

## Tomato Leaf Disease Detection USING CNN TENSORFLOW

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

# Tensorflow module
import tensorflow as tf
from tensorflow import keras

from tensorflow.keras import models, layers

from tensorflow.keras.callbacks import ModelCheckpoint, EarlyStopping, ReduceLROnPlateau

from tensorflow.keras.models import Model
from tensorflow.keras import layers
from tensorflow.keras.preprocessing import image
from tensorflow.keras.preprocessing.image import ImageDataGenerator

# fixed Values
batch_size = 32
image_size = 255
channels=3
seed=123
ep = 10

train = "/kaggle/input/tomato-plant-dataset/TomattoLeaf/train"
val = "/kaggle/input/tomato-plant-dataset/TomattoLeaf/valid"

Split training and testing from train of 80% 20%

train_generator = ImageDataGenerator(validation_split = 0.2,
                                      featurewise_center=True,
                                      preprocessing_function = None,
                                      rotation_range = 45,
                                      rescale=1./image_size,
                                      zoom_range = 0.2,
                                      horizontal_flip = True,
                                      vertical_flip = True,
                                      fill_mode = 'nearest',
                                      shear_range = 0.2,
                                      height_shift_range = 0.1,
                                      width_shift_range = 0.1)

test_datagen = ImageDataGenerator(rescale=1./image_size, validation_split = 0.2)
validation_generator = ImageDataGenerator(rescale=1./image_size)
```

```

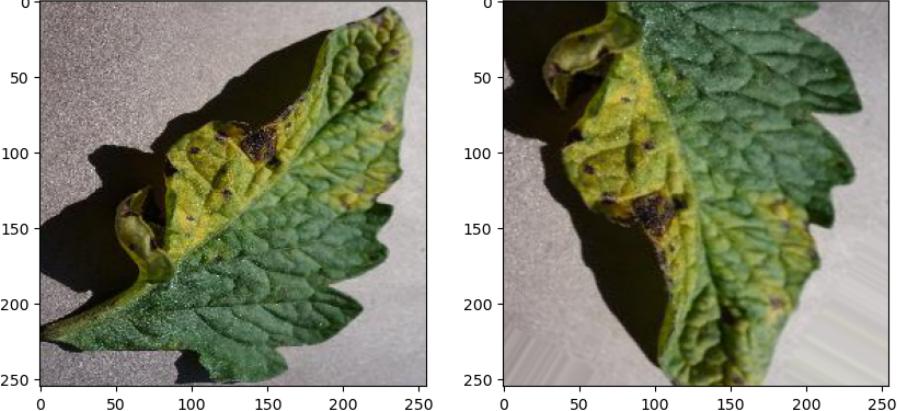
# Load an example image
path = "/kaggle/input/tomato-plant-dataset/TomattoLeaf/valid/Tomato___Early_blight/03b7a13c-"
img = image.load_img(path, target_size = (image_size, image_size))

image_array = image.img_to_array(img)

# Reshape the array to (1, width, height, channels)
image_array = image_array.reshape((1,) + image_array.shape)

augmented_images = train_generator.flow(image_array, batch_size=1)
fig, ax = plt.subplots(1, 2, figsize=(10, 5))
ax[0].imshow(img)
ax[1].imshow(augmented_images.next()[0])
plt.show()

```



```

train_datagenerator = train_generator.flow_from_directory(
    train,
    target_size = (image_size, image_size),
    batch_size = batch_size,
    class_mode = "categorical",
    subset='training',
    shuffle=True,
)

test_datagenerator = test_datagen.flow_from_directory(train,
    target_size=(image_size, image_size),
    batch_size=batch_size,
    class_mode='categorical',
    subset='validation',
    shuffle=True)

```

```
validation_datagenerator = validation_generator.flow_from_directory(
    val,
    target_size = (image_size, image_size),
    batch_size = batch_size,
    class_mode = "categorical")
```

```
Found 14678 images belonging to 10 classes.
Found 3667 images belonging to 10 classes.
Found 4585 images belonging to 10 classes.
```

## CNN MODEL

```
input_shape = (image_size,image_size,channels)

model = keras.Sequential([
    layers.Conv2D(32,(3,3),activation="relu",padding="same",input_shape=input_shape),
    layers.BatchNormalization(),
    layers.Conv2D(32,(3,3),activation="relu",padding="same"),
    layers.BatchNormalization(),
    layers.MaxPooling2D(3,3),

    layers.Conv2D(64,(3,3),activation="relu",padding="same"),
    layers.BatchNormalization(),
    layers.Conv2D(64,(3,3),activation="relu",padding="same"),
    layers.BatchNormalization(),
    layers.MaxPooling2D(3,3),

    layers.Conv2D(128,(3,3),activation="relu",padding="same"),
    layers.BatchNormalization(),
    layers.Conv2D(128,(3,3),activation="relu",padding="same"),
    layers.BatchNormalization(),
    layers.MaxPooling2D(3,3),

    layers.Conv2D(256,(3,3),activation="relu",padding="same"),
    layers.BatchNormalization(),
    layers.Conv2D(256,(3,3),activation="relu",padding="same"),
    layers.BatchNormalization(),

