A **Generalizing**, **racially unbiased** image classification model, for a **small** and **imbalanced** dataset.

Predicting the Presence of Congenital Conditions from Facial Features

INTRODUCTION

- Mowat-Wilson syndrome and Noonan syndrome are very rare congenital conditions. It is important to diagnose these conditions early on, to start care and treatment.
- Both conditions have characteristic facial features as one of their symptoms.
- We investigated the possibility of constructing a model that could predict the presence of these conditions, based on images of faces.
- Because of the rarity of the conditions, not many images were available. Additionally, the dataset had very few images of African individuals.
- Therefore, the main challenge was building a racially unbiased model with the ability to generalize.

METHODOLOGY

1. The dataset consisted of 83 Mowat-Wilson images, 60 Noonan images, and 210 control images. Out of the total 353 images, only 32 were images of African individuals.
2. The low volume of data meant that using each pixel in the images themselves as training data wasn't viable.
3. After aligning and resizing the images to be homogenous, facial feature coordinates were extracted using the face++ API.
4. Pairwise distances were calculated for the coordinates. These distances were used as the training data.
5. Various different dataset configurations, feature selection methods, and classification algorithms were tested.
6. The best-performing combinations were selected to be used in the final ensemble of classifiers.
7. The final model was an ensemble of 6 different probabilistic Support Vector Machine (SVM) classifiers.

RESULTS

- The model's ability to generalize was tested using 46 unseen images.. The model obtained the following performance results:
  - Accuracy: 0.84
  - Average F1-score: 0.80
  - Average recall: 0.81
  - Average precision: 0.81
- Additionally, the model was retrained and tested after removing 29 African images and 29 non-African images from the training set, and using them as unseen data.
- The results indicated that there was no significant difference in the model's performance on African and non-African images.

DISCUSSION

- Under normal circumstances, image classification problems are usually solved using Convolutional Neural Networks. Unfortunately, this approach requires a large number of images for each class before the model will be successful (at least 1000 images per class). This is why an alternative approach had to be considered.
- Using the pairwise distances between facial features proved to be an effective solution. It did, however, also cause the training data to have a very large number of features, and very little samples.
- In retrospect, it makes sense that Support Vector Machine (SVM)-based feature selection methods, combined with SVM classifiers performed the best. This is because SVMs are well suited to dealing with datasets that has many dimensions.
- By building an ensemble, the strengths of different classifiers were utilized, and the weaknesses of individual classifiers were neutralized.

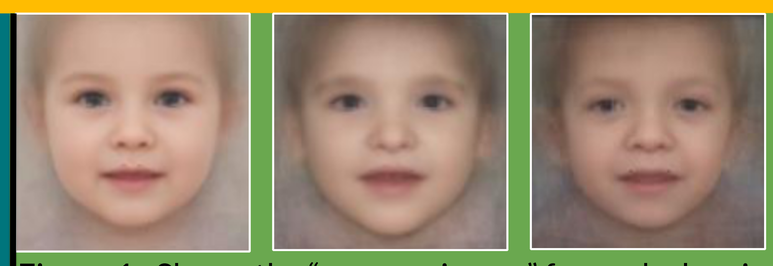

Figure 1: Shows the "average image" for each class in the dataset. From left to right: The Control group, the Mowat-Wilson syndrome group, and the Noonan syndrome group.

Figure 2: The data processing steps. The first image displays the original image. The middle image is the image after it's been aligned and resized. The image on the right shows the coordinate points that were placed on the facial features.

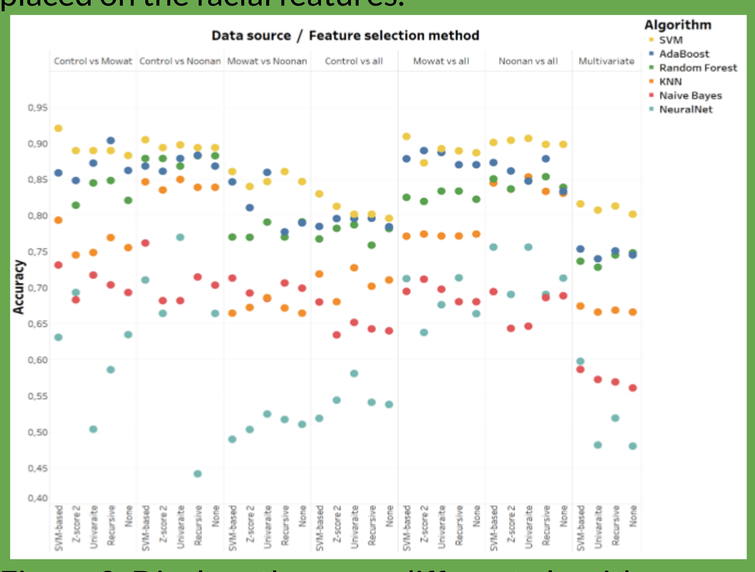

Figure 3: Displays the many different algorithms, feature selection, and dataset configuration methods that were tested.

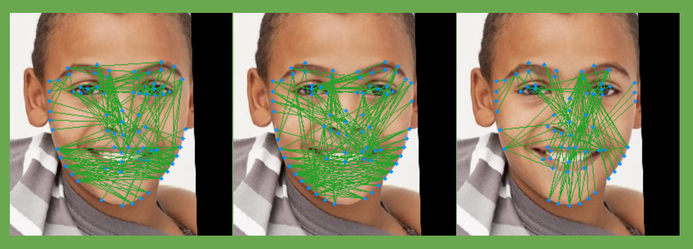

Figure 4: Visualizes some of the different pairwise distances that were used by the final classifiers.

By: Christopher Marais & Pieter van der Walt

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Department of Computer Science

Faculty of Engineering, Built Environment and Information Technology

Fakulteit Ingenieurswese, Bou-omgewing en Inligtingtegnologie / Lefapha la Boetšenere, Tikologo ya Kago le Theknolotši ya Tshedimošo

Capstone Project - MIT 808

Course Coordinators:
Dr. Vukosi Marivate (vukosi.marivate@cs.up.ac.za)
Abiodun Modupe (abiodun.modupe@cs.up.ac.za)

Scan me