UNCONVENTIONAL INDICATORS FOR DIABETIC DIAGNOSIS

R24-120

Project Proposal Report

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Department of Information Technology

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March 2024

Detect signs of diabetes by using foot ulcer and image analysis techniques

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Declaration

"I declare that this is our own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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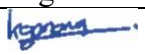
Kajanan T	IT2105062	

The above candidate is carrying out research for the undergraduate Dissertation under my supervision.

Signature of the supervisor Date

(Ms. Wishalya Tissera)

Signature of co-supervisor Date

(Ms. Karthiga Rajendran)

Abstract

Diabetes is a chronic disease that affects millions of people worldwide. foot ulcers are a common complication of diabetes and can lead to severe consequences such as amputation. Early detection and treatment of foot ulcers are essential to prevent these complications.

This research proposal aims to develop a new method for detecting signs of diabetes using foot ulcer and image analysis techniques. The proposed method will utilize computer vision techniques to automatically analyze images of foot ulcers and identify features that are indicative of diabetes.

This research will be conducted in three phases. Such as, a dataset of images of foot ulcers from diabetic and non-diabetic patients will be collected. The dataset will be used to develop and train a computer vision model that can automatically identify features that are indicative of diabetes.

The result of this research will have the potential to improve the early detection and treatment of foot ulcers in diabetic patients, thereby reducing the risk of complications and improving patient outcomes.

Keywords: Foot ulcer, Diabetes mellitus, Machine learning, Deep learning, Image processing

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Introduction

Diabetes stands as a pervasive metabolic disorder affecting millions globally, and among its myriad complications, foot ulcers emerge as both common and debilitating. The timely identification and effective management of these ulcers are paramount in averting severe complications. The prevailing diagnostic methodologies predominantly hinge upon manual examinations conducted by healthcare practitioners, a process that regrettably often translates into delayed diagnoses and treatments. In light of this, the exploration of image analysis techniques emerges as a promising frontier for early detection and intervention[1].

The current landscape of diabetes management is plagued by the inherent limitations of manual examinations. Healthcare professionals, despite their expertise, face challenges in promptly identifying and assessing foot ulcers, leading to a critical gap in timely intervention. The advent of image analysis technologies offers a transformative approach to address this lacuna. By leveraging advanced computational algorithms, these techniques can scrutinize medical imaging data with a precision and speed that surpasses human capabilities. This not only expedites the diagnostic process but also enhances the accuracy of identifying subtle indicators of early-stage foot ulcers.[4]

Moreover, the integration of image analysis into diabetes care holds the potential to establish a standardized and objective framework for diagnosis. This objectivity reduces the likelihood of subjective variations in assessments and ensures a consistent and reliable approach across diverse healthcare settings. Additionally, the automation of the diagnostic process allows for real-time monitoring, enabling swift adjustments to treatment plans based on evolving conditions.[7]

The integration of image analysis techniques into the realm of diabetes foot ulcer diagnostics marks a paradigm shift towards early detection and intervention. This innovative approach not only addresses the shortcomings of manual examinations but also introduces a standardized and objective methodology, promising improved patient outcomes and reduced healthcare burdens.

