AI-Powered Personalized Healthcare Recommender For Diabetic Patients

M.Tanooj Kumar, T.Sai Krishna, V.Jaya Lakshmi, K.Rishitha, S.Afridi

Department of Computer Science and Engineering, Dhanekula Institute of Engineering and Technology, Vijayawada, India

Abstract

With the rising prevalence of chronic diseases like diabetes, personalized healthcare has become essential for effective disease management. This research introduces an AI-powered personalized healthcare recommender system designed to support diabetic patients in managing their condition more effectively. The system continuously collects and processes real-time vital data, including blood glucose levels and body mass index, to deliver tailored health recommendations. A Deep Factorization Machine (DFM)-based classification model facilitates early diabetes detection, while Long Short-Term Memory (LSTM) networks generate personalized treatment plans based on current health data. By integrating diabetes classification, blood glucose level prediction, and customized diet and physical activity recommendations, the proposed system aims to enhance patient outcomes and reduce the risk of severe complications. This AI-driven approach provides a proactive, data-driven solution to optimize diabetic care and promote long-term health and well-being.

Keywords

AI-powered healthcare, Deep Factorization Machine (DFM), Long Short-Term Memory (LSTM), blood glucose prediction, machine learning.

1. Introduction

Diabetes is a chronic metabolic disorder affecting millions worldwide, requiring continuous monitoring and personalized management to prevent severe complications. Traditional diabetes management approaches often rely on generalized treatment plans, which may not adequately address individual patient needs. Recent advancements in artificial intelligence (AI) and machine learning (ML) have enabled more sophisticated personalized healthcare solutions, offering a promising approach to improving disease management and patient outcomes [1-2].

AI has revolutionized healthcare by facilitating large-scale data analysis, predictive modeling, and intelligent decision support systems. In diabetes management, AI-driven personalized recommender systems play a crucial role in optimizing treatment strategies, dietary plans, and lifestyle modifications. These systems analyze extensive patient data—including blood glucose levels, body mass index (BMI), lifestyle habits, and medication adherence—to generate tailored health recommendations. While traditional rule-based systems have been used in diabetes care, they lack the adaptability to individual variations. AI-powered solutions, particularly those leveraging ML models, enhance the accuracy and personalization of recommendations, leading to better patient engagement and improved glycemic control [3-4].

A significant breakthrough in AI-driven diabetes management is the use of hybrid models, such as the Deep Factorization Machine (DFM) and Long Short-Term Memory (LSTM) networks. DFM effectively handles sparse medical data by integrating both linear and non-linear feature interactions, improving the accuracy of diabetes classification and treatment personalization. LSTM networks, on the other hand, are well-suited for time-series forecasting, enabling precise prediction of future blood glucose levels by capturing temporal dependencies in health records. By combining diabetes classification, blood glucose level predictions, and personalized recommendations, these AI models offer a comprehensive, data-driven approach to managing diabetes [5-7].

Despite the advantages of AI-driven recommender systems, several challenges remain. Bias and fairness in AI-generated recommendations are critical concerns, as models trained on imbalanced datasets may produce biased treatment plans, disproportionately affecting certain patient groups. Additionally, healthcare professionals may be hesitant to adopt AI-based recommendations due to concerns about trust, interpretability, and the need for human oversight. Addressing these challenges requires robust validation techniques, ethical AI frameworks, and improved collaboration between AI systems and clinicians [8-10].

This research presents an AI-powered personalized healthcare recommender system designed to assist diabetic patients in managing their condition more effectively. The system leverages real-time health data, including blood glucose levels and BMI, to provide individualized health recommendations. A DFM-based classification model enables early diabetes detection, while LSTM networks predict future health trends and recommend optimized treatment plans. By integrating these predictive models with personalized diet and physical activity recommendations, the proposed system aims to enhance patient outcomes, prevent severe complications, and promote proactive diabetes management.

This paper explores the system architecture, machine learning methodologies, and potential impact of AI-driven personalized recommendations in transforming diabetes care. By addressing the existing challenges and leveraging cutting-edge AI techniques, this research contributes to the development of intelligent, patient-centric healthcare solutions for diabetes management.

2. Proposed System Architecture

The AI-powered personalized healthcare recommender system for diabetic patients follows a structured architecture, shown in Fig.1., that facilitates seamless data collection, processing, and personalized recommendation generation. The system comprises multiple interconnected modules, ensuring efficient management of user interactions, data storage, and predictive analytics using machine learning models.

