An abstract graphic on the left side of the slide featuring a network of blue dots connected by thin lines, set against a dark blue background with a light blue gradient on the right.

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

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# 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

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- 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





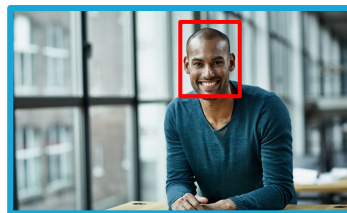
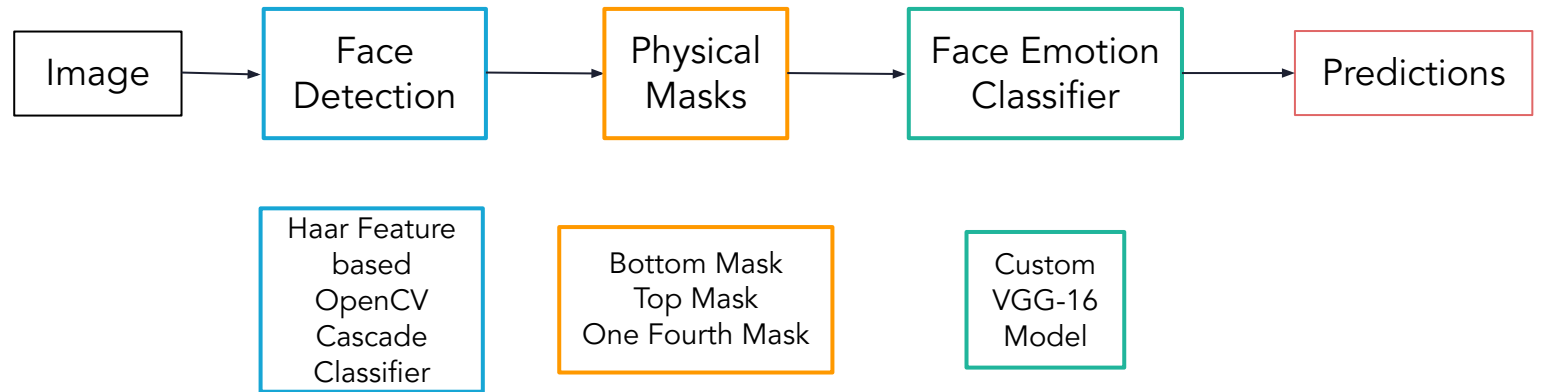


# Tackling Data Bias

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- 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



VGG-16

Happy



VGG-16

Happy



VGG-16

Happy



# Data Augmentation for Emotion Classification

Utilized a sharpness kernel to improve the model classification accuracy.

