Diabetic Foot Exam System

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Fall 2021
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Problem Description

What is a Diabetic Foot Exam?

A 3-minute professional evaluation to identify a diabetic patient's risk of foot ulceration. Exam components include:

- Patient history
- Dermatological assessment
- Musculoskeletal assessment
- Neurological assessment

Project Goals

Dermatological Assessment

- Calluses
- Blisters

Musculoskeletal Assessment

- Foot Deformities
  - Clawtoe
  - Hammertoe
  - Bunion

Project Equipment

- Raspberry Pi 3 Model B
- Raspberry Pi Camera Module v2
- Keyboard
- Mouse

Python Libraries and Packages

- PiCamera
  - Controlling the Raspberry Pi Camera Module
- Matplotlib
  - Python plotting library
- Python Imaging Library
  - Open, save, rotate image files
- TensorFlow
  - Software library for machine learning and AI

Image Dataset

- The dataset consists of 420 images placed into three categories.
  - Callus
  - Blister
  - Deformation
- Training images: 336
- Validation images: 84

Limitations and Constraints

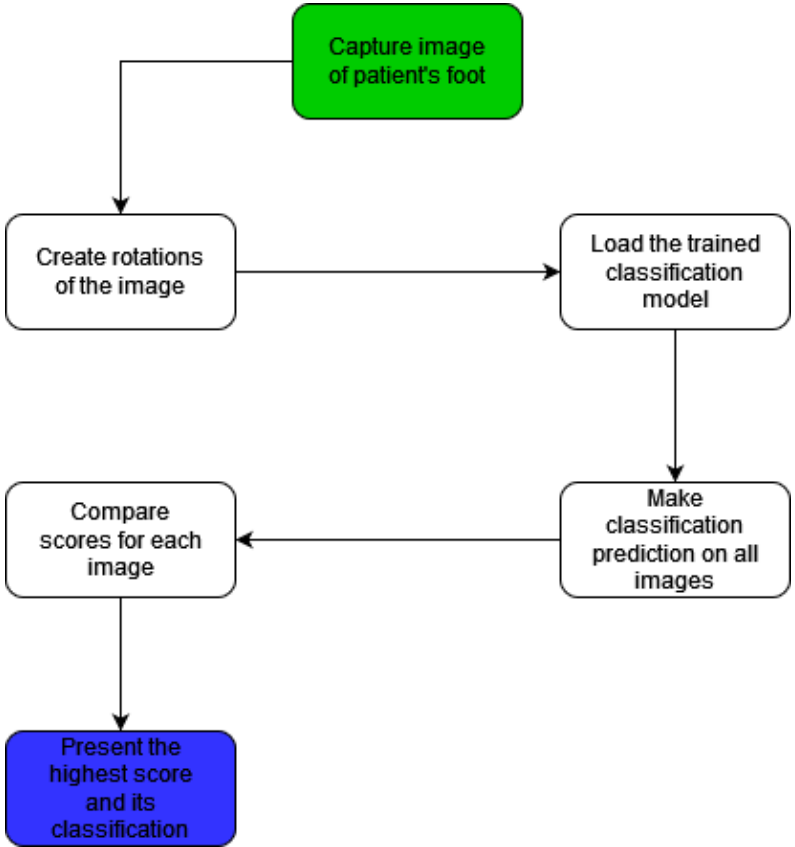
- Limited Dataset Size
  - Ideal size: 1,000 images per class
  - Actual size: 140 images per class
- Lack of Diversity in Data
  - Skin tone
  - Foot Placement
  - Aging Skin
- Address the most predominant condition

Solution and Implementation

Implementation Challenges

- TensorFlow version and Raspberry Pi compatibility
- Data uniqueness
- Dataset selection
- Camera position and lighting