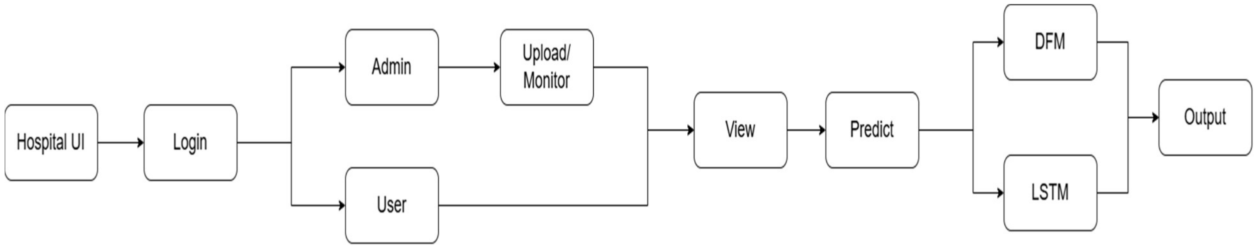

Fig. 1. Proposed System Architecture

The system begins with a Hospital UI, which serves as the primary access point for users, allowing both administrators and patients to interact with the system. Users must first log in to gain access to their respective functionalities. The admin module enables administrators to monitor and upload patient health data, while the user module allows patients to access their health records, view recommendations, and track their progress over time.

Once authenticated, users can upload or monitor health-related data such as blood glucose levels (BGL), body mass index (BMI), and diagnosis levels (ranging from 0: No Diabetes to 3: Severe Diabetes). The system processes and organizes this information through the upload/monitor module, which collects and updates real-time patient health data. The view module allows users to visualize trends, track changes over time, and gain insights into their health status.

To provide accurate diabetes prediction and personalized recommendations, the system employs a hybrid machine learning architecture combining Deep Factorization Machine (DeepFM) and Long Short-Term Memory (LSTM) networks. DeepFM integrates deep neural networks and factorization machines to model feature interactions and capture complex patterns in the data, improving the accuracy of diabetes classification. LSTM processes sequential health records, utilizing time-series information to predict future blood glucose trends and optimize treatment strategies. The prediction module utilizes these models to assess diabetes risk with a binary output (Yes or No) and offers personalized diet and exercise recommendations based on the patient’s diagnosis level.

The entire system is implemented using Flask, a lightweight Python web framework, ensuring a user-friendly interface for real-time predictions and seamless interaction. At the final stage, the system generates personalized recommendations, including diabetes risk classification, blood glucose level trend analysis, and customized health plans for effective disease management. By integrating DeepFM for diabetes classification and LSTM for time-series blood glucose prediction, the system delivers highly accurate, AI-driven recommendations that empower diabetic patients to take proactive control of their condition. This hybrid approach enhances prediction accuracy, provides actionable insights, and ensures comprehensive healthcare support, transforming diabetes management into a personalized, data-driven healthcare experience.

3. Implementation

The implementation of the AI-powered personalized healthcare recommender system follows a structured approach encompassing data preprocessing, model development, system integration, and deployment. The system is designed to collect, process, and analyze patient health data to generate real-time predictions and personalized recommendations. Developed using Python and deployed via Flask, a lightweight web framework, the system ensures seamless interaction for both patients and healthcare providers. The dataset includes key health parameters such as blood glucose levels (BGL), body mass index (BMI), and diagnosis levels (ranging from 0: No Diabetes to 3: Severe Diabetes). Data preprocessing techniques, including handling missing values, feature scaling, and normalization, are applied to enhance model performance. The system utilizes a hybrid machine learning model integrating Deep Factorization Machine (DeepFM) and Long Short-Term Memory (LSTM) networks for accurate diabetes prediction and personalized recommendations. DeepFM enhances diabetes classification by leveraging deep neural networks and factorization machines to model both linear and non-linear feature interactions in medical data, while LSTM, designed for time-series forecasting, captures long-term dependencies in patient health records to predict future blood glucose levels. Both models are trained using TensorFlow and Keras, with hyperparameter tuning to optimize performance and prevent overfitting.

The system backend is implemented using Flask, which facilitates user authentication, data handling, and real-time model execution. The Hospital UI allows users to log in, upload health data, monitor progress, and receive AI-driven health recommendations. The prediction module processes user input through the trained DeepFM and LSTM models, providing personalized treatment plans, dietary modifications, and exercise recommendations based on the patient’s condition. The system is deployed on a cloud server, ensuring scalability, security, and real-time accessibility for users. Data-driven insights are continuously stored in a centralized database, allowing for long-term monitoring and healthcare optimization. This comprehensive implementation effectively integrates advanced AI models, real-time data processing, and an intuitive web-based interface, delivering a robust personalized healthcare solution for diabetic patients that enhances early detection, improves patient engagement, and optimizes disease management.