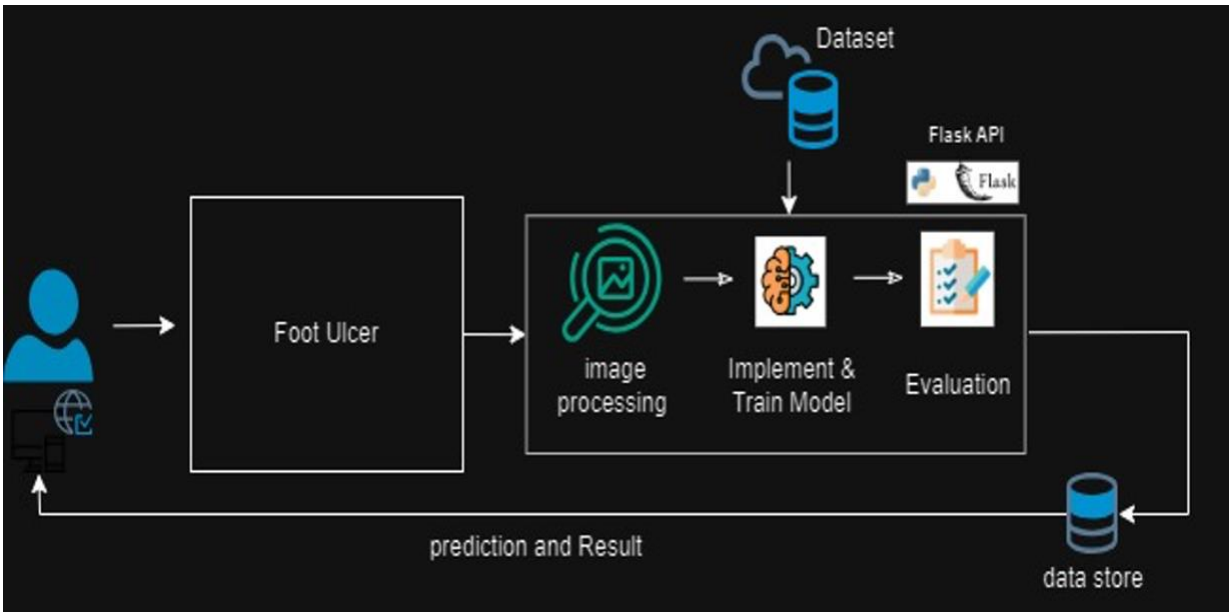

Figure 1 : Overall system diagram

Background & Literature Survey

Diabetes mellitus, a chronic metabolic condition characterized by increased blood glucose levels, affects millions worldwide. early detection and management are crucial to prevent severe complications. Traditional diagnostic methods, such as blood glucose monitoring, can be invasive and inconvenient. Nail analysis, on the other hand, offers a non-invasive and painless alternative for diabetes screening[2].

Image processing techniques have been employed to analyze nail color and texture for early detection. Computers' ability to distinguish a wide range of colors, coupled with the challenge of color identification by the human eye and the limitations of color blindness, make computer-aided nail analysis an efficient approach. While conventional pathological testing can be time-consuming and invasive, nail analysis provides a rapid and convenient method for diabetes screening[4][6].

According to previous studies, they have demonstrated the potential of nail analysis for diabetes detection. For instance, the research revealed that the RGB range values of different nail categories overlapped, indicating the need for improved identification methods for diabetes mellitus. [3]

Research gap

Within the extensive realm of diabetic foot ulcer management, a discernible lacuna exists in research that distinctly examines the incorporation of image analysis techniques for the early detection of diabetes via foot ulcer assessment. Although numerous studies have delved into the application of imaging technologies in managing diabetic foot ulcers, a distinct focus on leveraging image analysis for early diabetes detection remains conspicuously scarce. This gap in research is particularly notable as existing methodologies exhibit shortcomings in terms of precision and scalability, hindering their potential for widespread clinical application.

While the prevailing body of research has contributed significantly to advancing our understanding of diabetic foot ulcer management, the pivotal aspect of early diabetes detection remains relatively underexplored. The intricate interplay between image analysis techniques and the assessment of foot ulcers unveils a novel avenue for proactive healthcare interventions. The dearth of specific research in this domain underscores the untapped potential that could be harnessed for enhancing diagnostic precision and enabling timely medical interventions.

The identified research gap not only signifies a need for targeted investigations but also emphasizes the inadequacy of existing methods in meeting the demands of a broader clinical landscape. The limitations in precision and scalability have practical implications for the feasibility of implementing these methodologies on a larger scale, impeding their potential impact on public health outcomes. Addressing this research void is essential for developing nuanced, efficient, and scalable approaches that can revolutionize early diabetes detection through the analysis of foot ulcers.