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

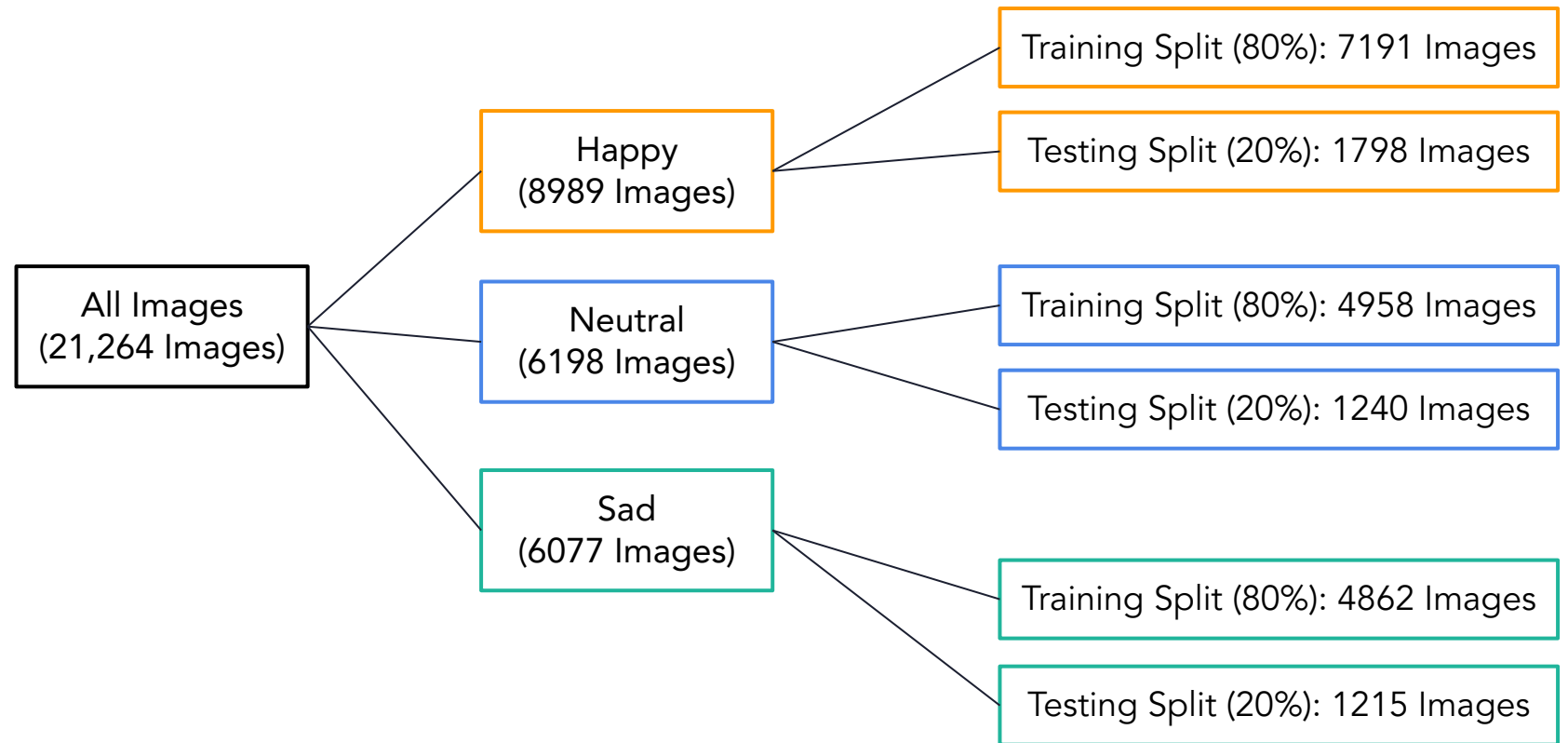
Original Image



Sharpened Image

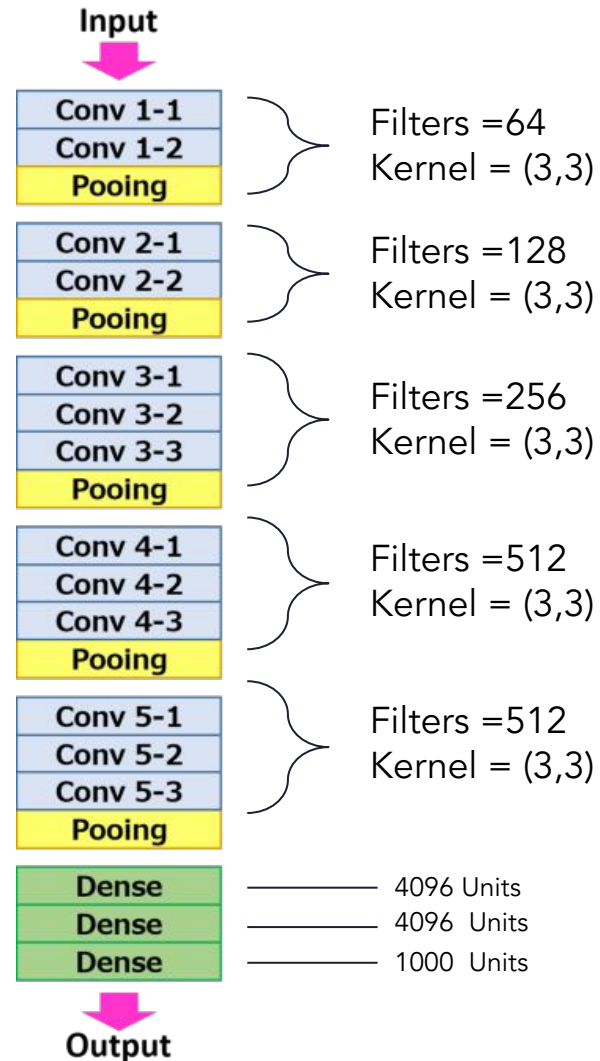


# Data Pipeline





# VGG -16 Model



Optimizer: Adam

Learning Rate: 0.0001

Loss: Sparse Categorical Cross Entropy

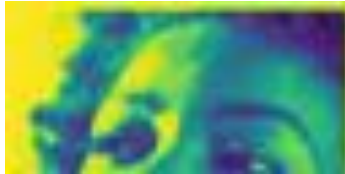
Batch Size: 64



Original Image



Top-Half Mask



Bottom-Half Mask



One-Fourth Mask

## 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

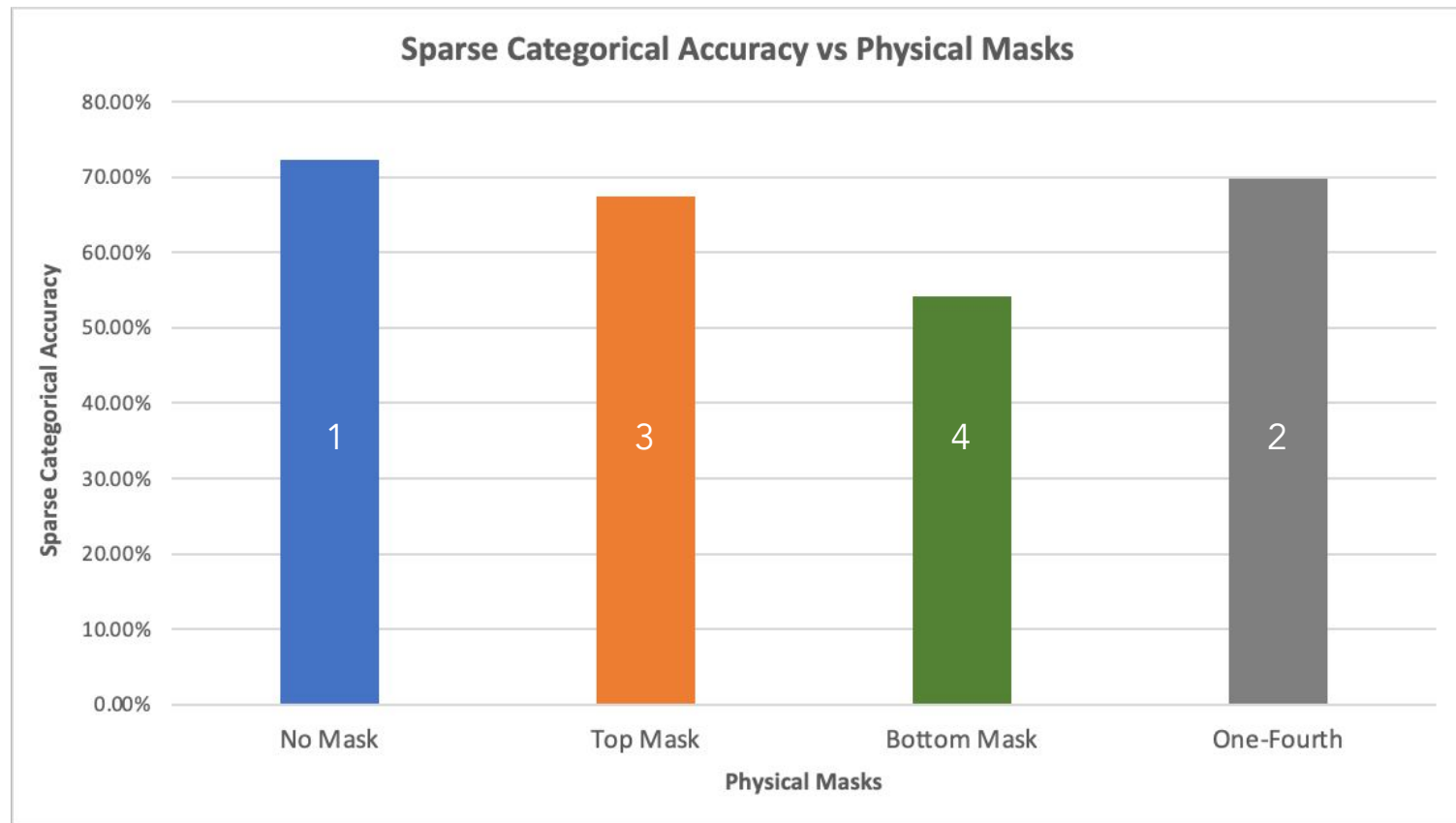
For Physical Layer Augmentation Techniques, we implemented the following:

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



# 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

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

## Recall

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





# Conclusion

- We can remove  $\frac{1}{4}$  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.
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# Flask Web-App

## Home Page

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**Welcome to Face Emotion Detection Engine!!**

Please upload an image below to proceed!!

Choose File No file chosen

Submit



# Step-1 Face Detection

## Step 1: Face Detection

Please find below the original image, grayscale boxed image, and cropped image.

Click on the button below to proceed to Step 2

Back

Step 2

Original Image



Grayscale Boxed Image



Grayscale Cropped Image



# Step-2 Emotion Detection

## Step 2: Emotion Detection

Please find below the original image, top-half, bottom-half, three-fourths masked images, and the model classification! The model classifies between HAPPY, SAD, and NEUTRAL

