CAPSTONE PROJECT #2

FACE MASK DETECTION WITH NEURAL NETWORKS

CHRIS STELLATO
github.com/chris-stellato
stellatocjs@gmail.com
chris-stellato.com

PROJECT SUMMARY

BUILDING A NEURAL NETWORK

This project uses Python, TensorFlow, and Keras to create a convolutional neural network that can analyze images of humans and predict if they are wearing a face mask or not.

The dataset is a combination of multiple image sets with a total of 900 images of individual humans, with 54 % wearing a face mask.

The following methods were used to create a highly accurate machine learning model:

- Process images and evaluate performance of Random Forest and Gradient Boosting classifier models.
- Create python code to organize image files.
- Process images with TensorFlow Keras Image Data Generator.
- Evaluate multiple versions of Keras Sequential models and VGG16-based model.
- Test custom VGG16 model on real-world photo submissions.

I'VE GOT THE TICKETS
I'VE GOT MY PHONE

DID YOU REMEMBER TO WEAR A MASK?

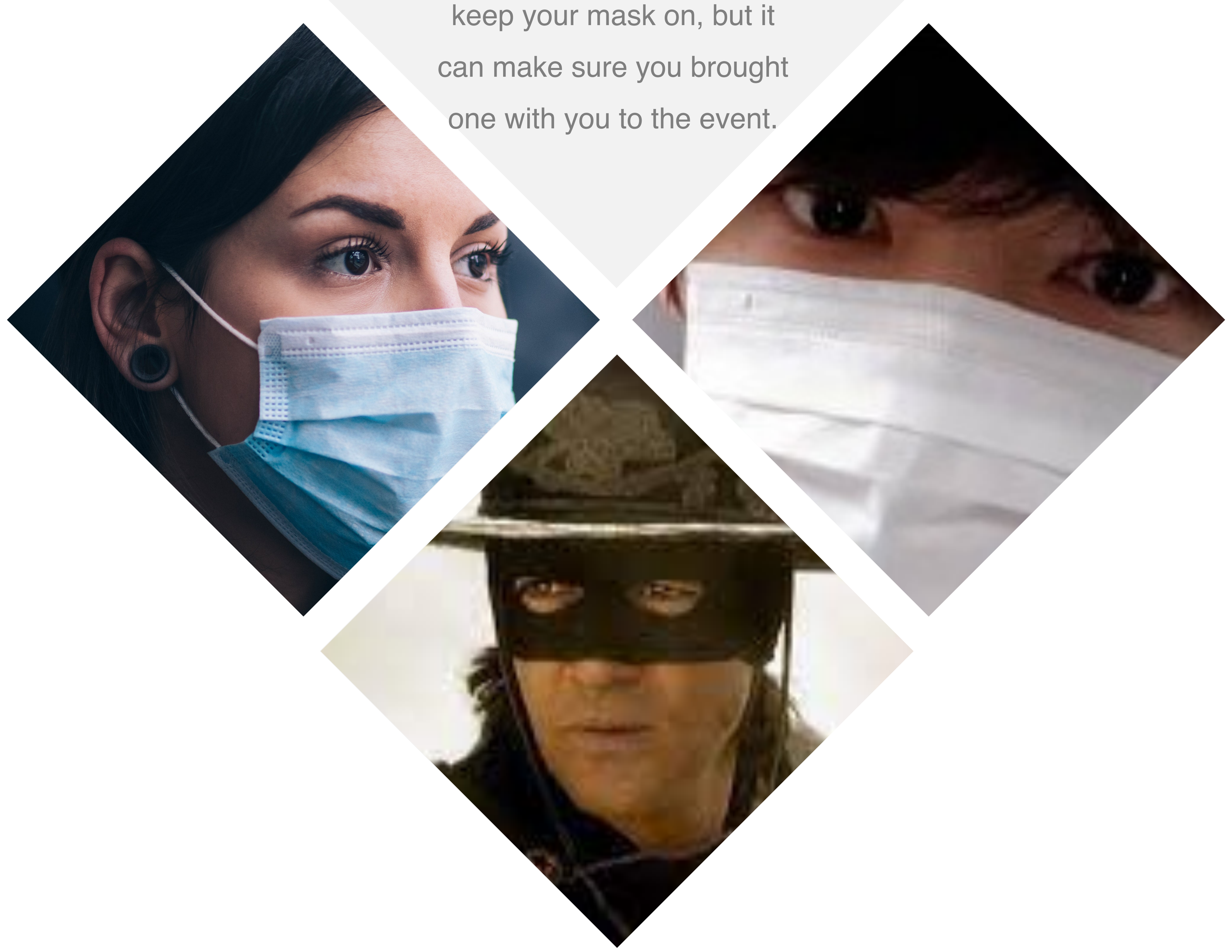
DATASET

BINARY CLASSIFICATION IMAGE SET

Download link: github.com/chris-stellato/capstone2

PICTURE THIS:

An image classifier can't keep your mask on, but it can make sure you brought one with you to the event.



The sample training dataset is an assortment of 900 images, including jpg, gif, and png formats. There are 900 images total, classified in 'mask' and 'no_mask' folders.

Image set 1: unsplash.com Images

Download link: https://www.kaggle.com/sumansid/facemask-dataset

Image set 2: Kaggle user Vinay Kudari

Download link: https://www.kaggle.com/vinaykudari/facemask

Image set 3: Wildcards

Download link: github.com/chris-stellato/capstone2

PROJECT MOTIVATION

HOW CAN THIS MACHINE LEARNING MODEL HELP US?

AWARENESS

Remind patrons upon entering an event venue or travel area to have their mask on and ready.

