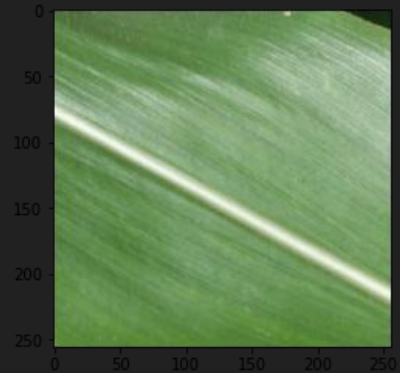


# Convolutional Neural Network of Corn Leaf Disease Images



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# Problem

- Corn and maize leaf diseases can seriously reduce productivity if not identified and treated quickly and appropriately
- More corn is produced worldwide by weight than any other grain
- Increased production of corn is of highest importance in feeding a growing world population in years to come

# Solution

- Development of a means for farmers to carry out rapid surveys of fields and give proper identification of leaf diseases
- Allows for earlier detection and proper identification so proper crop treatments can be applied

# Solution and Project Goal

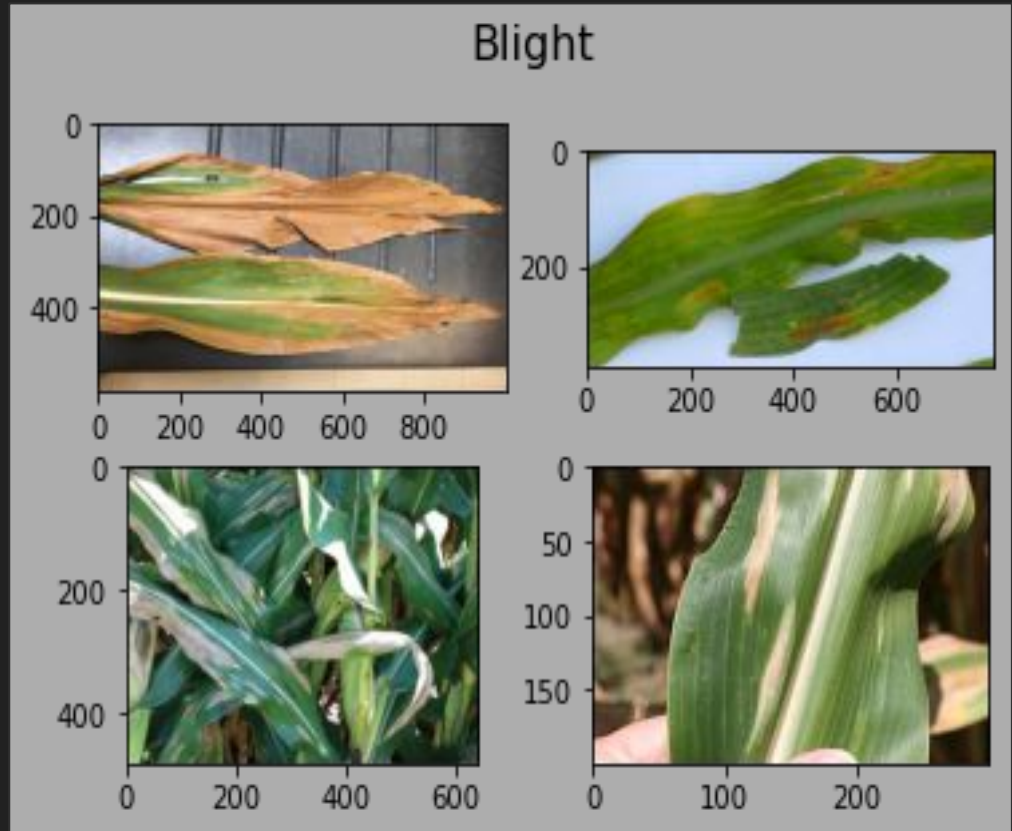
- Development of a Convolutional Neural Network (CNN) for the classification of corn leaf disease images
  - Made accessible to farmers with digital photography and smartphones
  - Allows for larger scale surveys of fields for leaf diseases

