PAADARAKSHA - DIABETIC FOOT ULCER DETECTION AND LOCALIZATION USING DEEP LEARNING TECHNIQUES

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Diabetes, Diabetic Foot Ulcers (DFU), Convolutional Neural Network (CNN), Softmax classifiers, YOLOv8-DFU, Transfer learning, Localization.

Introduction

- Diabetes is one of the most prevalent epidemic metabolic disorders, responsible for a significant amount of physical, psychological and economic loss in human society.
- India has around 101 million people living with diabetes and another 136 million people in pre-diabetes stages, found a recently published study by the Madras Diabetes Research Foundation and Indian Council of Medical Research as per 2023.
- Diabetic Foot Ulcers (DFUs) are a prevalent and critical complication of diabetes that affects millions of individuals worldwide.

Nearly 12–25% of individuals with diabetes are prone to developing diabetic foot ulcers (DFUs).

Objectives:

- To develop a model to detect and segment the foot ulcer in the diabetic patients.
- To design the model to locate the exact location of the ulcer in the feet.

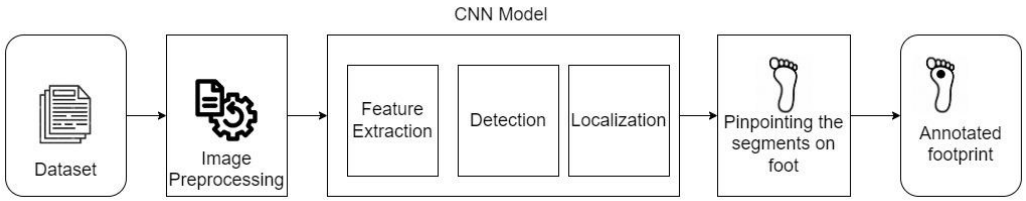
Methodology

The methodology for ulcer detection and localization involved several key steps. Initially, a diverse dataset of foot ulcer images was collected from various sources to ensure representation of different ulcer types and severities. This dataset underwent rigorous preprocessing, including standardization of resolutions and augmentation techniques to enhance diversity and prepare the data for model training.

A YOLOv8 model optimized for mean average precision (mAP) was trained using stochastic gradient descent (SGD) with momentum on the prepared dataset. The dataset was split into training and validation sets to monitor and optimize model performance during training.

Simultaneously, a web-based user interface was developed using Streamlit, allowing users to input their gender and foot sole size for personalized ulcer detection. Foot sole images captured using OpenCV's camera module were processed through the trained YOLOv8 model to detect and localize ulcers. The detected ulcers were then mapped onto a foot sole blueprint based on user input parameters.

Post-processing involved masking out the detected ulcer from the input image, resulting in a clear visualization of the ulcer on the foot sole blueprint. Evaluation of the system's performance included standard metrics like accuracy, precision, recall, and F1-score, along with user feedback and usability testing, demonstrating the system's effectiveness in accurately detecting and localizing foot ulcers for improved clinical practices and patient care.



Results and Conclusions

- The aim is to tackle the multifaceted challenge of detecting DFUs, performing multi-class classification, and precisely localizing them using deep-learning techniques
- Through the utilization of Convolutional Neural Networks (CNNs) and image segmentation models, it demonstrates the ability to accurately identify the presence of DFUs and categorize them according to their respective stages

- Precise localization and mapping of categorized diabetic foot ulcers onto footwear soles offer a comprehensive understanding of their positioning, enabling healthcare professionals to devise effective treatment strategies

Scope for Future Work

- Continuously refine the CNN model to improve ulcer detection accuracy by gathering more diverse data, refining model architecture, and experimenting with advanced techniques like ensemble learning or attention mechanisms.
- Investigate semantic segmentation methods to precisely outline ulcer boundaries in foot images, enhancing localization and annotation accuracy.
- Expand the web application's capabilities to offer clinical insights such as risk assessment based on ulcer characteristics, treatment recommendations, and specialist referrals.
- Conduct clinical validation studies to evaluate the automated ulcer detection system in real-world healthcare settings, collaborating with institutions and regulatory bodies to facilitate adoption.