Physical Layer Data Augmentation Techniques for Face Recognition and Face Emotion Classification

Ashish Vinodkumar
Pranav Manjunath

Duke University

Objectives

- To build a Deep Learning Model that can accurately detect faces and predict face emotions.
- Understand if adding physical layer augmentation techniques to train a Deep Learning Model will help improve model performance, while reducing the number of pixels used.
- Compare the model results for various physical layer augmentation techniques and conclude which technique performs the best when predicting Face Emotions.

Abstract

- We explored various physical layer augmentation techniques such as top-half mask, bottom-half mask, one-fourth mask on the Face Emotion Classification Dataset.
- We used a VGG-16 model architecture for Face Emotion Classification.
- We further used the following metrics to assess performance:

  Accuracy

  Precision

  Recall

  F1 Score

Data Source

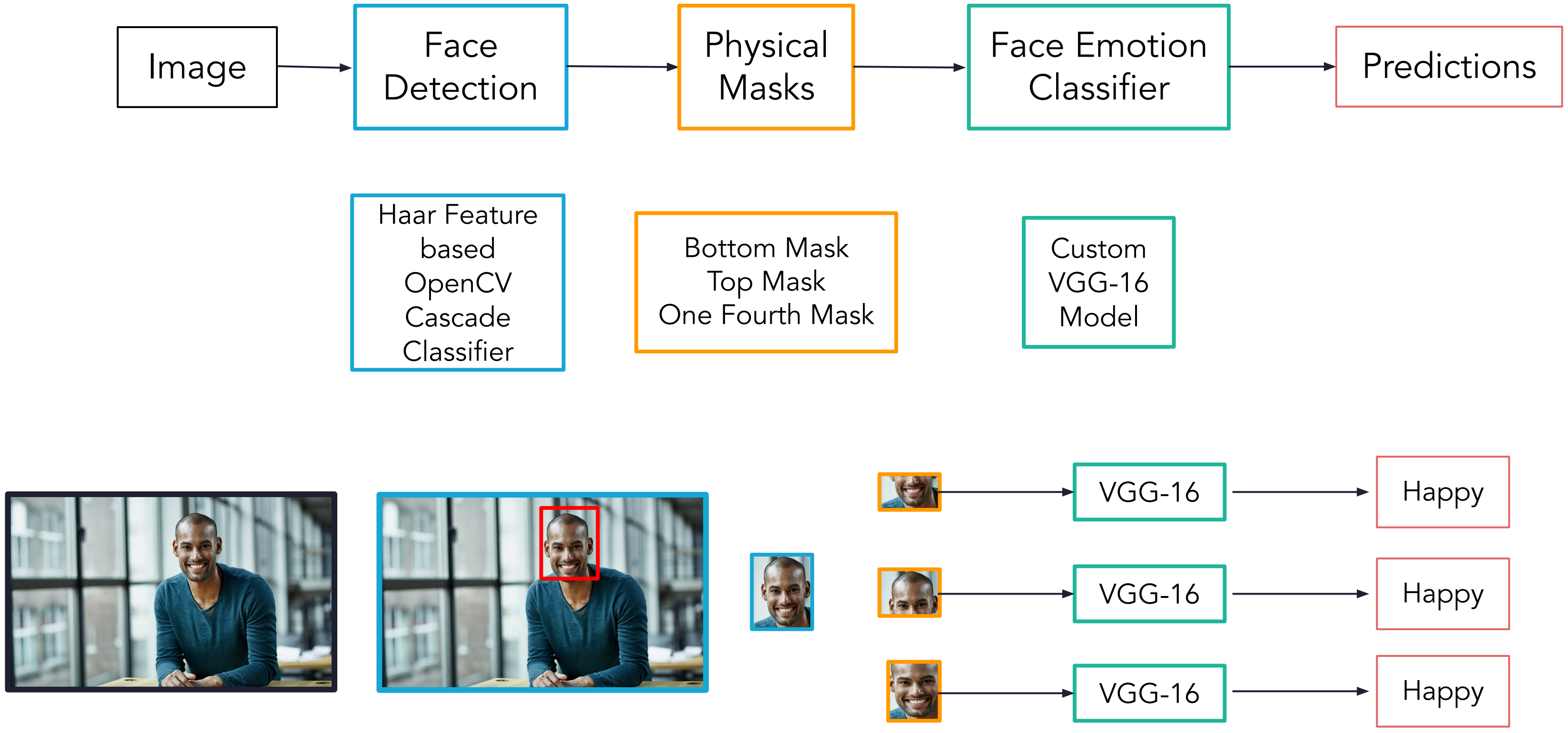
Took a subset of the "Face expression recognition dataset" by Jonathan Oheix on Kaggle. Consists of only grayscale (black-and-white) images.

