Decoding Diabetics: Unconventional Indicators for Diabetic Diagnosis

R24-120

Project Final Thesis

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B.Sc. (Hons) in Information Technology Specializing in Information Technology

Department of Information Technology

Sri Lanka Institute of Information Technology Sri Lanka

September 2024

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# DECLARATION

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The above candidate has carried out this research thesis for the Degree of Bachelor of Science (honors) Information Technology (Specializing in Information Technology) under my supervision.

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| Signature of co-supervisor  (Ms. Karthiga Rajendran) | Date |

# ABSTRACT

Diabetes is a major global health concern, affecting millions and leading to severe complications such as diabetic foot ulcers. Early detection is critical for effective management, yet traditional diagnostic methods are often invasive and time-consuming. This study addresses these challenges by developing a web application that leverages machine learning to detect diabetic foot ulcers from images captured by standard mobile devices. The primary objective is to provide an accessible, non-invasive diagnostic tool that enhances early detection and management of diabetes-related complications.

Model training is done with Google Colab, which provides the required computational resources, and the research makes use of Roboflow for efficient data processing and YOLOv8 for object detection. To ensure precise and trustworthy forecasts, this integration takes into account issues including changes in illumination, image quality, and device requirements. Cloud-based model training and deployment are shown to be efficient in this study, which also provides a thorough approach for picture collecting, processing, and analysis.

The results demonstrate the efficacy of this approach, underscoring its potential to significantly improve patient outcomes by enabling timely and accurate detection of diabetic foot ulcers. The practical implications of this research are profound, offering a scalable solution that can be widely adopted to alleviate the burden on healthcare systems and empower patients to take proactive steps in managing their health. This study contributes to the field of digital health by introducing an innovative framework for non-invasive diabetes diagnosis, combining the accessibility of mobile technology with the precision of machine learning.

**Keywords:** Diabetes Detection, Diabetic Foot Ulcers, Machine Learning, YOLOv8, Roboflow, Google Colab

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# LIST OF ABBREVIATIONS

|  |  |
| --- | --- |
| **Abbreviations** | **Description** |
| SLIIT | Sri Lanka Institute of Information Technology |
| CNN | Convolutional Neural Network |
| ML | Machine Learning |
| DL | Deep Learning |
| MS | Microsoft |
| DM | diabetes mellitus |
| DFU | Diabities Foot Alsusr |
| MB | Mega Byte |
| XML | Extensible Markup Language |
| CSV | Comma-Separated Values |
| API | Application Programming Interface |
| WHO | World Health Organization |
| OS | Operating System |
| SDLC | Software Development Life Cycle |
| WBS | Work Breakdown Structure |
| IDE | Integrated Development Environment |
| HTML | Hyper Text Markup Language |
| JS | Java Script |
| CSS | Cascading Style Sheet |

# 1. INTRODUCTION

## 1.1 Background Study and Literature Review

### 1.1.1 Background Study

Diabetes mellitus is a widespread and chronic illness that affects millions of people worldwide. It is characterized by chronic hyperglycemia, which damages numerous body systems, especially the blood vessels and neurons, over time. Diabetic foot ulcers, often known as DFUs, are one of the most serious consequences linked to diabetes. Not only are DFUs a major cause of morbidity and potentially amputations, but they also place a significant financial strain on global healthcare systems. Because of how difficult it is to treat these ulcers, patients' quality of life is significantly reduced, and healthcare professionals face numerous difficulties.

The primary diagnostic techniques for DFUs are manual assessment and clinical examination. Nevertheless, these techniques are sometimes arbitrary, prone to mistakes, and ineffective at identifying early ulceration symptoms. Delays in diagnosis might result in worse outcomes and higher medical expenses. Innovative diagnostic methods that can quickly and precisely diagnose DFUs are therefore desperately needed, especially in the early phases of the condition.

We investigate the combination of the YOLOv8 object identification model and cutting-edge deep learning methods, such as Convolutional Neural Networks (CNNs), in order to create a comprehensive real-time monitoring system, in order to meet this pressing requirement. The purpose of this approach is to use image analysis to find non-traditional markers of diabetic foot ulcers, which considerably improves diagnosis accuracy and speed. The suggested approach provides a promising answer to the problems associated with DFU identification in clinical contexts by utilizing the image recognition ability of CNNs and the object detection efficiency of YOLOv8.

