IT4010 – Research Project - 2024

Topic Assessment Form

Project ID: 24-25J-109

1. Topic (12 words max)

Patient-Centered Mobile Application for Comprehensive Diabetes Self-Management and Optimization

2. Research group the project belongs to

Centre of Excellence for AI (CEAI)

3. Research area the project belongs to

Machine Learning (ML)

4. If a continuation of a previous project:

Project ID	
Year	

5. Brief description of the research problem including references (200 – 500 words max) – references not included in word count.

Diabetes is a chronic disease that affects millions of people worldwide. Managing diabetes requires maintaining blood sugar levels within a healthy range through medication, diet, exercise, and continuous monitoring. Current diabetes management methods are often too generalized and do not take full advantage of modern technology, resulting in suboptimal care and poorer patient outcomes.

A significant challenge in diabetes management is determining the right insulin dosage. Insulin needs vary greatly among individuals based on factors such as blood glucose levels, diet, exercise, and personal health. Traditional methods of determining insulin dosage often rely on trial and error, leading to incorrect dosages and poor blood sugar control (Davidson, 2015). Machine learning algorithms have the potential to analyze complex data and predict the optimal insulin dosage more accurately, thereby improving patient outcomes (American Diabetes Association, 2022).

Accurately tracking food intake is also crucial for managing diabetes, but it can be difficult and time-consuming to log meals manually. Automated systems that use image recognition technology to identify foods and analyze their nutritional content can make this process easier and more accurate (Anthimopoulos et al., 2017). However, existing solutions often struggle with accuracy and user-friendliness, highlighting the need for further research and development (Meyers et al., 2015).

Regular physical activity is essential for managing diabetes as it helps improve insulin sensitivity and regulate blood sugar levels. Generic exercise recommendations do not account for individual differences in how people respond to exercise. Personalized exercise plans based on real-time data, such as blood sugar levels, dietary intake, and BMI, can be more effective in managing diabetes (Colberg et al., 2016). Research shows that personalized exercise plans are more beneficial, but implementing such systems requires sophisticated predictive models (Umpierre et al., 2011).

Continuous education and support are vital for effective diabetes management. Patients need timely information and guidance on various aspects of diabetes care, including diet, exercise, medication management, and coping strategies. Personalized chat assistants that use natural language processing (NLP) can provide real-time advice and reminders, making it easier for patients to manage their diabetes (Bickmore et al., 2018). However, current chat assistants often lack the level of personalization needed for comprehensive diabetes care.

Monitoring blood sugar levels and insulin dosages regularly is critical, but the large volume of data generated can be overwhelming for healthcare providers. Analytical tools that use machine learning can help make sense of this data and provide useful insights, aiding healthcare providers in making better treatment decisions (Klonoff, 2012). Developing a clinical decision support system that leverages data analytics can help optimize treatment plans and improve patient outcomes (Rigla et al., 2015).

Diabetes can lead to serious complications such as heart disease, nerve damage, eye problems, and kidney disease. Educating patients about these risks and providing personalized preventive measures is crucial for comprehensive diabetes management (Fowler, 2008). Despite the availability of information, there is a need for integrated systems that offer tailored recommendations based on each patient's risk factors (Nathan et al., 2009).

In summary, the primary problem in diabetes management is the lack of personalized, integrated care solutions that utilize modern technology. This research aims to develop a comprehensive, patient-centered diabetes management system that leverages advanced technologies like machine learning, image recognition, NLP, and data analytics to provide personalized care for people with diabetes.

References

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- Umpierre, D., et al. (2011). Physical activity advice only or structured exercise training and association with HbA1c levels in type 2 diabetes. JAMA, 305(17), 1790-1799.
- Rigla, M., et al. (2015). Smart systems for personalized management of diabetes. Expert Review of Medical Devices, 12(3), 287-299.
- Bickmore, T. W., et al. (2018). Automated interventions for multiple health behaviors using conversational agents. Patient Education and Counseling, 101(10), 1943-1950.
- Klonoff, D. C. (2012). Continuous glucose monitoring: roadmap for 21st century diabetes therapy. Diabetes Care, 28(5), 1231-1239.
- Fowler, M. J. (2008). Microvascular and macrovascular complications of diabetes. Clinical Diabetes, 26(2), 77-82.
- Nathan, D. M., et al. (2009). Medical management of hyperglycemia in type 2 diabetes: a consensus algorithm for the initiation and adjustment of therapy. Diabetes Care, 32(1), 193-203.

6. Brief description of the nature of the solution including a conceptual diagram (250 words max)

Our diabetes management solution integrates four cutting-edge components to provide comprehensive and personalized care for diabetes patients. This holistic approach leverages advanced data science and machine learning techniques to optimize treatment and support.