Happy	Neutral	Sad
8989 Image	6198 Images	6077 Images

Tackling Data Bias

- Ensured that there were at least 5000 images in training for each emotion
- Balanced proportion of males and females
- Various races present in the dataset
- Various facial views (front and side views)
- Balanced proportion of age groups

Methodology



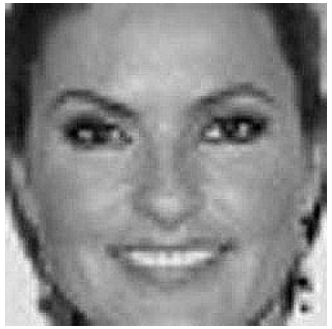
Data Augmentation for Emotion Classification

Utilized a sharpness kernel to improve the model classification accuracy.

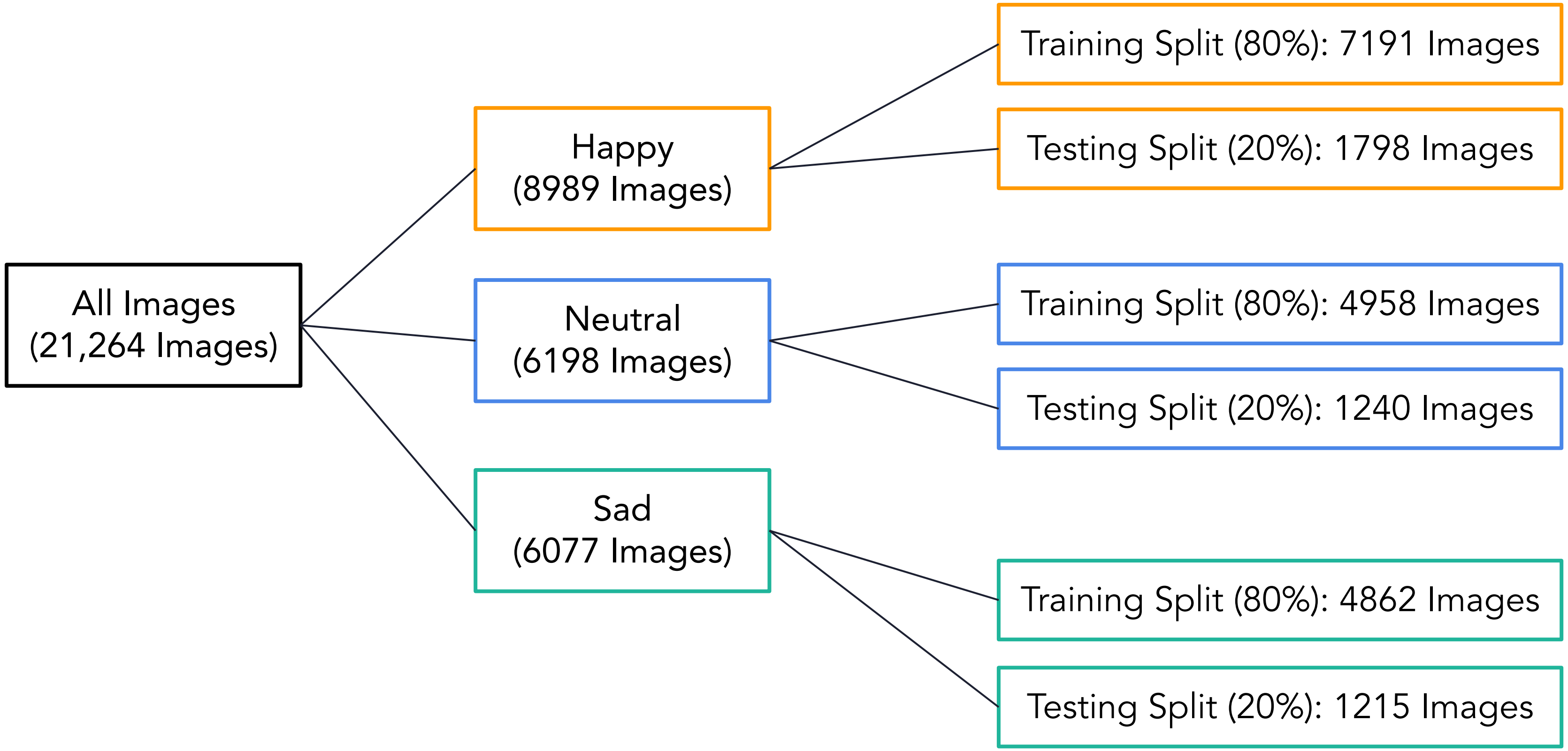
$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