ACCESS

Automatically grant patrons access to a venue if they satisfy the mask-wearing requirements upon entry.

SENTIMENT

Understand sentiment around mask-wearing within your community.

PRODUCTIZATION

Gain insight to help connect with customers and design better products.

PERFORMANCE TESTING

LEARNING MODEL SELECTION

Testing various learning models with a variety of hyperparameters, we find a model with the best balance of resource usage, speed, and accuracy predicting on unseen images.

IMAGE PROCESSING

Optimize images for detecting presence of a face mask.

RANDOM FOREST MODELS

Fast to produce and fast to train. Better than random guessing (70% accuracy).

GRADIENT BOOSTING MODELS

More complex model gave insignificant performance boost.

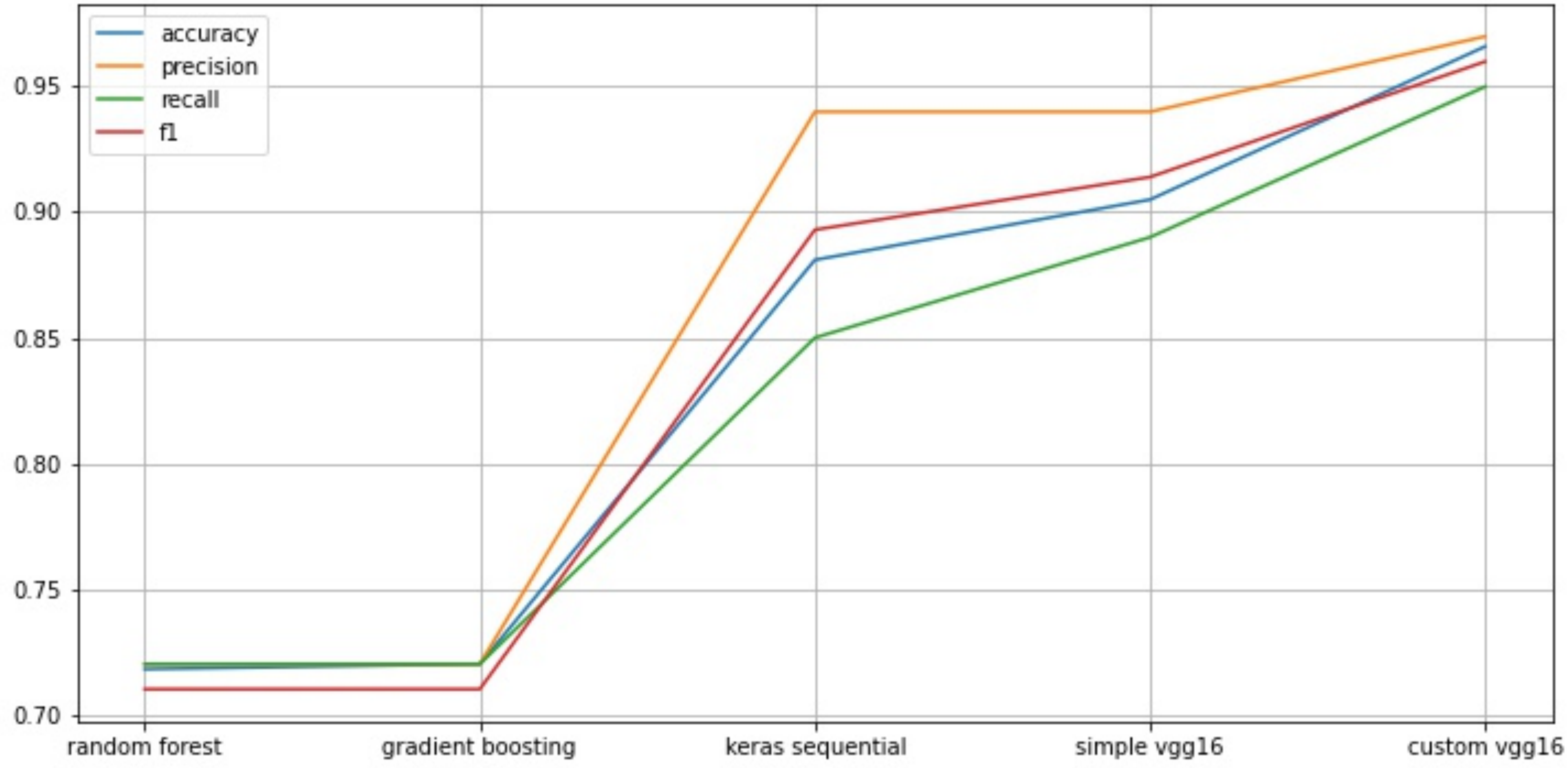
NEURAL NETWORKS

Able to expand image data for extensive neural network training. Accuracy of 97% on holdout image data.