# Who might be interested?

- Farmers in general
- Farmers in less developed nations where more advanced agricultural technology is not always accessible
  - Early detection becomes more important

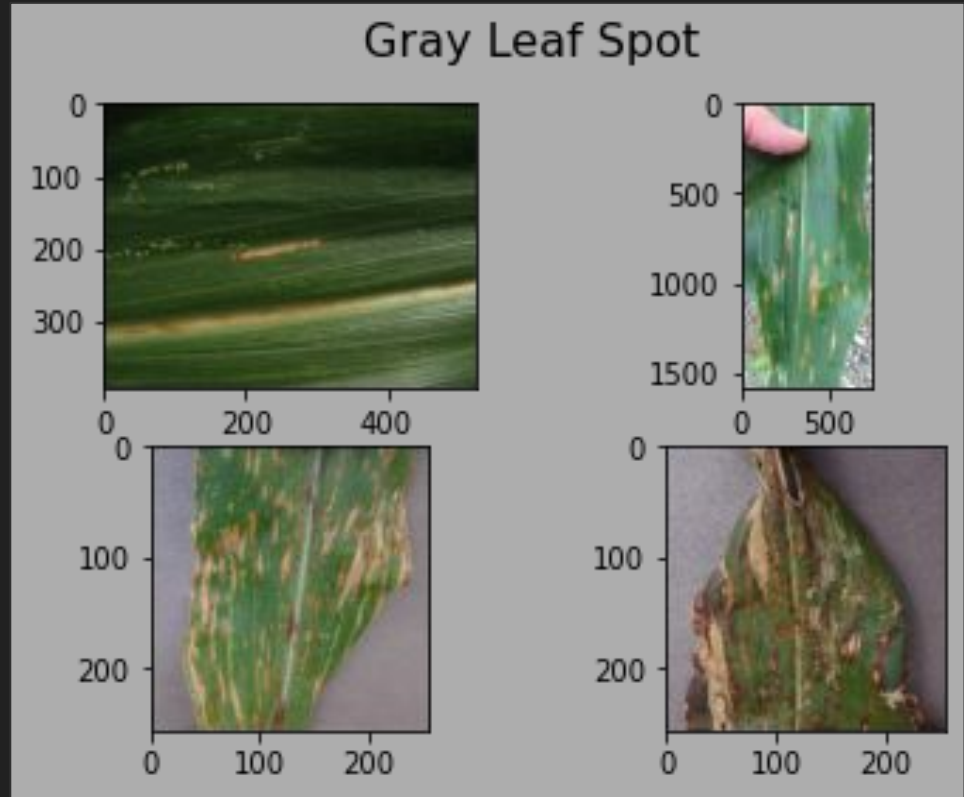
# Blight

- *Setosphaeria turcica*
- Leaves are persistently wet for 6 plus hours
- temperatures are between 64 and 81 degrees Fahrenheit