Algorithm Flow



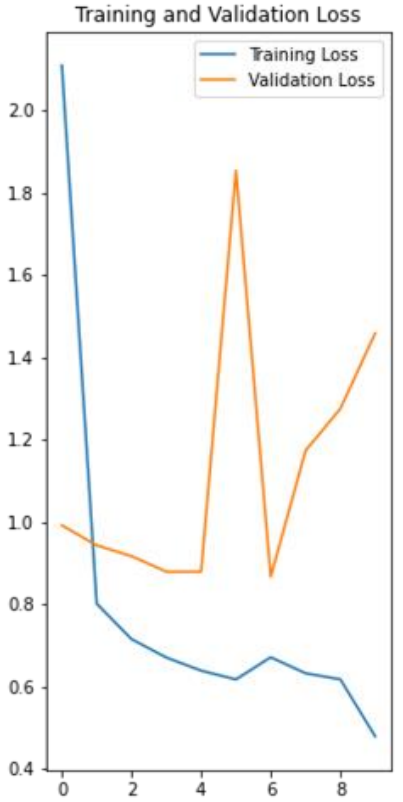
Training and Validation Loss

Training Comparison

- Training Loss (start): 2.1089
- Training Loss (end): 0.4783

Validation Comparison

- Validation Loss (start): 0.9912
- Validation Loss (end): 1.5483



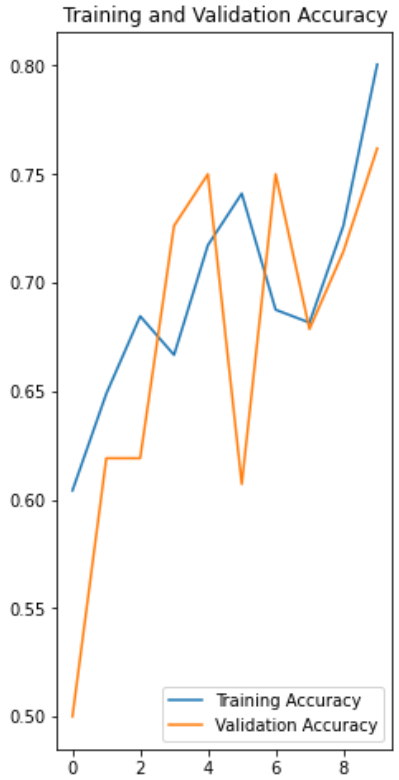
Training and Validation Accuracy

Training Comparison:

- Training Accuracy (start): 0.6042
- Training Accuracy (end): 0.8006

Validation Comparison

- Validation Accuracy (start): 0.5000
- Validation Accuracy (end): 0.7619



Loss and Overfitting

```
=================================================================
Total params: 47,341,091
Trainable params: 47,341,091
Non-trainable params: 0
_________________________________________________________________
Epoch 1/10
34/34 [==============================] - 149s 4s/step - loss: 2.1089 - accuracy: 0.6042 - val_loss: 0.9912 - val_accuracy: 0.5000
Epoch 2/10
34/34 [==============================] - 147s 4s/step - loss: 0.8012 - accuracy: 0.6488 - val_loss: 0.9427 - val_accuracy: 0.6190
Epoch 3/10
34/34 [==============================] - 146s 4s/step - loss: 0.7147 - accuracy: 0.6845 - val_loss: 0.9164 - val_accuracy: 0.6190
Epoch 4/10
34/34 [==============================] - 146s 4s/step - loss: 0.6700 - accuracy: 0.6667 - val_loss: 0.8786 - val_accuracy: 0.7262
Epoch 5/10
34/34 [==============================] - 147s 4s/step - loss: 0.6380 - accuracy: 0.7173 - val_loss: 0.8786 - val_accuracy: 0.7500
Epoch 6/10
34/34 [==============================] - 146s 4s/step - loss: 0.6167 - accuracy: 0.7411 - val_loss: 1.8535 - val_accuracy: 0.6071
Epoch 7/10
34/34 [==============================] - 147s 4s/step - loss: 0.6706 - accuracy: 0.6875 - val_loss: 0.8663 - val_accuracy: 0.7500
Epoch 8/10
34/34 [==============================] - 147s 4s/step - loss: 0.6317 - accuracy: 0.6815 - val_loss: 1.1728 - val_accuracy: 0.6786
Epoch 9/10
34/34 [==============================] - 147s 4s/step - loss: 0.6168 - accuracy: 0.7262 - val_loss: 1.2744 - val_accuracy: 0.7143
Epoch 10/10
34/34 [==============================] - 149s 4s/step - loss: 0.4783 - accuracy: 0.8006 - val_loss: 1.4583 - val_accuracy: 0.7619
```

Evidence of some overfitting

Case Study: Raspberry Pi Image

Bottom View

- Prediction: Deformation
- Confidence: 84.54%
- Correct classification: Callus

Side View

- Prediction: Deformation
- Confidence: 96.45%
- Correct classification: Callus

Case Study Results: Dermatological

Prediction: Deformation

Confidence: 92.36%

Correct Classification: Callus

Prediction: Callus

Confidence: 80.73%

Correct Classification: Callus

Case Study Results: Musculoskeletal

Prediction: Deformation

Confidence: 78.41%

Correct Classification: Deformation

Prediction: Callus

Confidence: 99.62%

Correct Classification: Deformation

Future Considerations

Recommendations for Improvement

- Build data set with original images
- Verify data for uniqueness
  - Ensure each image is unique
- Separate deformation categories
  - Determine more accurate characteristics for a class
- Address patients with multiple areas of concern

Conclusion

- Inaccurate results with high confidence levels
- Evidence of overfitting
- Larger, more diverse dataset is needed
- Additional study needed to determine impact of lighting and camera position

References

- https://care.diabetesjournals.org/content/31/8/1679
- https://diabetesed.net/wp-content/uploads/2017/05/3-minute-foot-exam.pdf
- https://www.ibm.com/cloud/learn/overfitting
- https://www.tensorflow.org/
- https://keras.io/