In conclusion, the existing gap in research on the integration of image analysis techniques for early diabetes detection through foot ulcer assessment highlights a crucial area where advancements are necessary. Bridging this gap could pave the way for innovative diagnostic tools with enhanced precision and scalability, ultimately contributing to more effective and widespread clinical applications in the field of diabetes management.[4].

	Research Paper A (DOI: https://doi.org/10.1186/s12938-024-01210-6)	Research Paper B (Doi:https://doi.org/10.1007/s11042-024-18304-x)	Research Paper C (DOI: https://doi.org/10.1089/wound.2023.0194)	**Proposed System**
Global Prevalence of Diabetes	✓	✓	✓	✓
Historical Perspective	✗	✗	✗	✓
Images of foot ulcer	✓	✓	✓	✓
Telemedicine Standards	✗	✗	✗	✓
Definition and Prevalence of Diabetics by foot ulcer	✓	✓	✓	✓

Table 1 : Comparing with previous researches

Research Problem

This research proposal confronts a critical issue in managing diabetes: the deficiency of effective automated tools for detecting diabetes signs through foot ulcer analysis. The existing challenge lies in the inadequacy of current methods, often lacking precision for early detection, thereby complicating diabetic care management. The key objective is to forge a dependable and precise system proficient in scrutinizing foot ulcer images to discern early diabetes indicators. This technological advancement proves vital for enhancing patient outcomes and curbing healthcare costs[5].

The crux of this research involves the development of a sophisticated model capable of accurately predicting diabetes and delineating the severity stages of associated wounds. This model aspires to be a comprehensive tool, not confined to mere identification but extending to a nuanced understanding of diabetes progression. By automating the analysis of foot ulcer images, the proposed system aims to expedite diagnostics, allowing for swift interventions that can significantly elevate patient results[6].

The significance of this research resonates in its potential to revolutionize diabetes care by addressing the current void in efficient tools for early detection. The envisioned model goes beyond conventional approaches, offering a holistic solution that contributes to improving patient outcomes and reducing the financial burden on healthcare systems. In essence, this research is a crucial step towards advancing healthcare practices, fostering enhanced patient well-being, and creating a more cost-effective and efficient approach to managing diabetes[7].

Research Objectives

Main objective

The primary goal of this research is to create an automated system adept at identifying indications of diabetes through the analysis of foot ulcer images. The focus lies in developing a technology-driven solution that can efficiently and autonomously detect early signs of diabetes. This research aims to streamline and enhance the diagnostic process, contributing to improved healthcare practices by providing a reliable tool for early detection of diabetes through the analysis of foot ulcer images.

Specific objective

1. To collect an accurate dataset of foot ulcer images from diabetic patients.
2. To implement image processing and machine learning algorithms for feature extraction and classification.
3. To optimize machine learning algorithms for accurate foot wound analysis.
4. To implement a user-friendly interface for accessibility.
5. To categorize foot ulcer into severity stages for better risk assessment.
6. To design a simple app to make the program easy to use.

Methodology

The methodology employed in this research adopts a systematic approach aimed at developing and validating an automated system for the early detection of diabetes through the analysis of foot ulcer images. The step-by-step process ensures a robust and reliable tool to contribute significantly to healthcare practices.
To commence, a diverse dataset comprising foot ulcer images from diabetic patients is gathered, encompassing a wide array of ulcer types and stages. This inclusive dataset forms the foundation for comprehensive analysis. The initial phase involves subjecting these images to pre-processing techniques, enhancing their quality, and standardizing features to ensure consistency in subsequent analysis.

Moving forward, advanced image processing techniques are employed for the extraction of relevant features from the foot ulcer images. This includes delving into texture analysis, shape descriptors, and color features, enabling a nuanced understanding of the images' characteristics. The utilization of these sophisticated techniques ensures a comprehensive evaluation of the data, laying the groundwork for accurate detection.