Original Image

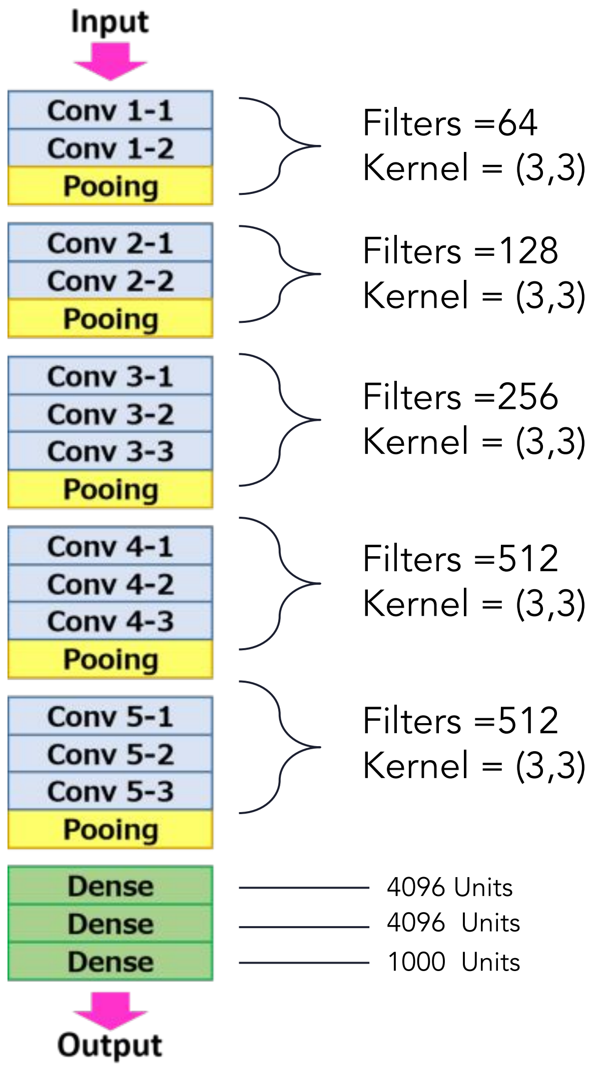
Sharpened Image



Data Pipeline



VGG -16 Model



Optimizer: Adam
Learning Rate: 0.0001
Loss: Sparse Categorical Cross Entropy
Batch Size: 64

Hyperparameters We Experimented With

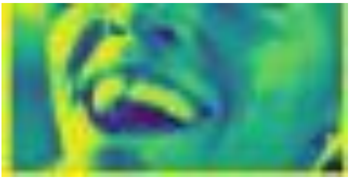
We decided to use a VGG-16 Model with the following hyperparameters:

- Learning Rate: 1e-3, 1e-4, 1e-5
- L2 Regularization: 1e-4, 1e-3, 1e-5
- Dropout: 0.05, 0.5, 0.6, 0.7

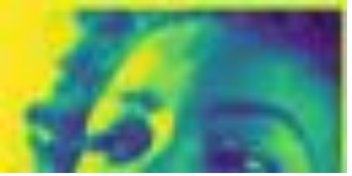
For Physical Layer Augmentation Techniques, we implemented the following:

- Top-Half Mask
- Bottom-Half Mask
- One-Fourth Mask

Original Image



Top-Half Mask

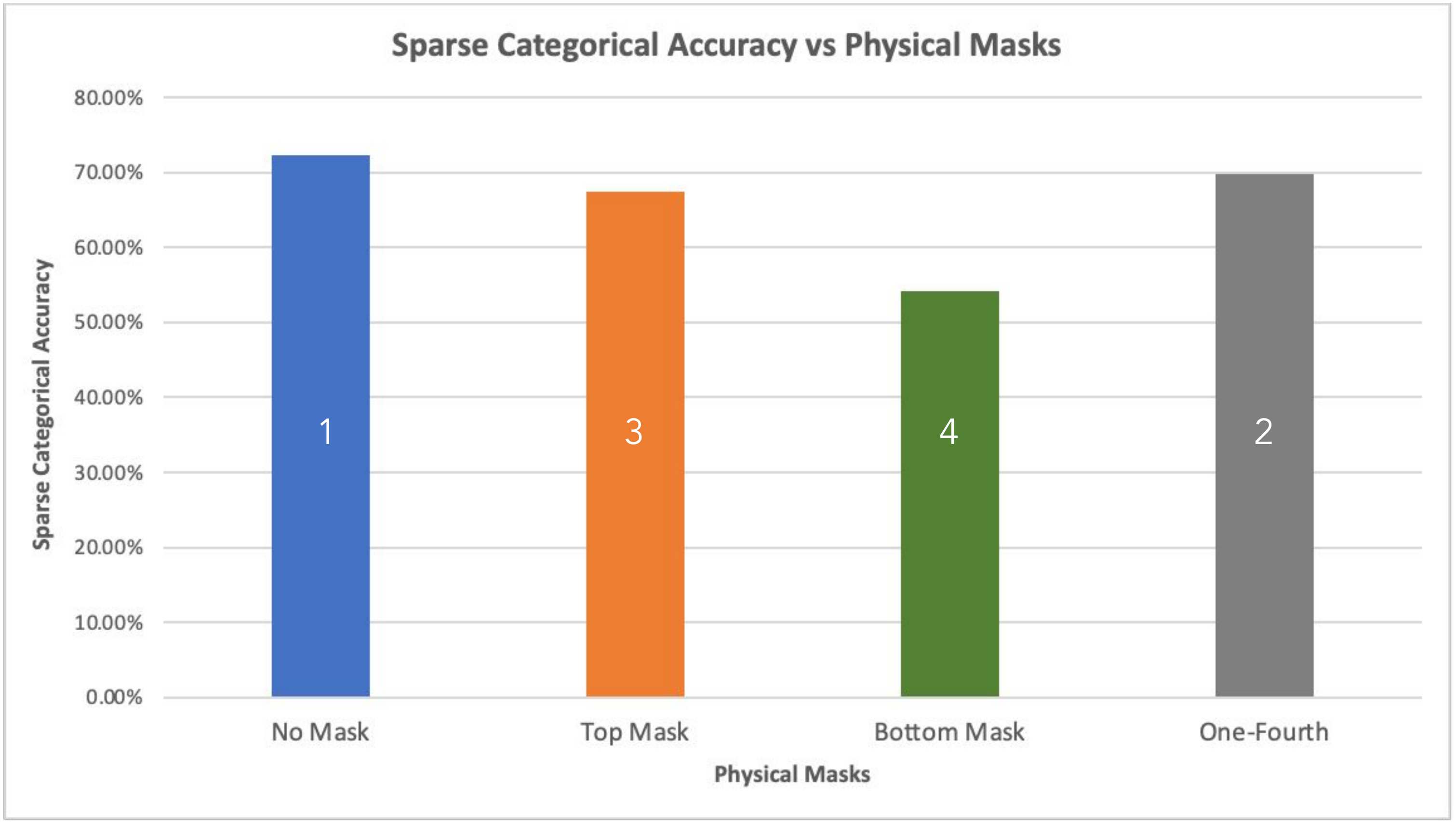


Bottom-Half Mask

One-Fourth Mask

Results

	Validation Metrics	Overall
No Mask	Accuracy	72.31%
	F1 Score	72.29%
Top Mask	Accuracy	67.42%
	F1 Score	67.85%
Bottom Mask	Accuracy	54.16%
	F1 Score	54.40%
One-Fourth Mask	Accuracy	69.76%
	F1 Score	69.77%



Results (cont'd): Precision & Recall

Precision

Precision	Happy	Sad	Netural
No Mask	86%	61%	65%
Top Mask	85%	55%	58%
Bottom Mask	64%	54%	42%
One-Fourth	86%	56%	65%