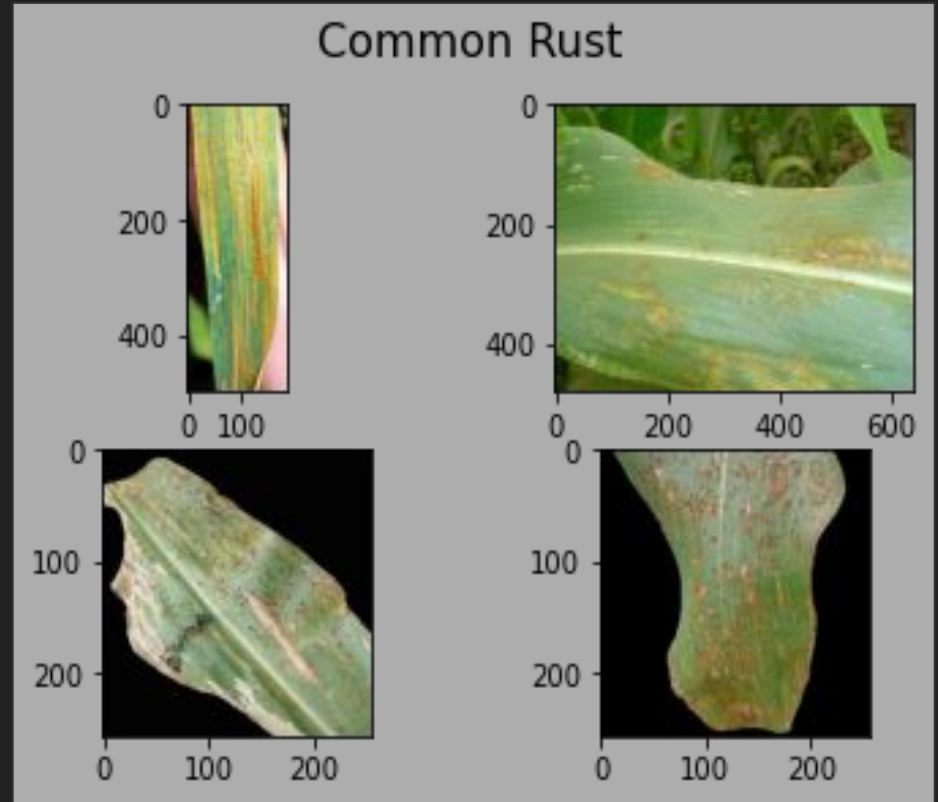
# Gray Leaf Spot

- *Cercospora zeae-maydis*
- Temperatures remain above 80 degrees Fahrenheit for 12 plus hours
- High humidity



# Common Rust

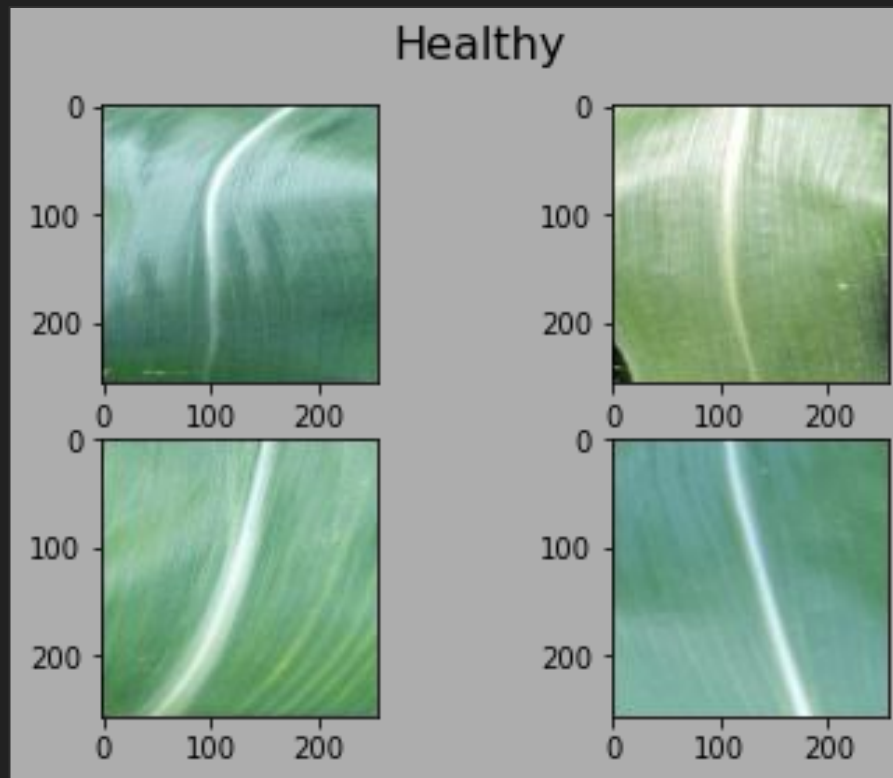
- *Puccinia sorghi*
- High humidity
- Night time temperatures are between 65 and 70 degrees Fahrenheit





# Data

- Total of 4,188 images
  - 1,306 common rust
  - 574 gray leaf spot
  - 1,146 blight
  - 1,162 healthy
- Images accessible on Kaggle Corn and Maize Leaf Disease Dataset