PERFORMANCE TESTING

MODEL PERFORMANCE

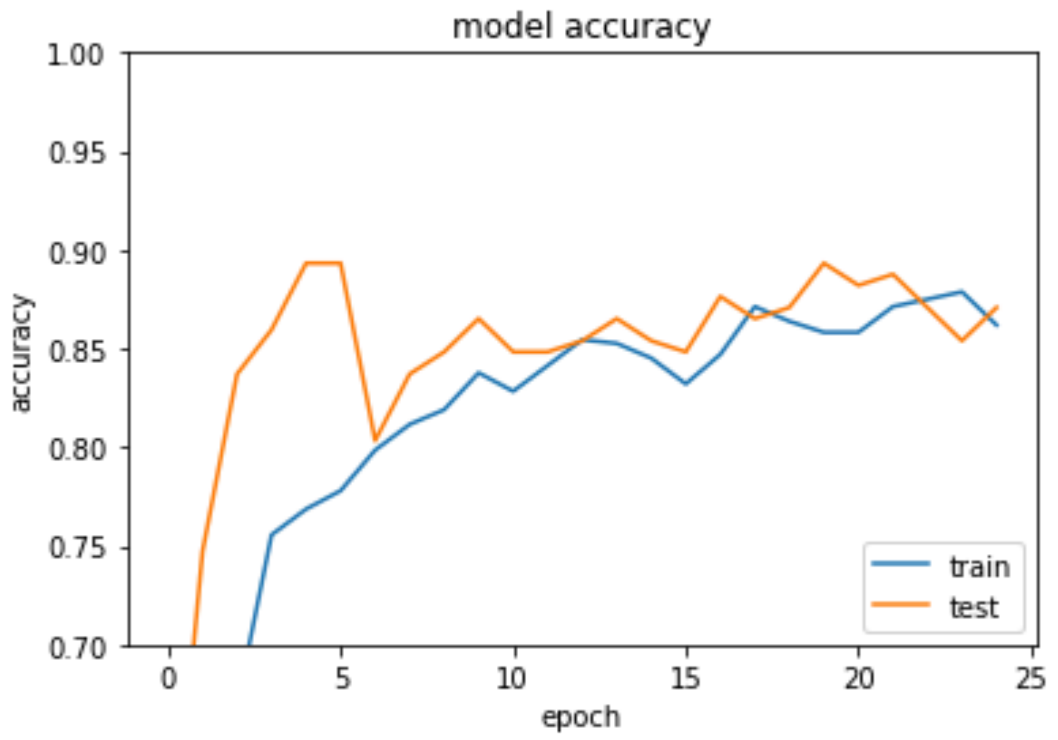
Improving accuracy, precision, and recall results. Achieved through repeated cycles of model training, evaluation, and improvement during the project window.

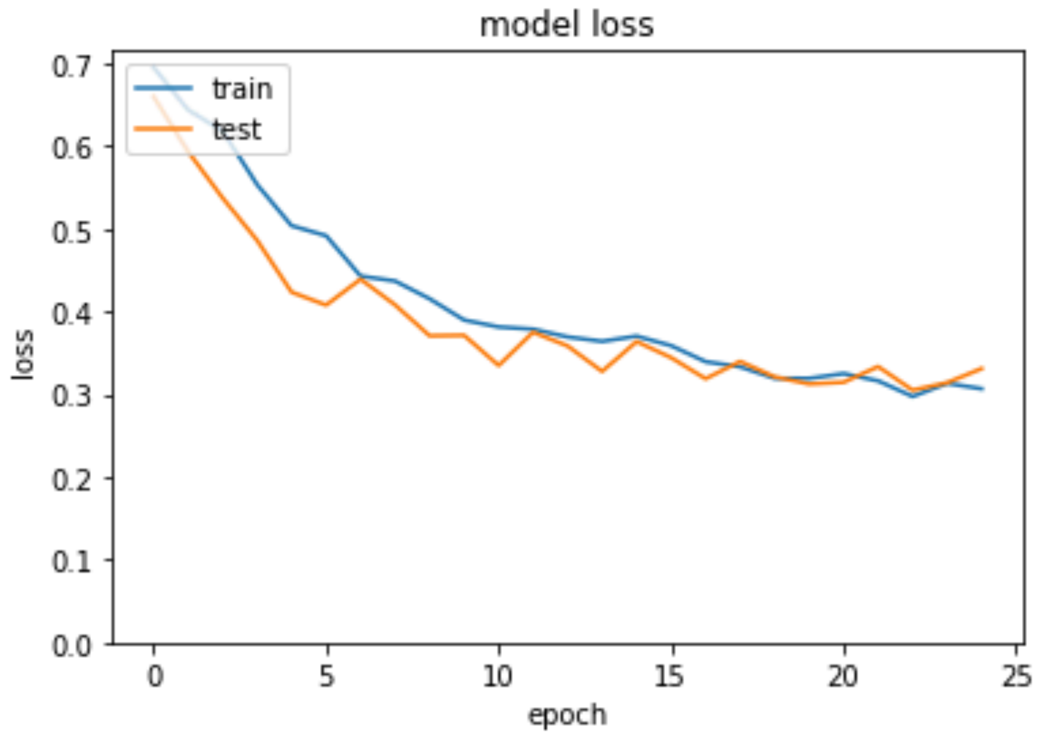


PERFORMANCE TESTING

MODEL COMPARISONS

Accuracy and loss improvements over repeated epochs, until progress plateaus. Learning rates = 0.0001