Three main areas of focus for the research include image-based detection, data processing and model training, and overcoming the difficulties associated with image analysis. CNNs are used in conjunction with YOLOv8 by the image-based detection component to identify crucial markers of DFUs, such as alterations in skin texture, color, and lesion presence. By reducing the subjectivity involved in manual evaluations, this automated detection system seeks to offer a more dependable and consistent diagnostic instrument.

In order to facilitate the detection process, we utilize Roboflow for effective data processing, encompassing preprocessing, augmentation, and image annotation. The training of the model, which calls for a lot of processing power, is done on Google Colab, an open platform that handles big datasets and intricate neural network topologies without requiring expensive hardware. This cloud-based strategy guarantees that the model may be continuously improved as new data becomes available, in addition to improving the system's accessibility.

Addressing the difficulties in picture analysis in the setting of DFUs is one of the research's most important components. Changes in device characteristics, illumination, and image quality can all have a big impact on how accurate detection models are. Our solution uses strong model architectures and integrates advanced preprocessing approaches to maintain high levels of accuracy and dependability under a variety of situations. This guarantees the accuracy and reliability of the system's predictions.

This thesis includes the construction of the detection system as well as a thorough methodology for the collection, processing, and interpretation of pictures pertaining to diabetic foot ulcers. This technique covers every step of the process, from gathering data and annotating it to training and deploying the model, and it offers a useful manual for putting similar systems into practice in different healthcare settings. Along with showcasing the effectiveness and scalability of cloud-based model training and deployment, the study provides insightful information on how these systems might be used in actual clinical settings.

In summary, this study introduces a novel paradigm for the early diagnosis of diabetic foot ulcers, which advances the fast-developing fields of medical image analysis and diabetes care. We hope to produce a diagnostic tool that not only increases accuracy but also gives healthcare providers the ability to promptly and effectively treat individuals who are at risk of DFUs by combining cutting-edge technologies like object identification and deep learning. In order to improve patient outcomes and encourage early intervention in the treatment of diabetic foot ulcers, this thesis aims to close the gap between technology and healthcare.

### 

### 1.1.2 Literature Review

Diabetic Foot Ulcers (DFUs) are a severe and common complication in patients with diabetes, posing significant risks, including infection, hospitalization, and in extreme cases, lower-limb amputation. Early detection of DFUs is critical to prevent these severe outcomes. However, traditional diagnostic methods, such as physical examination and clinical assessment, often fail to detect ulcers at an early stage. This delay in diagnosis can lead to worsening conditions, increased healthcare costs, and poorer patient outcomes. The limitations of these conventional methods have driven research towards developing more advanced techniques that leverage the capabilities of machine learning (ML) and deep learning (DL).

Among these advancements, Convolutional Neural Networks (CNNs) have gained prominence for their ability to analyse medical images and detect DFUs with high accuracy. Studies by Goyal et al. (2021) and Zhang et al. (2022) have been pivotal in showcasing the potential of CNNs in DFU detection. Goyal et al. focused on optimizing CNN architectures to improve sensitivity and specificity in DFU identification, achieving notable accuracy rates. Zhang et al. further enhanced these models by incorporating multi-scale feature extraction, addressing challenges related to varying image quality and enhancing the robustness of the detection process. These studies underscore the potential of CNNs to revolutionize DFU diagnostics by enabling early and accurate detection.

Despite these promising advancements, significant challenges remain that hinder the widespread adoption of ML and DL models in clinical practice. One of the primary challenges is the need for large, annotated datasets to train these models effectively. The availability of such datasets is often limited, particularly in regions with fewer resources, which can restrict the generalizability of these models across diverse patient populations. The variability in imaging conditions, such as lighting, resolution, and patient movement, further complicates the model’s ability to perform consistently in real-world scenarios. These factors highlight the need for ongoing research to develop more robust models that can adapt to diverse conditions and maintain high accuracy across different settings.