The subsequent phase entails the development of machine learning models, notably convolutional neural networks (CNNs) and support vector machines (SVMs), catering to classification and prediction tasks. Training these models involves utilizing the amassed dataset, and to guarantee their robustness and generalization, cross-validation techniques are implemented. This iterative process fine-tunes the models, ensuring their adaptability to diverse scenarios and datasets.

Performance evaluation is a crucial aspect of this methodology, involving a meticulous assessment of sensitivity, specificity, accuracy, and other pertinent metrics related to the proposed system. This thorough evaluation guarantees the reliability and effectiveness of the automated tool, providing insights into its real-world applicability.
In summary, the research methodology revolves around a systematic sequence of steps, from dataset collection and pre-processing to feature extraction, model development, and validation. This meticulous approach ensures the creation of a dependable, accurate, and adaptable system for the early detection of diabetes through foot ulcer image analysis, thereby contributing significantly to advancing healthcare practices[3][4].

Individual system architecture

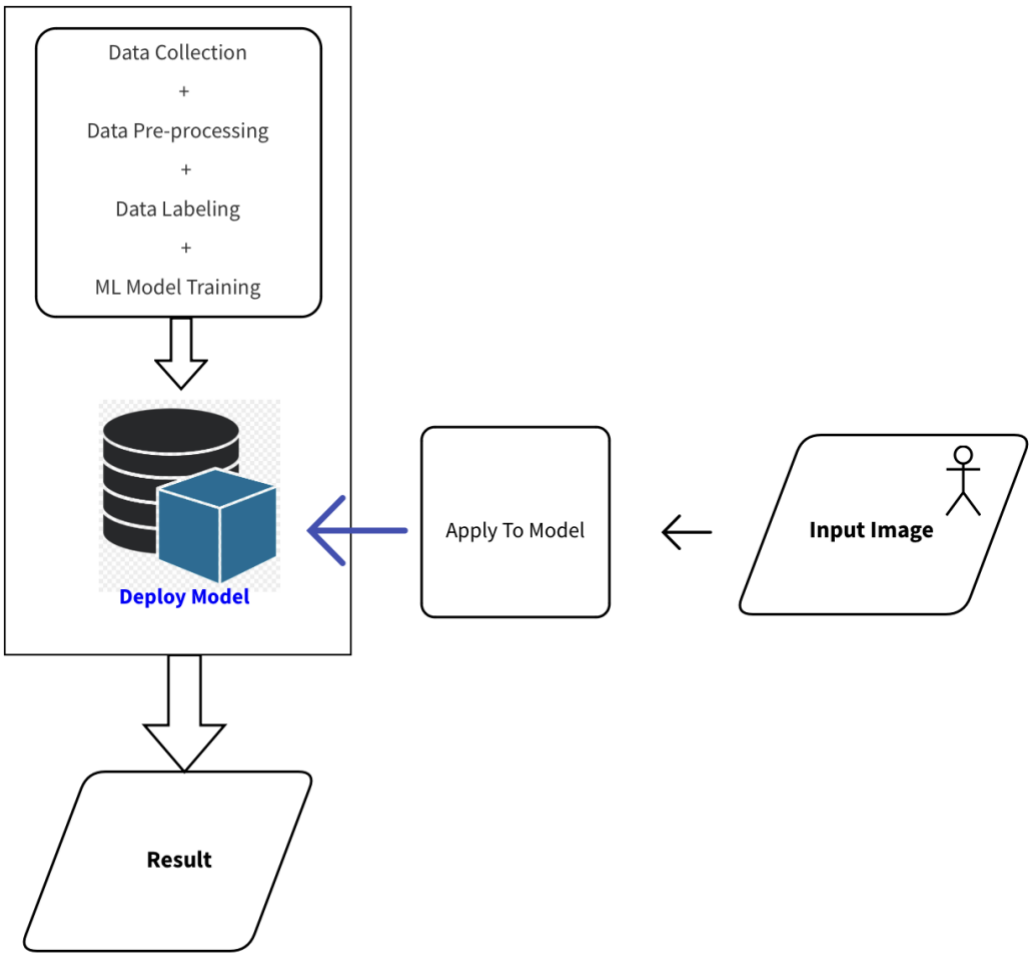

Figure 2 Individual system architecture

1. A user app that allows users to take photos of their foot ulcer and upload them to the cloud.
2. A web service that deploys the ML model and provides a REST API for the app to call.
3. An Azure Storage account that stores the training data and the ML model.
4. An Azure ML Studio instance that is used to train and deploy the ML model.
5. An Azure ML Compute instance that is used to run the ML model.

1. The user takes a photo of their foot ulcer and uploads it to the app.
2. The app sends the photo to the web service.
3. The web service calls the ML model to predict the disease severity.
4. The ML model returns the prediction to the web service.
5. The web service sends the prediction back to the app.
6. The app displays the prediction to the user.

The ML model is trained using a dataset of foot ulcer images. The solution is deployed to Azure using Azure App Service, Azure Storage, Azure ML Studio, and Azure ML Compute. Azure App Service is used to host the web service. Azure Storage is used to store the training data and the ML model. Azure ML Studio is used to train and deploy the ML model. Azure ML Compute is used to run the ML model.

The solution is designed to be scalable and reliable. The web service is hosted in Azure App Service, which is a highly scalable and reliable platform. The training data and the ML model are stored in Azure Storage, which is a durable and reliable storage service. The ML model is trained using Azure ML Studio, which is a powerful and user-friendly tool for training ML models. The ML model is deployed to Azure ML Compute, which is a dedicated compute service for running ML models.