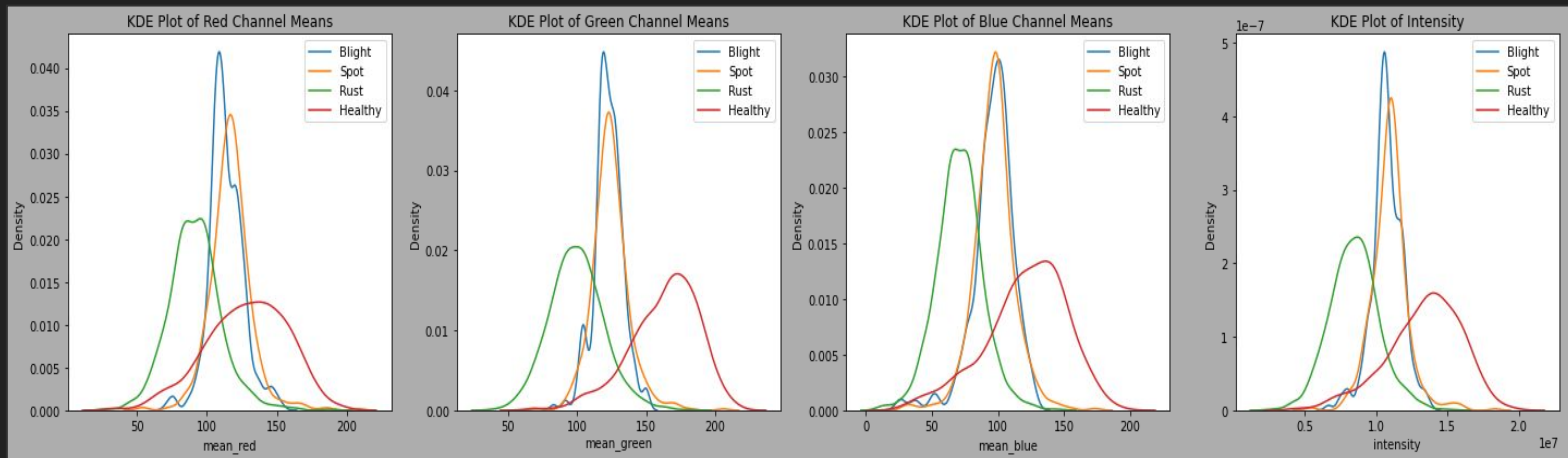
# Average Images



- Brighter green in healthy average image
- Dark edges in common rust average image due to differing methods of photography

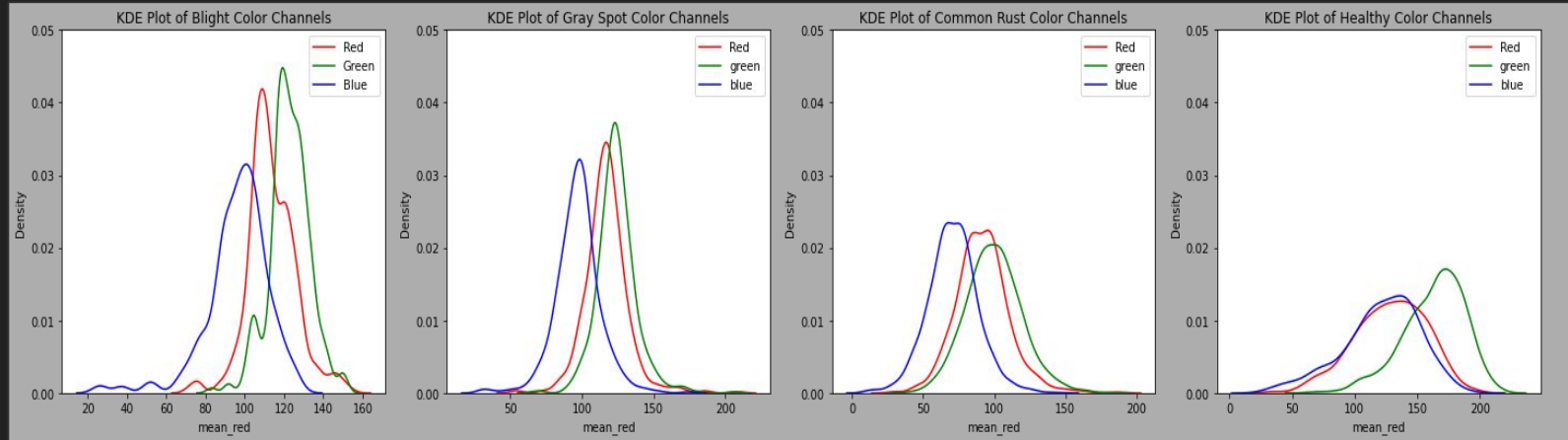
# Red, Green, Blue, and Intensity Averages