Recall

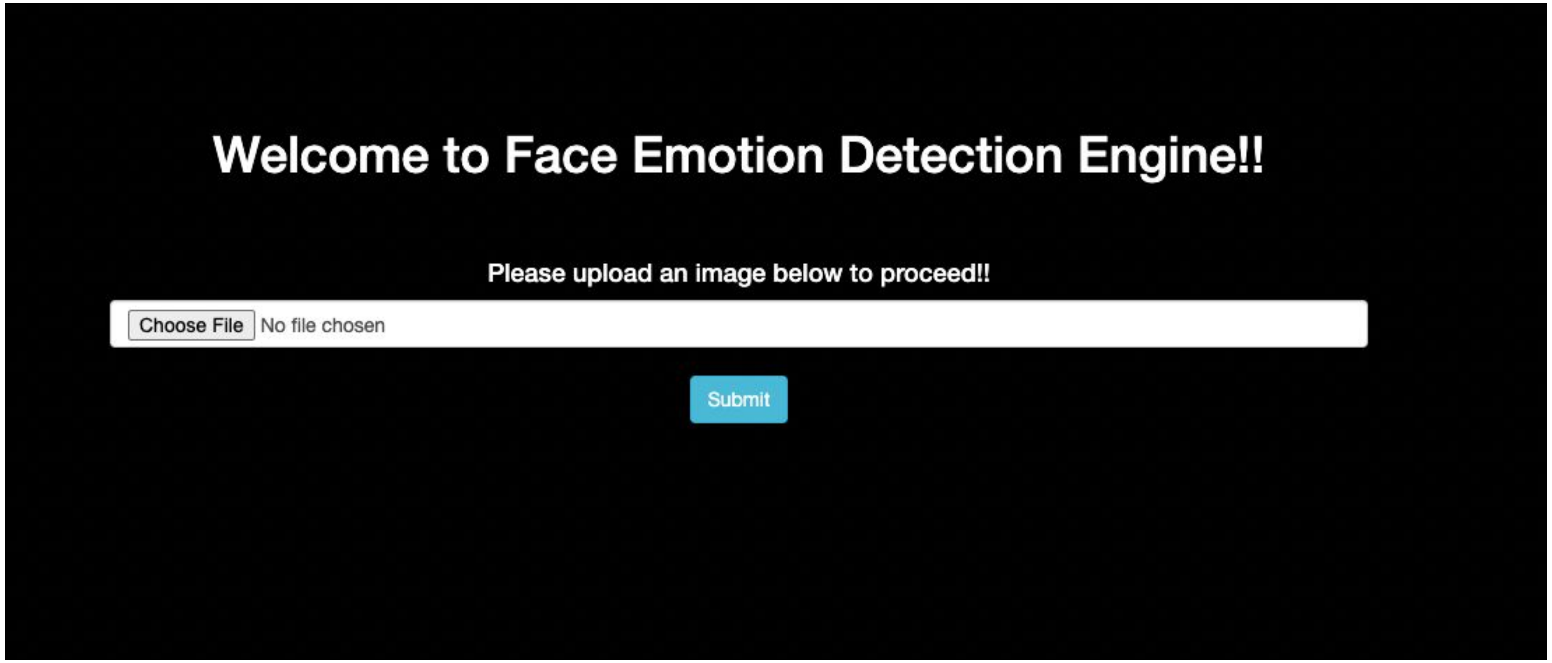
Recall	Happy	Sad	Netural
No Mask	84%	71%	56%
Top Mask	77%	60%	60%
Bottom Mask	61%	50%	48%
One-Fourth	81%	74%	50%

