DIABETIC FOOT ULCERATION SMART HOME SENSOR

TEAM 28

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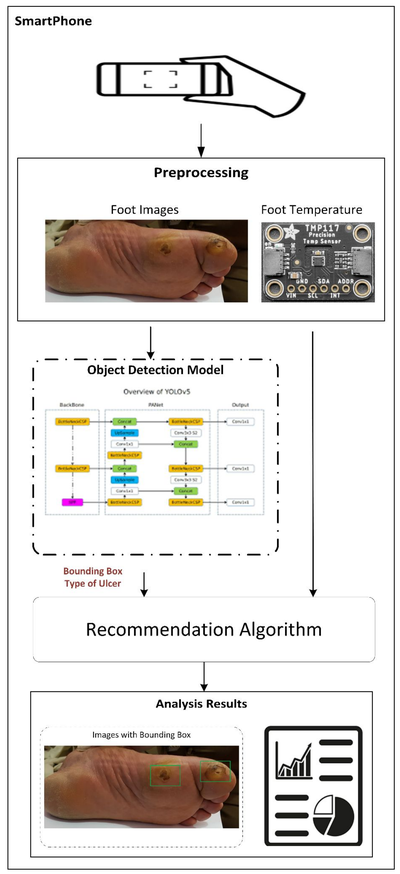
Introduction

Diabetic foot ulcerations (DFU) are the biggest cause of lower extremity amputation in the US. Regular foot exams greatly decrease the chance of amputation. However, more than half of diabetic patients don't get timely and proper foot care due to financial concerns and lack of access to medical resources.

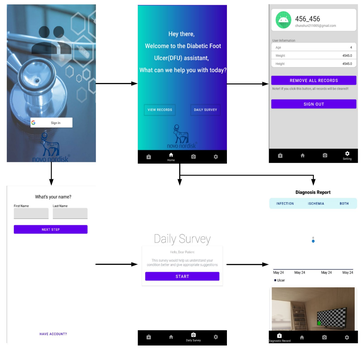
In order to solve this issue, we created a smartphone app which provides pre-diagnosis for diabetic patients. It combines image processing and temperature sensor data to help patients manage their DFUs.

System Overview



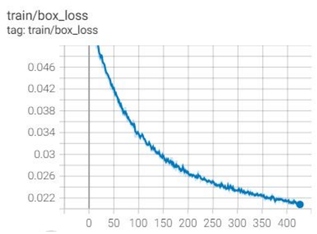
Mobile App

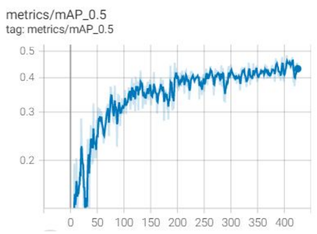
- Built for Android smartphones
- User account to track progress
- Daily surveys to gain data about current ulcer status
- Deep learning model that uses picture of feet to recognize ulcers
- Provide recommendations based on user entered data, temperature, and model results
- Went through user testing by multiple interviews with diabetics in cooperation with Novo Nordisk



Deep Learning Model

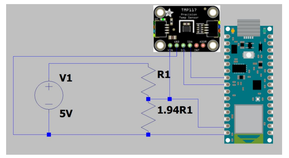
- A custom yolov5 model is trained on NVIDIA Tesla P100-PCIE-16GB GPU
- The dataset used to train the model was labelled and annotated using RoboFlow
- The dataset consists of 699 images in the training set, 100 images in the validation set and 60 images in the test set
- Data augmentation like rotation, crop, shear, brightness, blur and mosaic is applied on the dataset to create additional images
- At epoch 325, the best weight is achieved giving a mean average precision (mAP_0.5) of 43.2% for all classes (Infection, Ischaemia, Both and None)
- The class "both" indicates that the ulcer has both infection and ischaemia
- The class "none" indicates it is neither infection nor ischaemia
- The pytorch model is then exported to torchscript to deploy it in the Android application.
- Different models like faster_rcnn_resent50 and faster_rcnn_fbnetv3a_dsmask_c4 were tried out. Yolov5s model gave the best mAP_0.5

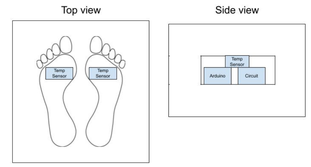




Sensors

- Measures temperature of ball of foot using TMP117 temperature sensor
- Integrates temperature sensor with Arduino Nano microcontroller
- Works with a platform on which the users rest their feet to get temperature readings
- Sends temperature measurements to android application through Bluetooth Low Energy (BLE)





Results & Future Enhancements

- The android application, deep learning model and temperature sensor work together to create a well functioning smart home sensor for DFUs.
- Sensor sometimes has difficulty in coming in contact with the foot, but still provides temperature readings
- The deep learning model has a mean average precision (mAP_0.5) of 43% for a small data set. Refer to the model predictions below:

Incorrect prediction
(no ulcers recognized)

Correct prediction

- Train YOLOv5 model further to get better accuracy by modifying few layers and try different augmentation techniques that haven't been tried yet
- Train on bigger dataset e.g DFU Challenge dataset
- Develop ML model to generate the medical recommendations for patient
- Integrate more sensors to monitor foot condition
- Feature to record user's eating patterns and exercise
- Integrate existing commercial diabetic devices into our platform

References

[1] Joseph Redmon, Santosh Divvala, Ross Girshick, Ali Farhadi, "You Only Look Once: Unified, Real-Time Objection Detection" , CVPR, 2016, October, 2016.
[2]Bill. Cassidy, Connah. Kendrick, et al., "Diabetic Foot Ulcer Grand Challenge 2021": Evaluation and Summary, Nov, 2021.
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