- Healthy and rust leaves have most divergent averages
- Blight and gray leaf spot have most similar averages



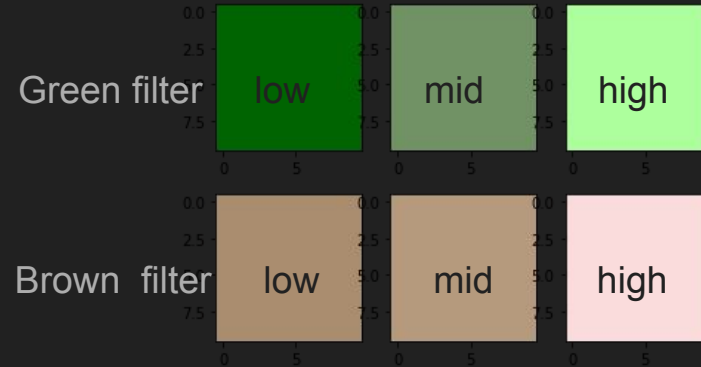
# Red, Green, and Blue Averages

- Averages for RGB differ across the categories



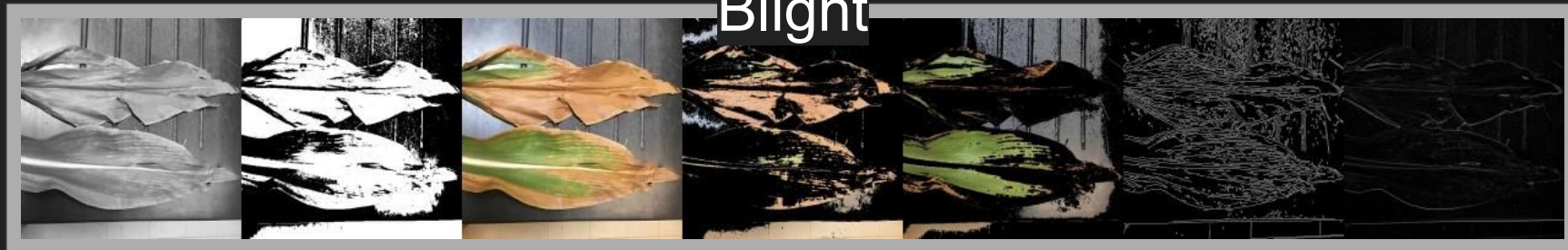
# Python Image Processing

- Done with desire that processed images would cause leaf diseases to be better identified by CNN
  - Grayscale
  - Binary
  - Brown filter
  - Green filter
  - Canny Edges
  - Sobel Edges
- Brown and green filters developed through the creation of a function to filter for preselected ranges of RGB values