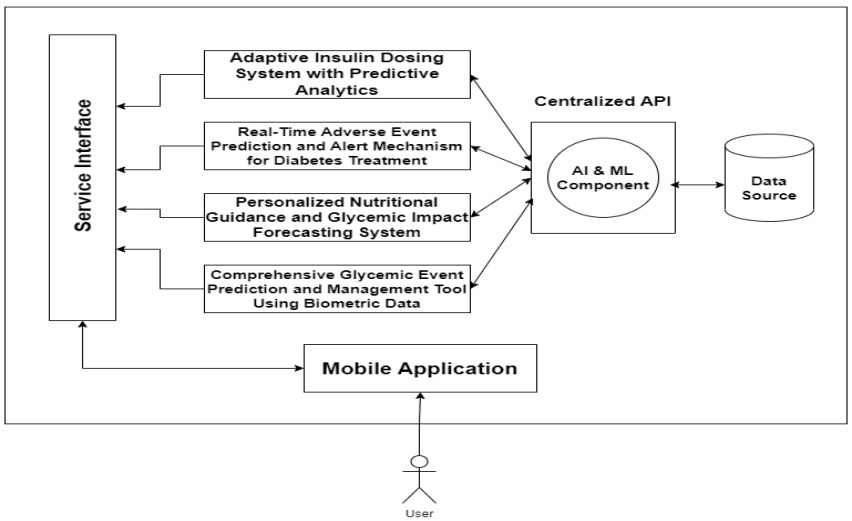
Adaptive Insulin Dosing System with Predictive Analytics: Using predictive modeling and reinforcement learning, this component calculates optimal insulin dosages based on real-time blood glucose readings, patient-specific factors, and historical data. The goal is to mimic the body's natural insulin regulation, ensuring stable glucose levels.

Hypoglycemia Prediction and Prevention Self-Management Tool Using Biometric Data: This component focuses on the early detection and management of adverse events associated with diabetes treatments. Using machine learning models, it analyzes patient medical history, medication records, and symptom logs to predict potential side effects. The system provides real-time alerts and actionable recommendations to both patients and healthcare providers, enabling prompt interventions and adjustments to treatment plans. This proactive approach enhances patient safety and reduces the risk of adverse reactions, improving the overall effectiveness of diabetes care.

Personalized Nutritional Guidance and Glycemic Impact Forecasting System: This system addresses the need for individualized dietary management in diabetes care by using advanced recommendation algorithms and predictive models. It creates personalized meal plans based on dietary preferences and needs, while forecasting the impact of meals on blood glucose levels. By analyzing dietary), the system continuously refines recommendations to ensure optimal glycemic control. This tailored approach helps patients make informed dietary choices, enhancing their ability to manage blood sugar levels effectively.

Real-Time Side effects prediction and Alert Mechanism for Diabetes Treatment: This component focuses on the early detection and management of adverse events associated with diabetes treatments. Using machine learning models, it analyzes patient medical history, medication records, and symptom logs to predict potential side effects. The system provides real-time alerts and actionable recommendations to both patients and healthcare providers, enabling prompt interventions and adjustments to treatment plans. This proactive approach enhances patient safety and reduces the risk of adverse reactions, improving the overall effectiveness of diabetes care.

Conceptual Diagram



7. Brief description of specialized domain expertise, knowledge, and data requirements (300 words max)

1. Domain Expertise:

The project requires comprehensive expertise in diabetes management, including insulin therapy, glycemic control, and the clinical implications of both hypoglycemia and hyperglycemia. Specialized knowledge in endocrinology, patient safety, and the management of diabetes-related complications is crucial for developing effective and clinically relevant tools.

2. Knowledge:

A strong foundation in data science and machine learning is essential, particularly in predictive modeling, reinforcement learning, and real-time alert systems. Proficiency in natural language processing (NLP) and algorithm development is necessary for creating and refining predictive models. Understanding how to integrate these models with continuous glucose monitoring (CGM) systems and other biometric data is also critical.

3. Data Requirements:

The project needs access to a diverse set of data, including continuous glucose monitoring (CGM) readings, patient medical histories, medication records, symptom logs, dietary logs, and real-time physiological metrics. This data is crucial for developing, training, and validating predictive models, ensuring personalized recommendations, and providing actionable insights for managing diabetes effectively. Collaborations with clinical experts, such as Dr. Rameshkumar(Senior Registrar in Endocrinology-National Hospital Sri Lanka), and Dr. Pasanthan(Medical Officer - NHSL), will be essential for data validation and ensuring the accuracy and relevance of the tools.

Data Sources:

- **Electronic Health Records (EHRs):** Comprehensive patient medical histories and treatment plans.
- **Wearable Devices and Glucometers:** Real-time health metrics and activity data.
- **Patient Self-Reports:** Symptom logs, dietary intake, and behavioral data through the mobile application.
- **Public Health Databases:** Aggregated data for training machine learning models, ensuring robustness and generalizability.

8. Objectives and Novelty

Main Objective

Our primary objective is to create a comprehensive, AI-powered diabetes management system designed to revolutionize patient care by delivering highly personalized treatment plans. This system will utilize state-of-the-art machine learning algorithms and data science techniques to seamlessly integrate various data sources, enabling real-time analysis and predictive modeling. By addressing the unique needs of each patient, the system aims to optimize insulin delivery, predict and mitigate potential side effects, offer tailored nutritional guidance and post glycemic event care. Ultimately, this approach seeks to improve clinical outcomes, enhance patient adherence to treatment protocols, and significantly improve the overall quality of life for individuals managing diabetes.