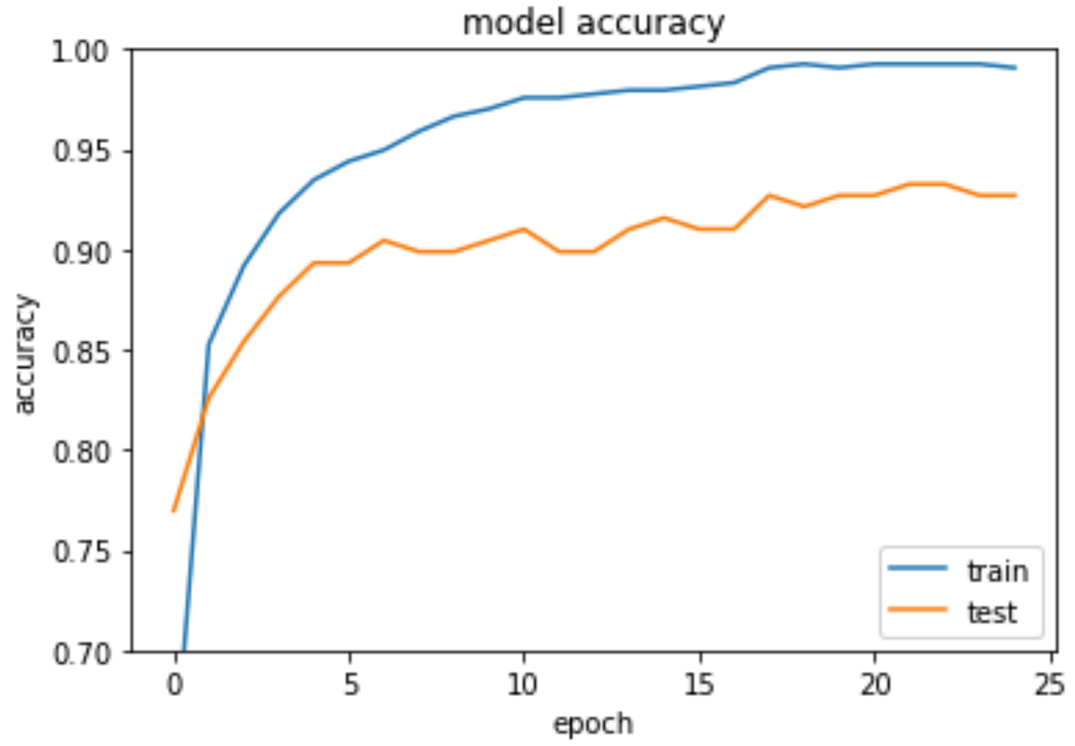


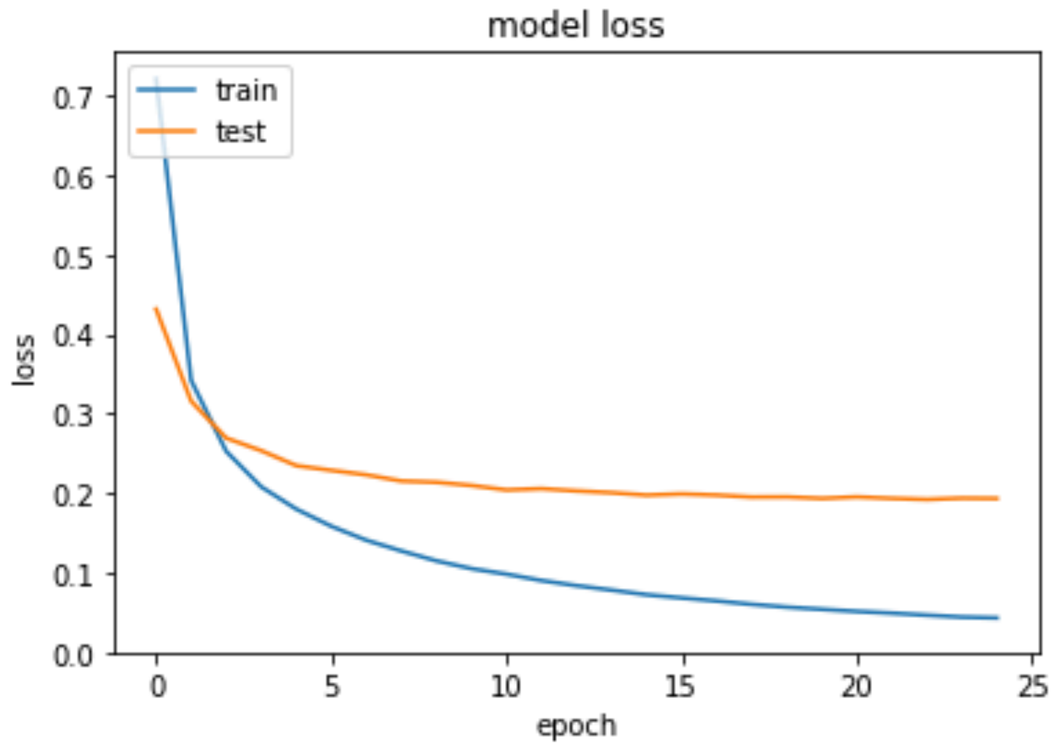


BASIC SEQUENTIAL

TensorFlow Keras Sequential Model

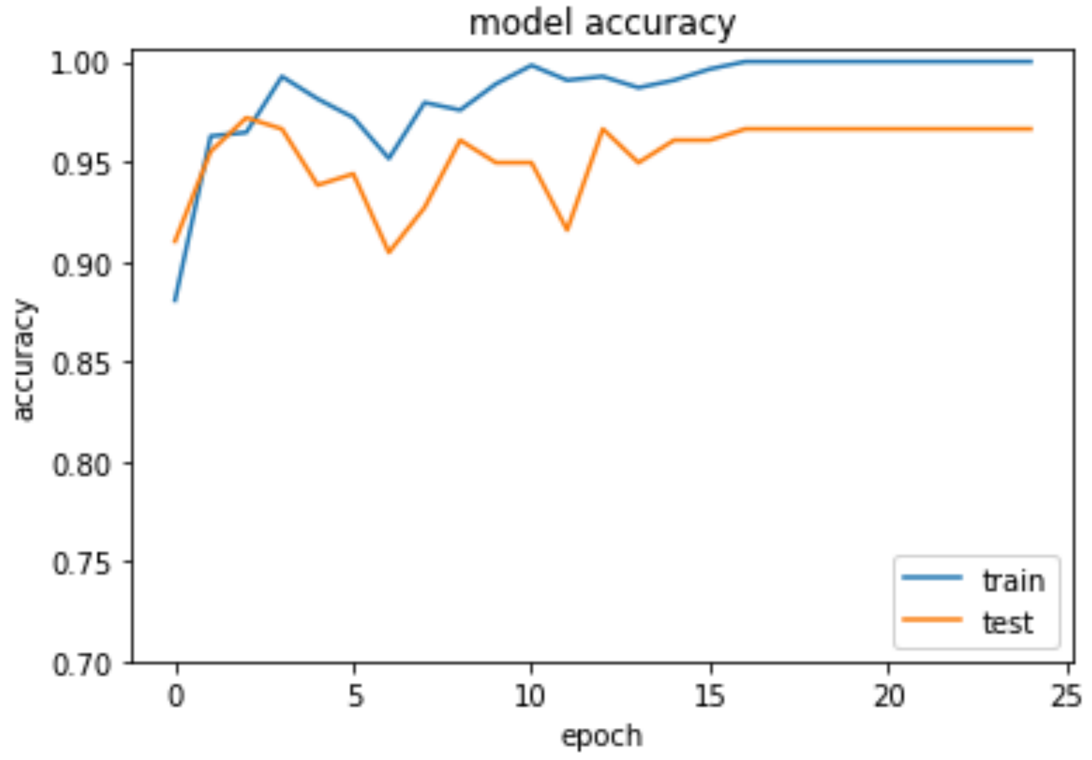