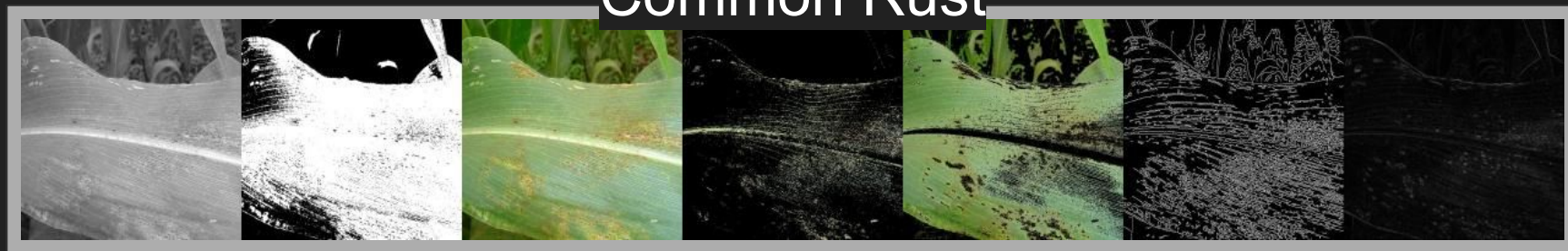


# Processed Images Used In CNN

Blight



Common Rust



Grayscale

Binary

RGB

Brown filter

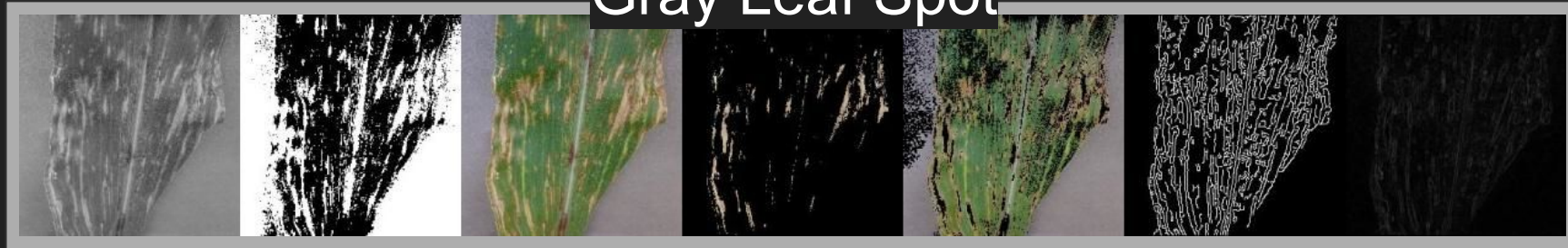
Green filter

Canny edges

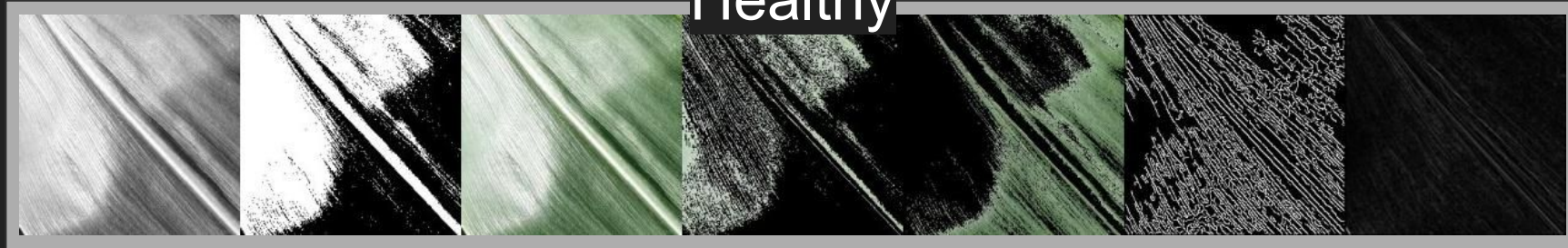
Sobel edges

# Processed Images Used In CNN

## Gray Leaf Spot



## Healthy



Grayscale

Binary

RGB

Brown filter

Green filter

Canny edges

Sobel edges

# CNN Modeling

- CNN models developed using
  - Only RGB images
  - RGB and all processed images
  - With and without image augmentation
  - With and without VGG16 transfer learning