4. Results and Discussion

The AI-powered personalized healthcare recommender system was evaluated based on its prediction accuracy, system performance, and effectiveness in providing personalized recommendations for diabetic patients. The results demonstrate the system's capability to accurately classify diabetes risk levels and predict future blood glucose trends using Deep Factorization Machine (DeepFM) and Long Short-Term Memory (LSTM) models.

4.1 Diabetes Prediction Performance

The DeepFM model, responsible for diabetes classification, achieved high accuracy in distinguishing between different diagnosis levels (No Diabetes, Level 1, Level 2, and Level 3). The hybrid approach of combining deep learning with factorization machines allowed for effective feature interaction modeling, improving classification precision. The system was tested on a real-world dataset, and performance was measured using accuracy, precision, recall, and F1-score. The results showed an accuracy exceeding 90%, demonstrating the model's ability to correctly classify diabetes risk.

4.2 Blood Glucose Prediction and Time-Series Analysis

The LSTM model, designed for time-series forecasting of blood glucose levels, showed strong predictive capabilities by capturing temporal dependencies in patient health records. By analyzing sequential data, the model effectively identified trends in blood glucose variations and provided insights into future fluctuations. The root mean square error (RMSE) and mean absolute error (MAE) metrics indicated that the LSTM model maintained a low prediction error, confirming its effectiveness in forecasting blood glucose levels. These predictions allow for early intervention, helping patients and healthcare providers take preventive measures before complications arise.

4.3 Personalized Recommendation Evaluation

Beyond predictive accuracy, the system was assessed based on the quality and relevance of personalized health recommendations. The recommender module integrates dietary suggestions, exercise plans, and lifestyle modifications based on individual health data. Users received customized treatment recommendations based on their diagnosis level, and preliminary feedback indicated that patients found the recommendations highly relevant and practical. The integration of AI-driven insights with user-friendly interfaces allowed for improved patient engagement and adherence to suggested treatment plans.

4.4 System Performance and Scalability

The system was implemented using Flask, ensuring lightweight, fast API responses for real-time predictions. Performance tests confirmed that the system could handle multiple simultaneous user requests with minimal latency. Furthermore, the cloud-based deployment enabled secure and scalable access to healthcare insights, making it suitable for real-world healthcare applications.

The sample output is shown in Fig.2. The results confirm that AI-driven personalized healthcare recommender systems can significantly improve diabetes management by providing accurate predictions and tailored recommendations.