epochs = 25,

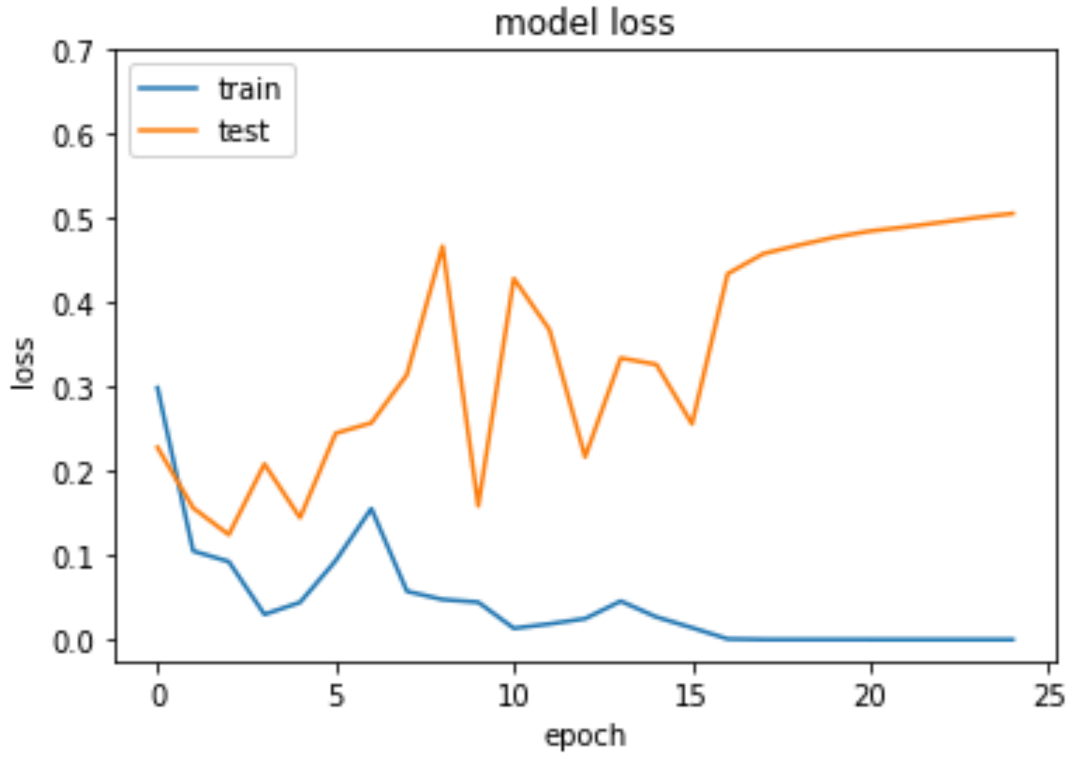




SIMPLE VGG16

VGG16 model with all layers deactivated except final output layer. Automated callbacks saved weights after 5 epochs.