Description of personal and Facilities

The proposed study on detecting signs of diabetes using foot ulcer images and image analysis techniques, I will assume the role of Principal Investigator (PI) and lead all aspects of the research project. With a background in medical imaging, data analysis, and machine learning, I will oversee the entire research process from data collection to dissemination of results. Collaborating closely with my supervisor, who will provide guidance, mentorship, and oversight throughout the project, I will ensure that the research adheres to high scientific standards and ethical guidelines. The supervisor's expertise in the field of diabetes research and image analysis will complement my skills and enhance the rigor and validity of the study. Additionally, I will have access with necessary computational resources and software tools for image processing and machine learning tasks. Regular meetings with my supervisor will facilitate progress updates, feedback sessions, and troubleshooting of research challenges. Through continuous learning and professional development opportunities, I will further refine my skills and knowledge in medical imaging and diabetes research, ensuring the successful completion of the project. This collaborative effort between myself and my supervisor, coupled with access to appropriate facilities, will enable the effective execution of the research and contribute to advancements in early detection and stage of diabetes through foot ulcer image analysis.

Requirements

Functional requirements

The system will be able to capture foot ulcer images in a standardized manner to ensure consistency and accuracy. It will employ robust feature extraction algorithms to effectively extract relevant information from the foot ulcer images. It will utilize advanced feature selection techniques to identify the most discriminative features for diabetes prediction. It will integrate machine learning algorithms to develop a predictive model for diabetes based on the extracted features. It will provide a user-friendly interface for healthcare professionals to facilitate foot ulcer image acquisition, feature extraction, and diabetes prediction.

Non-Functional requirements

The system should be efficient in terms of computational resources and time to ensure real-time prediction. It should be reliable and robust to handle variations in foot ulcer appearance due to factors such as allergic. It will be secure to protect patient information and maintain confidentiality. It will be scalable to handle a large volume of foot ulcer images.