Model Name	Image Augmentation	Transfer Learning	Validation Accuracy	Validation Loss
VGG16 Model	No	VGG16 (not trainable, input and output layers trainable)	97.6%	0.119
Simple Processed Image Model	Random horizontal and vertical flip	No	95.9%	0.203
Comparison Kaggle Model	Random height shift, zoom, rotation	VGG16 (All layers trainable)	95.5%	0.163
Random Forest	No	No	86.6%	
Simple RGB Model	Random horizontal and vertical flip	No	85.3%	0.360

# VGG16 Model

**Model: "VGG16 Model"**

Layer (type)	Output Shape	Param #
input_2 (InputLayer)	[(None, 180, 1260, 3)]	0
vgg16 (Functional)	(None, 5, 39, 512)	14714688
global average pooling2d (Gl	(None, 512)	0
dense_8 (Dense)	(None, 4)	2052

Total params: 14,716,740

Trainable params: 2,052

Non-trainable params: 14,714,688

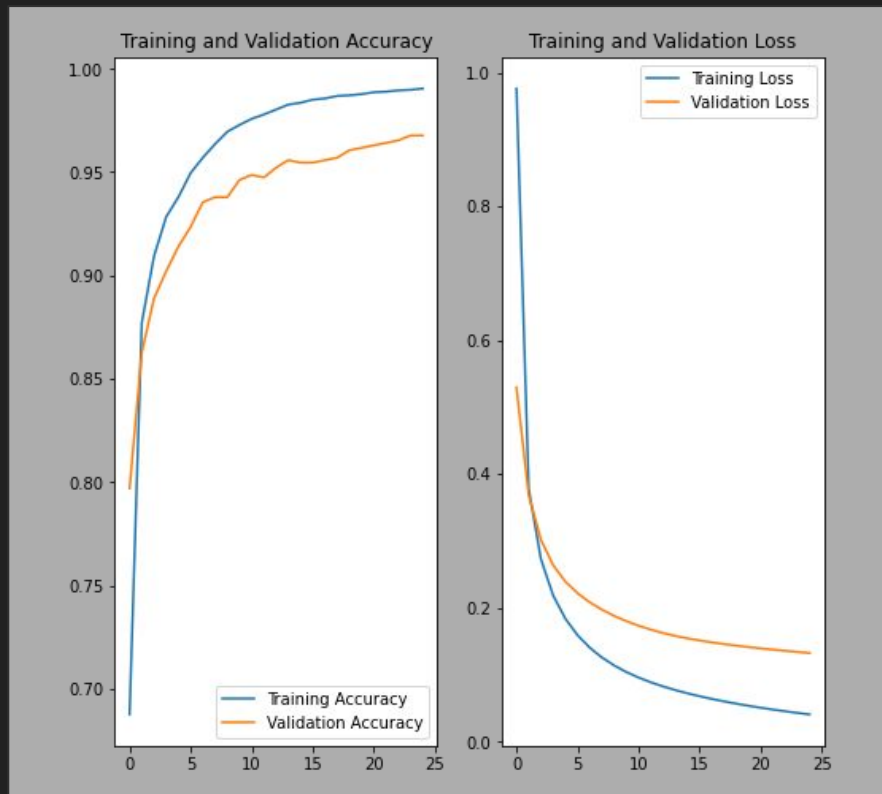
# CNN Filters



- Filter taken from the VGG16 block 2 convolutional layer 2 utilizing the Imagenet weights
- The rectangular shape of the filter is a reflection of the input image size of 180x1260 pixels for the VGG16 model
- Patterns and shapes of these filters are complex representations of images taken from the real world
- Not always known what each individual filter is representing or detecting, the patterns are the general means by which CNN identifies and categorizes images

# VGG16 Model

- Validation accuracy 97.6%
- Validation loss 0.119



# Conclusion

- Image processing increased model accuracy
  - Accuracy increased from 85.3% to 95.9% with processed images
- VGG16 transfer learning further increased accuracy
  - VGG16 model accuracy increased to 97.6%
  - Similar VGG16 model without processed images had 95.5% accuracy

# Future Work

- Further tuning of VGG16 model
- Assessing which of the 7 processed images contributes most to model accuracy
- Cropping of some images to reduce backgrounds