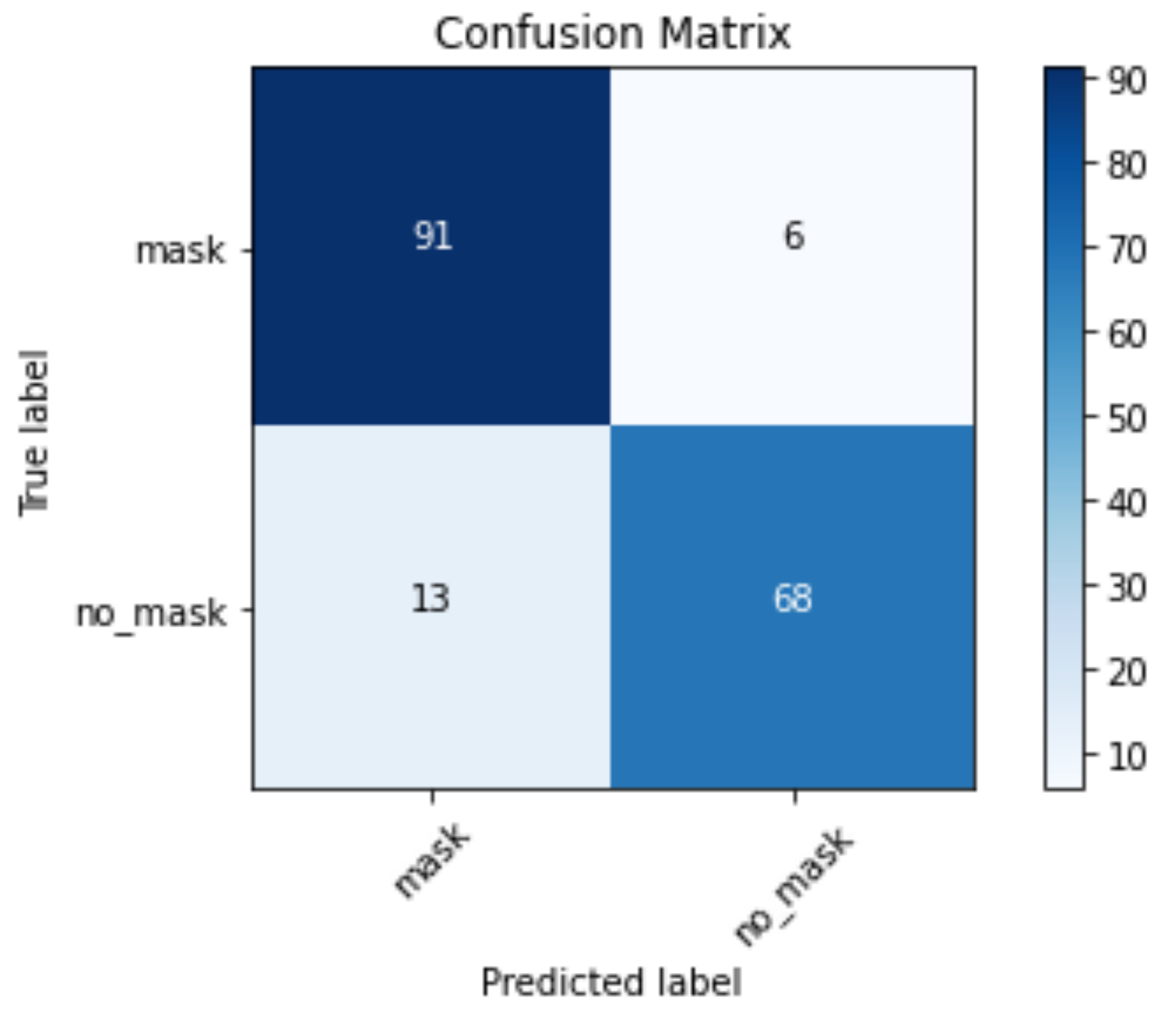


TUNED VGG16

VGG16 model with five million trainable parameters. Automated callbacks saved weights after 15 epochs.