System requirement

Hardware requirement

1. Minimum system requirements of user end device for the client app to work is as follows:
2. Operating system: IOS or Android
3. RAM: 1GB
4. Storage: 300 MB free space
5. Internet connectivity

The minimum system requirement for a back-end server is either Windows or Linux, 8GB of RAM and 30 GB of storage. 200 megabytes of database storage space is sufficient for the implementation phase. These system requirements may increase during use, and these resources should be scaled in that case.

Software Requirements

1. Visual Studio Code
2. PyCharm
3. Google Collab
4. Jupyter

Technological Requirement

1. Conventional Neural Networks (CNN)
2. Transfer learning (Pre-trained deep learning model) – VGG, and ResNet
3. Ensemble Learning: RandomForest, Gradient Boosting Machines (GBM), AdaBoost
4. Recurrent Neural Networks (RNNs)
5. Generative Adversarial Networks (GAN)
6. Graph Neural Networks (GNNs
7. Multimodal Fusion Model

Libraries

1. TensorFlow
2. Keras
3. Scikit-learn
4. PyTorch

Commercialization

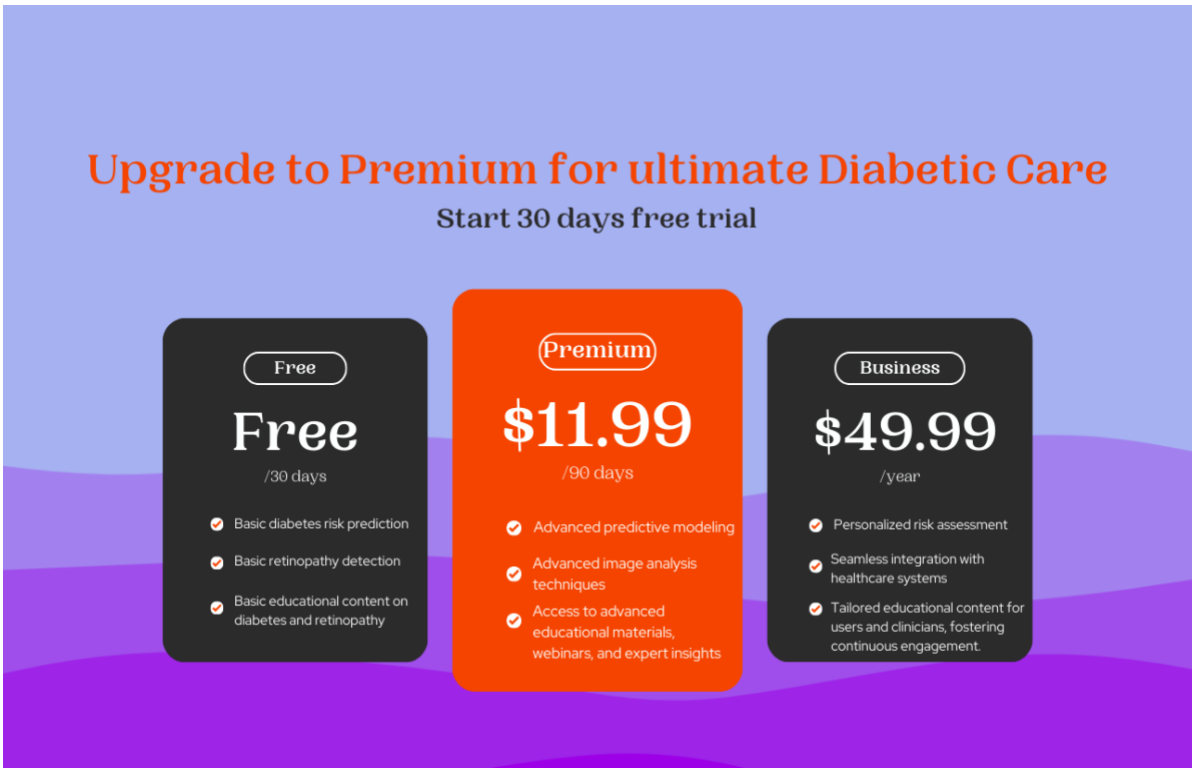

Figure 3 Commercialization

This mobile app is a premium subscription service that provides users with access to advanced features and content not available in the free version. Upgrading to premium unlocks access to more in depth risk assessment, advanced image analysis, and educational materials, such as webinars and expert insights. The premium subscription is $11.99 per month or $99.99 per year, and it comes with a 30-day free trial.