Conclusion

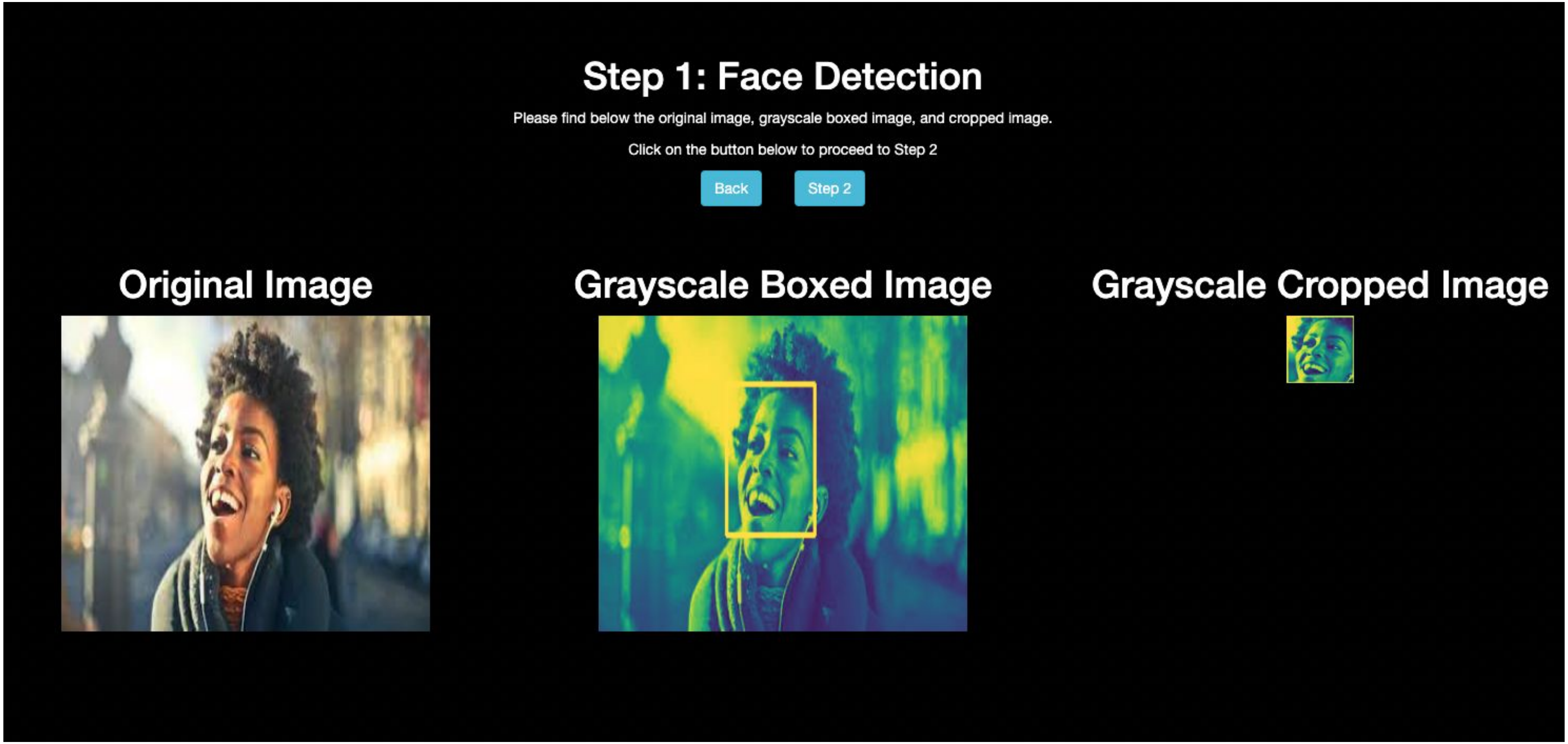
- We can remove ¼ pixels and still achieve near baseline accuracy.
- Each masked model performs the best when predicting the emotion Happy.
- As expected, the model performance indicates that the forehead is not extremely important while predicting face emotions.
- More importantly, the bottom half of the face is critical in predicting these facial emotions.

Flask Web-App

Home Page



Step-1 Face Detection



Step-2 Emotion Detection

Step-2 (cont'd) Emotion Detection Classification

Best-Model Classification

- One-Fourth Mask Model

Majority Ensemble Voting Classification

- Pools the classification results from baseline (no-mask), top-half mask, bottom-mask, and one-fourth mask models.
- Votes on the majority classification, to identify winning label.
- In case of tie, the best model classification is used as a tiebreaker.

References

1. Pei, Zhao, et al. “(PDF) Face Recognition via Deep Learning Using Data Augmentation Based on Orthogonal Experiments.” *ResearchGate*, https://www.researchgate.net/publication/336061375_Face_Recognition_via_Deep_Learning_Using_Data_Augmentation_Based_on_Orthogonal_Experiments.
2. Li, Jessica. “Labelled Faces in the Wild (LFW) Dataset.” *Kaggle*, 17 May 2018, https://www.kaggle.com/jessicali9530/lfw-dataset.
3. Oheix, Jonathan. “Face Expression Recognition Dataset.” *Kaggle*, 3 Jan. 2019, https://www.kaggle.com/jonathanoheix/face-expression-recognition-dataset/discussion/152419.
4. “Cascade Classifier.” *OpenCV*, https://docs.opencv.org/3.4/db/d28/tutorial_cascade_classifier.html.
5. Porcu, Simone, et al. *Evaluation of Data Augmentation Techniques for Facial ...* https://www.researchgate.net/publication/345940392_Evaluation_of_Data_Augmentation_Techniques_for_Facial_Expression_Recognition_Systems.

Thank You!