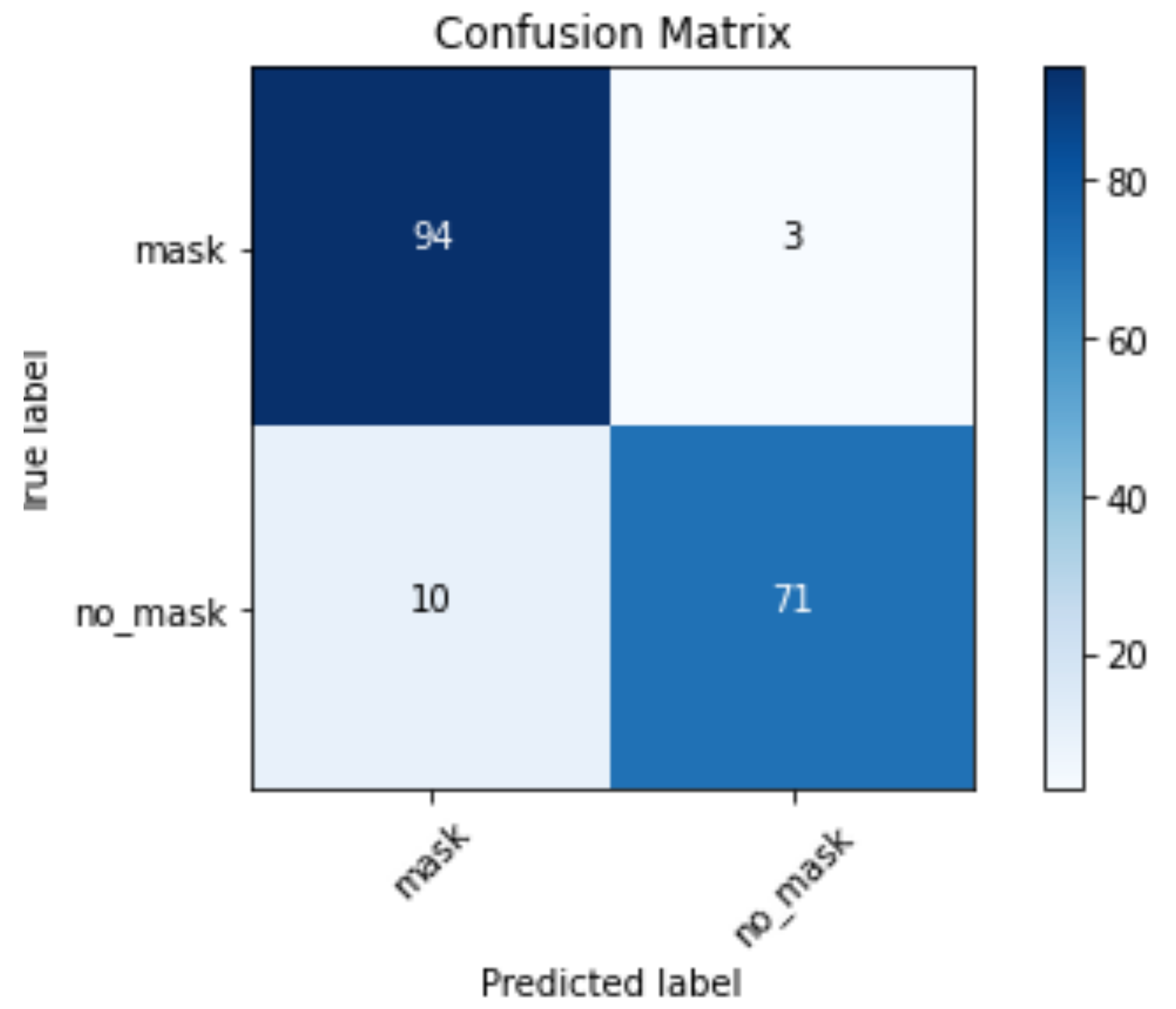
MODEL COMPARISONS

Progression of confusion matrices on holdout data using different neural network builds.



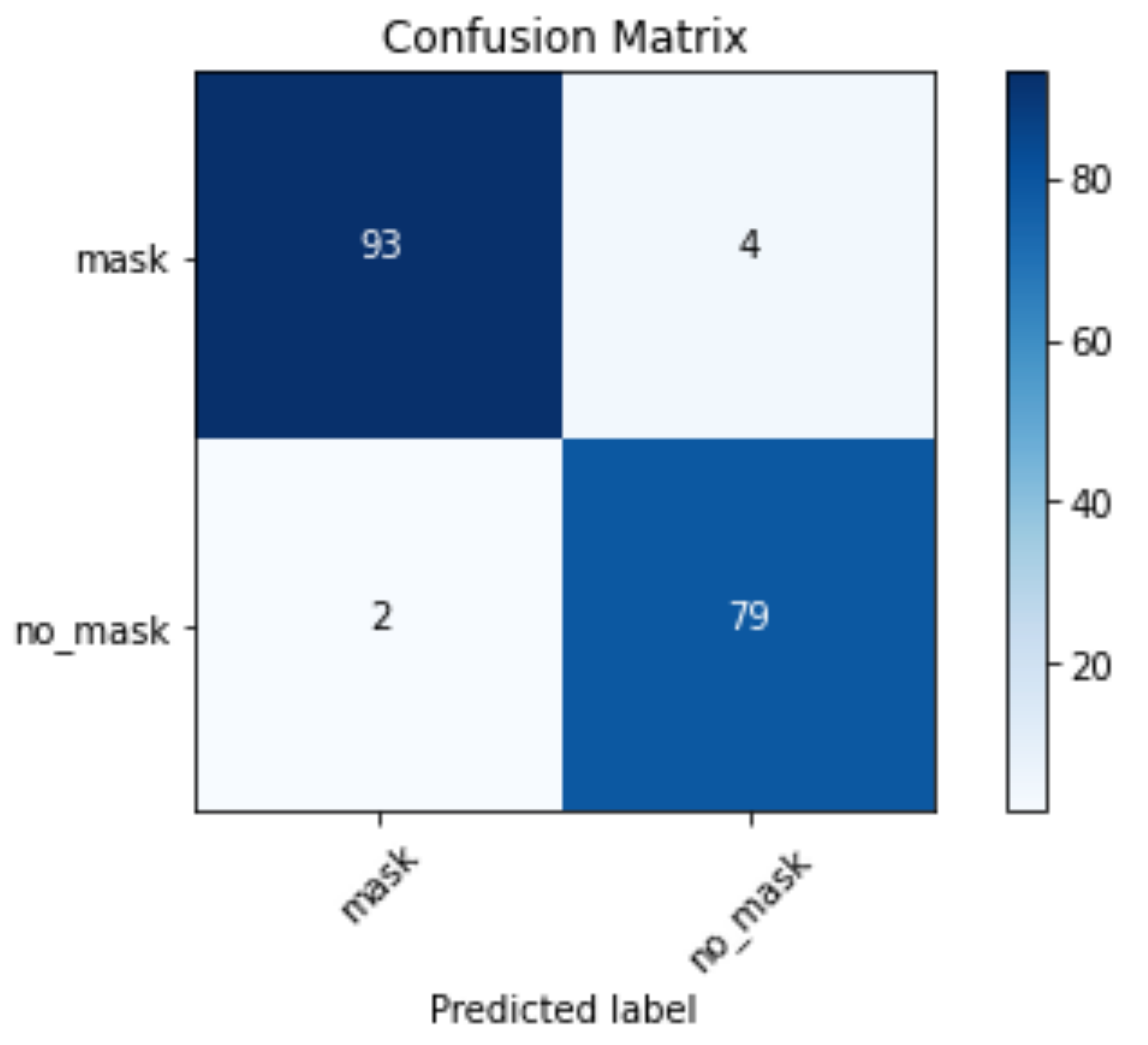
BASIC SEQUENTIAL

Produced a high number of false positives and low accuracy overall.



SIMPLE VGG16

Model accuracy improved, still biased towards false positives.



TUNED VGG16

Model sees significant improvements. Showing more false negatives than false positives.

BEST MODEL DURING TESTING:

CUSTOMIZED VGG16 SEQUENTIAL MODEL

By modifying the award-winning VGG16 image classification model, we are able to build a face mask image classifier with only a few minutes of training on the sample data. This could theoretically be run on a variety of devices, with or without a GPU.