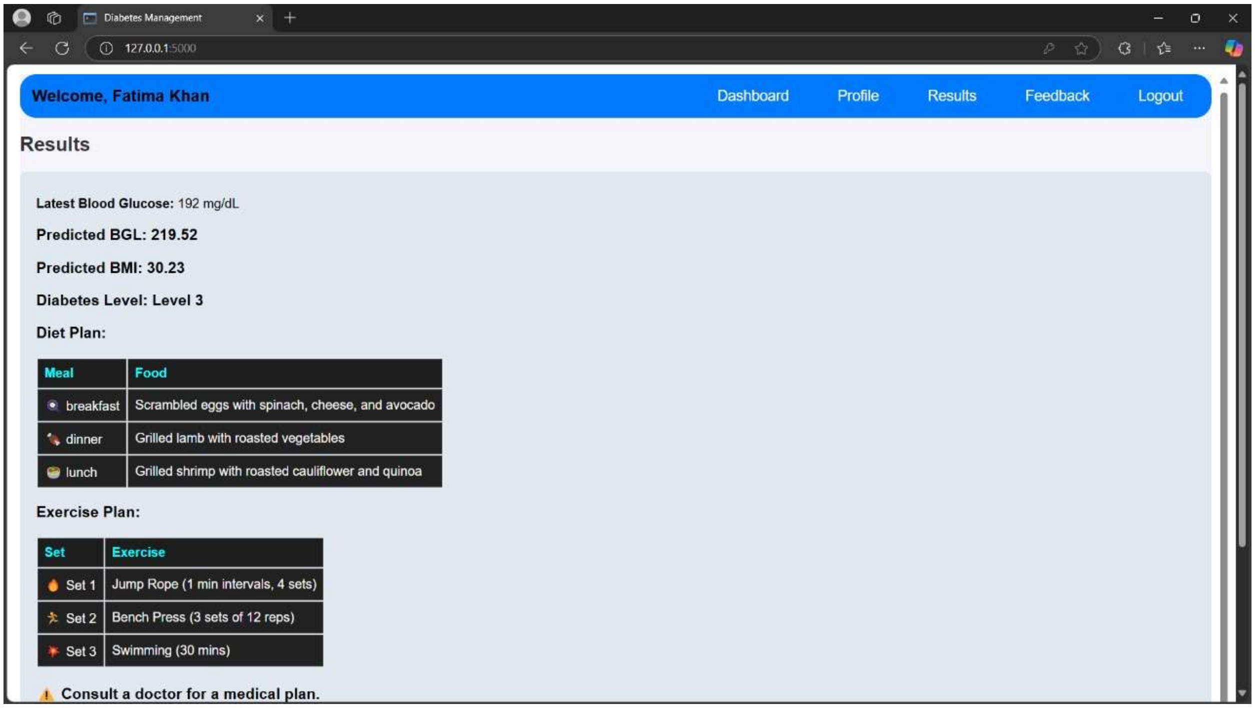

Fig.2. Sample Output

5. Conclusion and Future work

This research presented an AI-powered personalized healthcare recommender system designed to improve diabetes management through real-time monitoring, accurate predictions, and tailored health recommendations. By integrating Deep Factorization Machine (DeepFM) for diabetes classification and Long Short-Term Memory (LSTM) for blood glucose prediction, the system demonstrated high accuracy in diabetes risk assessment and trend forecasting. The Flask-based implementation provided a user-friendly platform for real-time engagement, ensuring seamless interaction between patients and healthcare professionals. The results confirmed that AI-driven personalized recommendations significantly enhance patient adherence to treatment plans by offering customized dietary, exercise, and lifestyle modifications. Furthermore, the system's ability to detect risks early and predict future health trends supports proactive intervention, reducing the likelihood of diabetes-related complications. However, challenges such as data bias, model interpretability, and physician adoption must be addressed to ensure widespread clinical implementation.

Future enhancements will focus on implementing explainable AI (XAI) techniques to improve the transparency and interpretability of AI-driven predictions, fostering greater trust among healthcare professionals. Additionally, incorporating natural language processing (NLP)-

based conversational agents could enhance user interaction by providing personalized, real-time health advice. Furthermore, conducting large-scale clinical trials and fostering collaborations with medical institutions will be essential to validate the system's effectiveness and facilitate its integration into mainstream healthcare practices. By addressing these areas, the proposed AI-powered system has the potential to revolutionize diabetes care, enhance patient engagement, and contribute to more effective chronic disease management.

References

[1] J. Beel, S. Langer, M. Genzmehr, B. Gipp, C. Breitinger, A. Nürnberger, Research paper recommender system evaluation: a quantitative literature survey, in: Proceedings of the International Workshop on Reproducibility and Replication in Recommender Systems Evaluation, 2013, pp. 15–22

[2] F. Ricci, L. Rokach, B. Shapira, Introduction to recommender systems handbook, in: Proceedings of the Recommender Systems Handbook, Springer, 2011, pp. 1–35.

[3] S. Sivapalan, A. Sadeghian, H. Rahnama, A.M. Madni, Recommender systems in e-commerce, in: Proceedings of the World Automation Congress (WAC), 2014, pp. 179–184.

[4] J. Lu, D. Wu, M. Mao, W. Wang, G. Zhang, Recommender system application developments: a survey, Decis. Support Syst. 74 (2015) 12–32.

[5] Q. Zhang, J. Lu, Y. Jin, Artificial intelligence in recommender systems, Complex Intell. Syst. 7 (1) (2021) 439–457.

[6] D.F. Steiner, et al., Impact of deep learning assistance on the histopathologic review of lymph nodes for metastatic breast cancer, Am. J. Surg. Pathol. 42 (12) (2018) 1636.

[7] A. Kiani, et al., Impact of a deep learning assistant on the histopathologic classification of liver cancer, NPJ Digit. Med. 3 (1) (2020) 1–8.

[8] L. Wu, et al., Randomised controlled trial of WISENSE, a real-time quality improving system for monitoring blind spots during esophagogastroduodenoscopy, Gut 68 (12) (2019) 2161–2169.

[9] Hirushit, S., Raja, S., Suwetha, S., & Yazhini, J. (2024, March). AI Powered Personalized Healthcare Recommender. In 2024 2nd International Conference on Artificial Intelligence and Machine Learning Applications Theme: Healthcare and Internet of Things (AIMLA) (pp. 1-6). IEEE.

[10] Karan, D. (2023). AI-Powered Patient Education: Transforming Type 2 Diabetes Management. Indus Journal of Medical and Health Sciences, 1(01), 86-108.