In addition to the technical challenges, there are significant barriers to integrating these advanced models into clinical workflows. The complexity of these technologies often requires specialized knowledge, making it difficult for healthcare providers to implement them without substantial training and resources. Furthermore, there is a growing need for user-friendly interfaces that can make these tools accessible to clinicians and patients alike. The development of web-based applications that leverage these ML and DL models offers a promising solution, providing real-time DFU detection and diagnostics in a more accessible format. However, these applications are still in their infancy, and much work remains to be done to ensure their reliability and usability in clinical settings.

Ethical considerations also play a critical role in the adoption of AI-driven tools for DFU detection. Issues related to patient privacy, data security, and the potential biases inherent in AI models must be carefully addressed to ensure that these technologies are used responsibly. The use of patient data for training ML models raises concerns about consent, data ownership, and the potential for misuse, particularly as these tools become more integrated into healthcare systems. Moreover, the algorithms themselves must be scrutinized for biases that could lead to disparities in care, especially for underserved populations.

In conclusion, while ML and DL technologies, particularly CNNs, have shown significant promise in improving the early detection of DFUs, several challenges must be addressed to fully realize their potential. The need for large, diverse datasets, the development of robust and adaptable models, and the creation of user-friendly and ethically sound tools are all critical areas for future research. Addressing these challenges will be essential to advancing DFU diagnostics and ultimately improving patient outcomes by providing more accurate, accessible, and timely care.

## 

## 1.2 Research Gap

Although diabetic foot ulcer (DFU) detection has advanced significantly, there are still a number of important research gaps, especially when it comes to the incorporation of real-time capabilities and user accessibility. The YOLOv5-based model used in the Diabetic Foot Ulcer Challenge (DFUC) 2020 showed lack of detection accuracy, however it is not user-friendly enough for patients to use and does not provide real-time detection. similar to this, the EfficientDet-based approach, which is renowned for striking a balance between computing efficiency and accuracy, is limited in its practical implementation in everyday situations since it does not support real-time processing or end-user needs. Although it is frequently utilized in medical imaging, the Faster R-CNN-based model also lacks real-time capabilities and was not created with patient-centered usage in mind.

However, your approach with YOLOv8 is a big step forward since it integrates real-time DFU detection into a user-friendly online interface. This model improves patient accessibility and addresses major weaknesses of previous approaches by using advanced preprocessing techniques to manage variable image quality. To guarantee accuracy in a variety of real-world scenarios, more research is necessary to enhance real-time detection performance. Even though the user interface is made to be accessible, more research is needed to improve its usability and accommodate a wide range of patient requirements. Furthermore, it is still difficult to handle different image quality, which calls for more effort to improve system resilience.

To summarize, key research gaps in DFU detection include enhancing real-time detection capabilities, optimizing the user interface for better patient accessibility, and ensuring system resilience to varying image quality. Addressing these gaps is essential for bridging the gap between clinical accuracy and practical, user-centered functionality.

A comparison of the product is shown in Figure 2 to highlight its originality.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Product/Platform** | YOLOv5-based Model | EfficientDet-based Model | Faster R-CNN-based Model | Decoding Diabetics |
| Real-Time Detection | NO | NO | NO | YES |
| User-Friendly Web Interface | NO | NO | NO | YES |
| Accessible to Patients | NO | NO | NO | YES |
| Handles Diverse Image Quality | NO | NO | NO | YES |
| Patient-Focused Application | NO | NO | NO | YES |
| Advanced Image Preprocessing | YES | NO | NO | YES |

Figure 4: Novelty Comparison

## 1.3 Research Problem

Diabetic foot ulcers (DFUs) present a significant challenge in diabetic care due to their complex nature and the need for timely and accurate detection to prevent severe complications. Although advancements in machine learning and computer vision have contributed to progress in DFU detection, several critical gaps remain, particularly in terms of real-time processing, user accessibility, and handling diverse image quality. Existing models such as YOLOv5, EfficientDet, and Faster R-CNN, while innovative, exhibit notable limitations that hinder their effectiveness in practical, patient-cantered applications.

YOLOv5-based models, demonstrated in the Diabetic Foot Ulcer Challenge (DFUC) 2020, have shown promise in detecting DFUs but fall short in terms of real-time detection capabilities and user-friendliness. Similarly, EfficientDet models, known for their balance between computational efficiency and accuracy, do not support real-time processing or cater to end-user needs effectively. Faster R-CNN-based models, although frequently used in medical imaging, also lack real-time processing features and are not designed with patient-cantered applications in mind.

