It also provides visualizations of algorithm accuracy to help users understand the performance of each model.

4. Results and Discussion

Figure 3 presents a performance comparison graph that visually depicts the performance metrics of all machine learning models used in the Diabetes Detection system. This graph provides a comprehensive overview of each model's performance, enabling users to identify trends and disparities among them. Performance metrics such as accuracy, precision, recall, and F1-score are typically evaluated and plotted on the graph. By presenting these metrics in a graphical format, users can easily interpret and compare the effectiveness of different models in predicting diabetes.

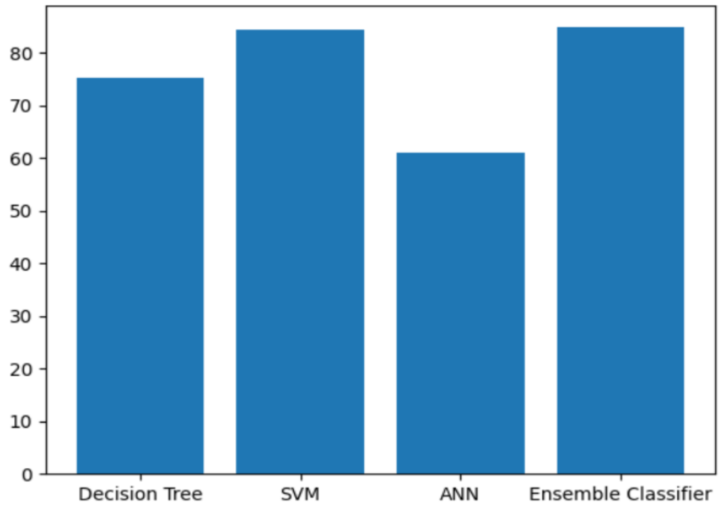

Figure 3: Presents the performance comparison graph of all models.

Figure 5 demonstrates the model prediction process on the uploaded test data within the user side GUI. Once the user uploads their healthcare dataset, the system utilizes machine learning models to predict the likelihood of diabetes based on the provided data. Prediction results are displayed in real-time on the GUI, allowing users to instantly access and interpret the outcomes. This figure provides users with actionable insights into their health status, empowering them to make informed decisions about their well-being. Figure 5 exhibits the proposed model's suggested diet plan based on the predictive analysis results. In cases where the analysis indicates the presence of diabetes or certain risk factors, the system generates personalized diet recommendations tailored to the individual's health needs. These recommendations are derived from evidence-based practices and dietary guidelines, providing users with practical strategies for managing their condition effectively.

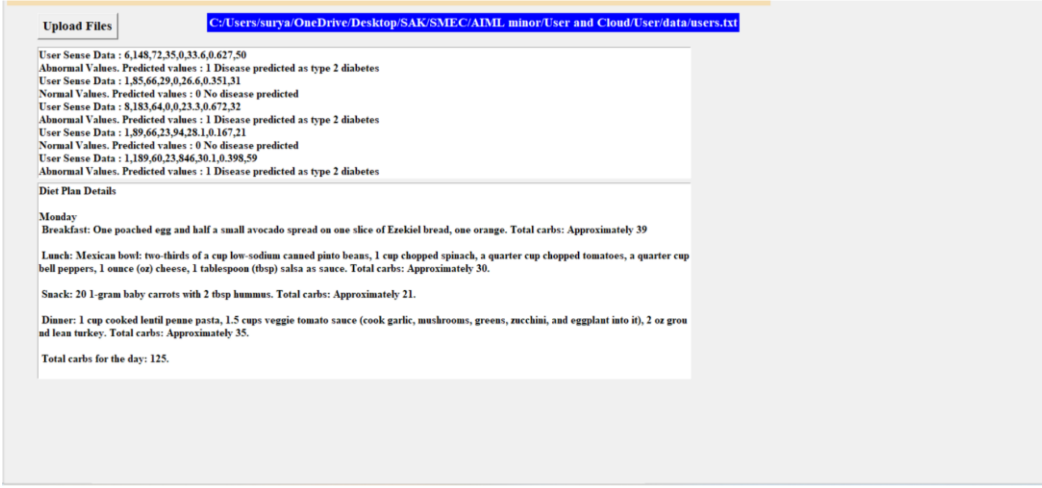

Figure 4: Model prediction on uploaded test data in user side GUI.

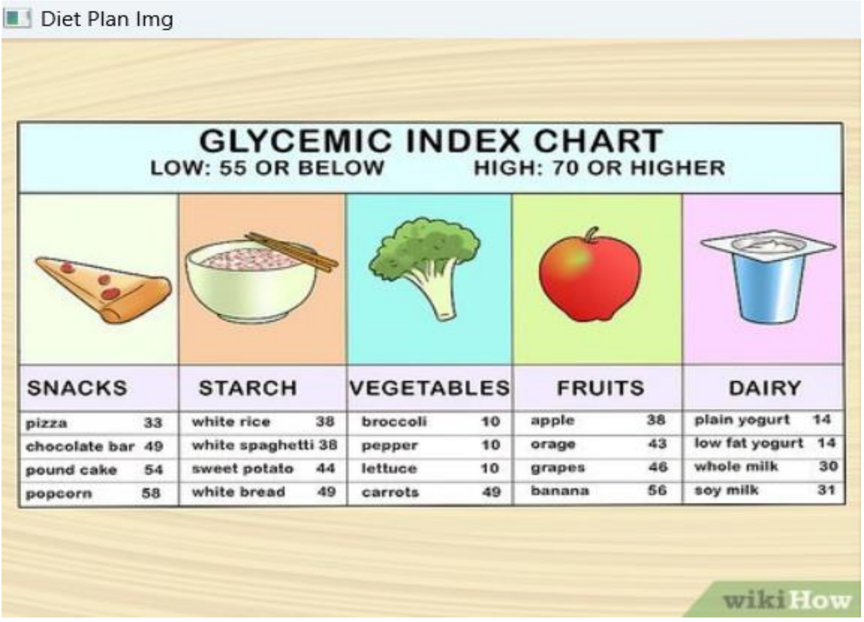

Figure 5: Shows the Proposed model suggests the desired diet.

5. Conclusion

In conclusion, the development of an ensemble framework-based system for diabetes detection and diet plan suggestion represents a significant advancement in healthcare analytics. Diabetes, being a chronic health condition affecting millions worldwide, requires continuous monitoring and personalized management to prevent complications. With the evolution of technology, particularly the advent of Big Data analytics and cloud computing in healthcare, there emerges an unprecedented opportunity to leverage vast amounts of patient data for better disease management. Traditionally, diabetes detection and diet planning have relied on rule-based systems or simplistic machine learning models, which may not adequately capture the complexity of patient data or adapt to dynamic health conditions. However, the adoption of ensemble frameworks in this context offers a promising solution. By integrating multiple models and algorithms, ensemble frameworks excel in capturing nuanced data patterns, leading to improved accuracy in diabetes prediction and the creation of personalized diet plans tailored to individual patient needs. Furthermore, the scalability of ensemble frameworks enables the efficient processing of large volumes of healthcare data, facilitating real-time analytics and decision-making. This transformative potential holds profound significance in revolutionizing healthcare analytics, ultimately leading to enhanced patient care and outcomes in diabetes management. Looking ahead, the future scope of ensemble framework-based diabetes detection and diet plan suggestion systems is promising and multifaceted. Firstly, there is a need for further research and development to enhance the sophistication and adaptability of ensemble models. This includes exploring new algorithms, optimizing model parameters, and refining ensemble techniques to achieve even greater accuracy in diabetes prediction and personalized diet planning.

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