Project Timeline (Gannt chart)

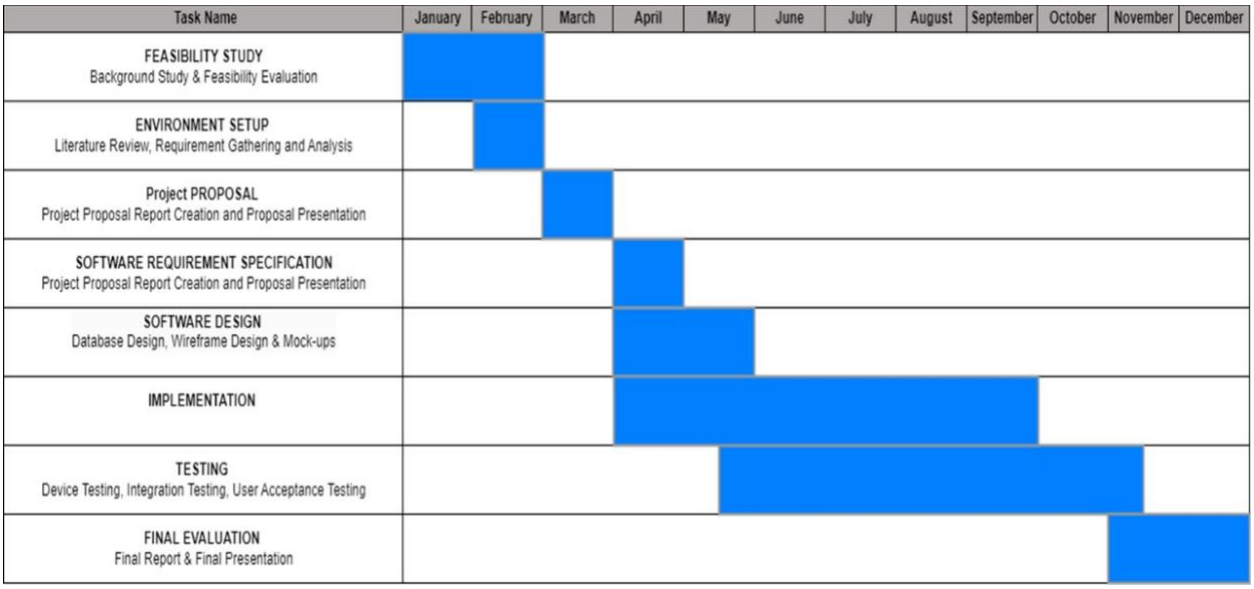

Figure 4 Gantt Chart

Conclusions

The proposed research aims to address a critical gap in diabetes management by leveraging image analysis techniques to detect signs of diabetes through foot ulcer analysis. By developing an automated system capable of accurately identifying early indicators of diabetes from foot ulcer images, this research has the potential to revolutionize diabetes care and improve patient outcomes significantly. The systematic methodology outlined in this proposal, coupled with the guidance of the supervisor, provides a solid foundation for executing the research effectively. Access to advanced computing facilities, software tools, and network resources ensures the necessary infrastructure for data analysis, and model development. Overall, the successful execution of this research holds the promise of enhancing early detection and intervention in diabetes management, ultimately leading to improved patient care and reduced healthcare costs. By advancing the field of diabetic foot ulcer analysis, this research contributes to the broader goal of leveraging technology to address healthcare challenges and promote well-being in society.

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