Neural network performance on sample data set:

Accuracy: 97%

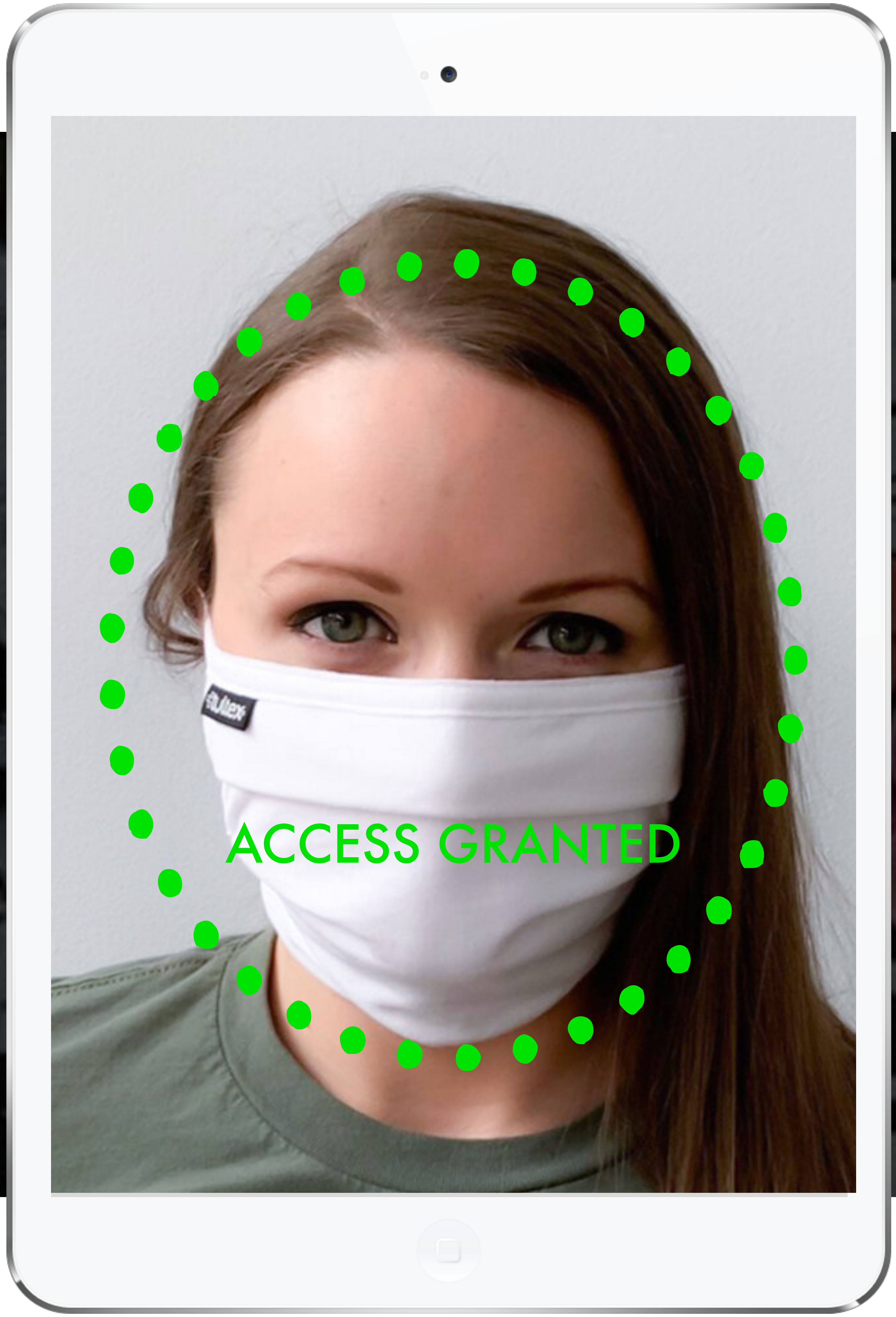
Recall: 97%

Precision: 95%

F1 Score: 96%

Tuning:

- Manage training time by only activating certain layers
- 5 million trainable parameters
- Best settings during testing:
    - Learning rate: 0.0001
    - Epochs: 15



MACHINE LEARNING IN ACTION

PUTTING OUR MODEL TO WORK

This type of model can be saved, uploaded, and implemented as one part of a broader system to categorize face mask usage. Whether a user is downloading concert tickets or entering a restricted zone at an airport, this helpful technology could remind the user to have an appropriate face covering when required.

THIS MODEL WAS TESTED ON

REAL PEOPLE

RESPONSIBILITY

A MODEL USED IN THE REAL WORLD HAS IMPACT ON REAL LIVES

Any application of a machine learning model requires an organization to calculate the cost of when a model fails to predict information correctly. Consider the different cost of failure for a face mask model: if the application targets a user with ads for stylish face coverings, the cost of failure is low. If the cost of failure results in a pilot not being able to start an airplane's engine for takeoff, the cost of failure is high.

Neural networks should be trained on data that is most similar to what they will encounter in production, and should be continuously evaluated and tuned to ensure failed predictions aren't having unanticipated consequences.

FURTHER EXPLORATION

How could we build on this type of machine learning framework?

CATEGORIZING

This style of model can be updated to categorize how an individual is wearing a face mask. Example: is the mask being worn correctly to cover the nose and mouth?

HANDLING GROUPS

In addition to analyzing images of individuals, the model could be modified to analyze multiple individuals within one single frame.

VIDEO ANALYSIS

This style of neural network could be applied to analyzing video in addition to still images. With larger training datasets and additional testing time, these methods can continue to produce better models for expanded use.

THANK YOU

CONTACT

CHRIS STELLATO
BOULDER, CO
STELLATOCJS@GMAIL.COM

LINKS

github.com/chris-stellato/capstone2
linkedin.com/in/cstellato
chris-stellato.com