Try a new image!

Back

Overall Classification is as follows:

Majority (Ensemble) Classification:

**Happy**

Best Model (Three-Fourths Model) Classification:

**Happy**

### Grayscale Cropped Image



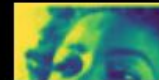
Happy: 1.0  
Sad: 0.0  
Neutral: 0.0

### Top-Half Masked Image



Happy: 1.0  
Sad: 0.0  
Neutral: 0.0

### Bottom-Half Masked Image



Happy: 1.0  
Sad: 0.0  
Neutral: 0.0

### Three-Fourths Masked Image



Happy: 1.0  
Sad: 0.0  
Neutral: 0.0





# Step-2 (cont'd) Emotion Detection Classification

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## 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.

An abstract background on the left side of the slide, featuring a dark blue field with a network of glowing blue dots connected by thin, light blue lines, creating a complex, interconnected pattern.

# 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](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](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](https://www.researchgate.net/publication/345940392_Evaluation_of_Data_Augmentation_Techniques_for_Facial_Expression_Recognition_Systems).



The background of the slide is a dark blue gradient. On the right side, there is a complex, glowing network of interconnected nodes and lines, resembling a molecular structure or a data network. The nodes are small blue dots, and the lines are thin, light blue. The overall effect is a sense of depth and connectivity.

Thank You!

A solid, horizontal teal bar that spans the width of the slide, positioned at the bottom.