Member Name	Sub Objective	Tasks	Novelty
Gunawardhana D.H.M.G.	Optimize insulin dosage recommendations using predictive modeling and reinforcement learning to maintain stable glucose levels.	**Literature Review:** Research current methods and advancements in insulin delivery and reinforcement learning applications in healthcare. **Data Collection:** Gather patient-specific data, including blood glucose readings, insulin dosages, dietary intake, and physical activity.	• Use of advanced reinforcement learning techniques for dynamic insulin adjustment. • Real-time integration of multiple data sources for precise insulin delivery.

		Data Preprocessing: Clean and normalize data, handle missing values, and feature engineering. **Model Development:** Develop and train predictive models (e.g., LSTM, reinforcement learning algorithms). **Model Evaluation:** Validate model performance using cross-validation, accuracy, RMSE, and other relevant metrics. **Integration:** Implement real-time insulin dosage adjustment algorithms and integrate with glucose meters and user inputs in the mobile app.	

Kajeevan J	To develop an advanced tool that uses biometric data to predict and manage hypoglycemic and hyperglycemic events in diabetes patients. It aims to provide real-time alerts, actionable recommendations, and post-event guidance to improve patient safety and glycemic control.	**Literature Review:** Recent advancements in AI and machine learning have improved diabetes management by enhancing glucose control and reducing glycemic events. Studies have demonstrated the effectiveness of predictive models and real-time alert systems, forming the basis for this tool's development. **Data Collection:** Collects continuous glucose monitoring (CGM) readings, heart rate, activity levels, historical glycemic event records, and patient feedback to create a comprehensive dataset for analysis. **Data Preprocessing:** Involves cleaning data, normalizing values, extracting relevant features, and integrating data from multiple sources to prepare it for model training. **Model Development:**	• The tool integrates diverse biometric data with advanced predictive analytics to offer real-time predictions, personalized recommendations, and post-event management, representing a significant advancement in diabetes care.

		Utilizes machine learning algorithms, such as random forests or gradient boosting, to predict glycemic events based on historical and real-time data. Models are trained and validated to ensure accuracy. **Model Evaluation:** Assesses performance using metrics like AUC-ROC, sensitivity, and specificity. Includes real-time testing and user feedback to refine the model and improve its effectiveness.	
Wimansa P.P.H.S.D.	Predict and alert patients about potential side effects of diabetes treatments using machine learning models.	**Literature Review:** Study existing methods for side effect prediction in diabetes management. **Data Collection:** Gather patient medical history, medication records, symptom logs, and related data. **Data Preprocessing:** Clean and preprocess data, ensuring	• Real-time prediction and alerting of side effects using machine learning. • Integration of patient-reported symptoms for continuous learning and improvement.

		consistency and handling missing values. **Model Development:** Develop predictive models (e.g., logistic regression, SVM) for side effect detection. **Model Evaluation:** Evaluate model accuracy, precision, recall, and F1 score. **Integration:** Create a real-time alert system and integrate with EHR and patient self-reporting in the mobile app.	
De Silva L.K.N.	Provide personalized meal plans that support diabetes management through advanced recommendation algorithms and optimization techniques.	**Literature Review:** Review existing nutritional guidance systems and AI-based meal planning. **Data Collection:** Collect dietary preferences, restrictions, nutritional needs, and historical dietary logs. **Data Preprocessing:** Process dietary data, extract	• AI-driven personalized meal plans using recommendation systems. • Predictive modeling to forecast meal impacts on blood glucose levels.

		features, and handle inconsistencies. **Model Development:** Develop recommendation systems and optimization algorithms for personalized meal planning. **Model Evaluation:** Assess the accuracy and relevance of meal recommendations using user feedback and validation metrics. **Integration:** Implement dietary recommendations and meal plans in the mobile app.	

9. Supervisor checklist

a) Does the chosen research topic possess a comprehensive scope suitable for a final-year project?

Yes		No	

b) Does the proposed topic exhibit novelty?

Yes		No	

c) Do you believe they have the capability to successfully execute the proposed project?

Yes		No	

d) Do the proposed sub-objectives reflect the students' areas of specialization?

Yes		No	

e) Supervisor's Evaluation and Recommendation for the Research topic:

10. Supervis

	Title	First Name	Last Name	Signature
Supervisor				
Co-Supervisor				
External Supervisor				
Summary of external supervisor’s (if any) experience and expertise				

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Topic Assessment Form

<u>This part is to be filled by the Topic Screening Panel members.</u>

Acceptable: Mark/Select as necessary

Topic Assessment Accepted	
Topic Assessment Accepted with minor changes (should be followed up by the supervisor)*	
Topic Assessment to be Resubmitted with major changes*	
Topic Assessment Rejected. Topic must be changed	

* Detailed comments given below

Comments

The Review Panel Details

Member's Name	Signature

*__Important__:

1. According to the comments given by the panel, make the necessary modifications and get the approval by the **Supervisor** or the **Same Panel**.
2. If the project topic is rejected, identify a new topic, and follow the same procedure until the topic is approved by the assessment panel.