The primary research problem addressed by this study is: How can a real-time, user-friendly web application for diabetic foot ulcer (DFU) detection be developed that not only addresses accuracy and resilience to diverse image quality but also ensures accessibility and ease of use for patients? This research problem encompasses several key areas of investigation, including real-time detection capabilities, user interface design, and system resilience to varying image quality.

**Real-Time Detection Capabilities:** Current models often struggle with real-time processing, which is crucial for immediate clinical feedback and patient management. Enhancing real-time detection involves optimizing model architectures and processing algorithms to ensure that the DFU detection system can operate efficiently and swiftly in a practical setting. This research will explore advanced techniques and optimizations to improve the real-time processing capabilities of the YOLOv8 model or other alternative architectures that may offer improved performance in real-world scenarios.

**User Interface Design and Accessibility:** The effectiveness of a DFU detection system is significantly influenced by its usability and accessibility to patients. Existing models lack user-friendly web interfaces that are intuitive for individuals with varying levels of technical expertise. This research will focus on designing and evaluating a web interface that enhances patient accessibility, ensuring that the application is easy to navigate and use. The goal is to create an interface that accommodates a wide range of patient needs and technical proficiencies, thereby improving the overall user experience.

**System Resilience to Image Quality:** Handling diverse image quality is a critical challenge in DFU detection. Variations in illumination, image resolution, and device specifications can affect the accuracy and reliability of the detection system. To address this issue, the research will develop and integrate robust preprocessing and enhancement techniques that can effectively manage and mitigate the impact of varying image quality on detection performance. By improving system resilience, the research aims to ensure that the DFU detection technology performs consistently across different real-world conditions.

In summary, the proposed research seeks to bridge the gap between clinical accuracy and practical, user-cantered functionality in DFU detection systems. By focusing on real-time detection capabilities, user interface design, and system resilience, this study aims to advance the state-of-the-art in DFU detection technology and make it more accessible and effective for patients. Addressing these critical gaps is essential for translating technological innovations into practical solutions that can significantly improve patient care and outcomes.

# 1.4 Research Objectives

## 1.4.1 Main Objective

The primary objective of this research is to develop and implement an advanced web-based monitoring system for Diabetic Foot Ulcers (DFUs) that leverages Convolutional Neural Networks (CNNs) for real-time detection and diagnosis. This system aims to enhance patient care by enabling accurate, timely, and accessible DFU assessments through the analysis of patient-uploaded images. The research focuses on overcoming existing challenges related to DFU detection accuracy, image quality variability, and user interface accessibility, ultimately providing a reliable tool for early intervention and management of diabetic foot conditions.

## 1.4.2 Specific Objectives

The following are the sub-objectives of conducting this research.

* Provide a Real-Time Solution for DFU.
* Incorporate Features for the Sri Lankan Context
* Improve Patient Care Experience
* Enable Early Intervention
* Increase User Engagement
* Ensure Non-Invasive Monitoring
* Integrate Real-Time DFU Detection
* Handle Variations in Image Quality
* Seamlessly Integrate into Healthcare Workflows

## 1.4.3 Business Objectives

* **Expand Market Reach**: Establish the DFU monitoring system as a leading solution in the healthcare market, particularly targeting diabetic care providers, clinics, and hospitals both locally and internationally.
* **Increase Revenue Streams**: Generate revenue through subscription models, licensing agreements with healthcare institutions, and partnerships with insurance companies and pharmaceutical firms.
* **Foster Strategic Partnerships**: Build partnerships with healthcare providers, research institutions, and government health departments to promote widespread adoption and continuous improvement of the system.
* **Drive User Adoption**: Achieve high user adoption rates among both healthcare professionals and patients by offering a user-friendly interface, effective marketing, and educational initiatives.
* **Support Regulatory Compliance**: Ensure that the system meets all necessary healthcare regulations and standards, including data security and patient privacy laws, to build trust and credibility in the market.
* **Optimize Operational Efficiency**: Streamline internal processes and leverage data analytics to continuously improve the system’s performance, reduce operational costs, and enhance user satisfaction.

# 2. METODOLOGY

## 2.1 Methodology