    layers.Conv2D(512,(5,5),activation="relu",padding="same"),
    layers.BatchNormalization(),
    layers.Conv2D(512,(5,5),activation="relu",padding="same"),
    layers.BatchNormalization(),

    layers.MaxPooling2D(3, 3),

    layers.Flatten(),

    layers.Dense(1024, activation='relu'),
```

```

        layers.Dropout(0.5),

        layers.Dense(512, activation='relu'),
        layers.Dropout(0.5),

        layers.Dense(10,activation="softmax"),

    ])

model.build(input_shape=input_shape)

opt = keras.optimizers.Adam(learning_rate=0.00001)
model.compile(optimizer=opt,loss="categorical_crossentropy",metrics=['accuracy'])

print('EfficientNet CNN has %d layers' %len(model.layers))
EfficientNet CNN has 30 layers

checkpoint = ModelCheckpoint('best_model.h5',
                            monitor='val_loss',
                            save_best_only=True,
                            save_weights_only = False,
                            mode='min',verbose = 1)

earlystop = EarlyStopping(monitor='val_loss',
                           min_delta = 0.0001,
                           mode = 'min',
                           verbose = 1,
                           restore_best_weights = True,
                           patience = 5)

reduce_lr = ReduceLROnPlateau(monitor = 'val_loss',
                             factor = 0.3,
                             patience = 2,
                             min_lr=0.00001,
                             min_delta = 0.0001,
                             mode = 'min',
                             verbose = 1)

fit_batch = round(len(validation_datagenerator))
step_batch = round(len(train_datagenerator))

history = model.fit(
    train_datagenerator,
    validation_data= validation_datagenerator,
    epochs = 10,
#    validation_steps = 12,
#    steps_per_epoch = 12,
    callbacks=[checkpoint, earlystop,reduce_lr])

```

```
Epoch 1/10
459/459 [=====] - ETA: 0s - loss: 0.3890 - accuracy: 0.8724
Epoch 1: val_loss improved from inf to 0.94454, saving model to best_model.h5
459/459 [=====] - 255s 556ms/step - loss: 0.3890 - accuracy: 0.8724
Epoch 2/10
459/459 [=====] - ETA: 0s - loss: 0.3251 - accuracy: 0.8976
Epoch 2: val_loss did not improve from 0.94454
459/459 [=====] - 243s 530ms/step - loss: 0.3251 - accuracy: 0.8976
Epoch 3/10
459/459 [=====] - ETA: 0s - loss: 0.3029 - accuracy: 0.9012
Epoch 3: val_loss improved from 0.94454 to 0.81381, saving model to best_model.h5
459/459 [=====] - 242s 527ms/step - loss: 0.3029 - accuracy: 0.9012
Epoch 4/10
459/459 [=====] - ETA: 0s - loss: 0.2764 - accuracy: 0.9111
Epoch 4: val_loss did not improve from 0.81381
459/459 [=====] - 244s 531ms/step - loss: 0.2764 - accuracy: 0.9111
Epoch 5/10
459/459 [=====] - ETA: 0s - loss: 0.2651 - accuracy: 0.9154
Epoch 5: val_loss improved from 0.81381 to 0.80372, saving model to best_model.h5
459/459 [=====] - 244s 531ms/step - loss: 0.2651 - accuracy: 0.9154
Epoch 6/10
459/459 [=====] - ETA: 0s - loss: 0.2457 - accuracy: 0.9222
Epoch 6: val_loss did not improve from 0.80372
459/459 [=====] - 241s 524ms/step - loss: 0.2457 - accuracy: 0.9222
Epoch 7/10
459/459 [=====] - ETA: 0s - loss: 0.2266 - accuracy: 0.9247
Epoch 7: val_loss did not improve from 0.80372
459/459 [=====] - 240s 523ms/step - loss: 0.2266 - accuracy: 0.9247
Epoch 8/10
459/459 [=====] - ETA: 0s - loss: 0.2259 - accuracy: 0.9263
Epoch 8: val_loss did not improve from 0.80372
459/459 [=====] - 243s 530ms/step - loss: 0.2259 - accuracy: 0.9263
Epoch 9/10
459/459 [=====] - ETA: 0s - loss: 0.2100 - accuracy: 0.9311
Epoch 9: val_loss did not improve from 0.80372
459/459 [=====] - 248s 541ms/step - loss: 0.2100 - accuracy: 0.9311
Epoch 10/10
459/459 [=====] - ETA: 0s - loss: 0.1940 - accuracy: 0.9379
Epoch 10: val_loss did not improve from 0.80372
Restoring model weights from the end of the best epoch: 5.
459/459 [=====] - 245s 533ms/step - loss: 0.1940 - accuracy: 0.9379
Epoch 10: early stopping

test_loss,test_accuracy = model.evaluate(test_datagenerator)

115/115 [=====] - 15s 130ms/step - loss: 0.7692 - accuracy: 0.7821
```

```

print(f"Test accuracy: {test_accuracy:.2%}")
print(f"Test loss: {test_loss:.2%}")

Test accuracy: 78.21%
Test loss: 76.92%

Training and validation Graphs

acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(acc) + 1)

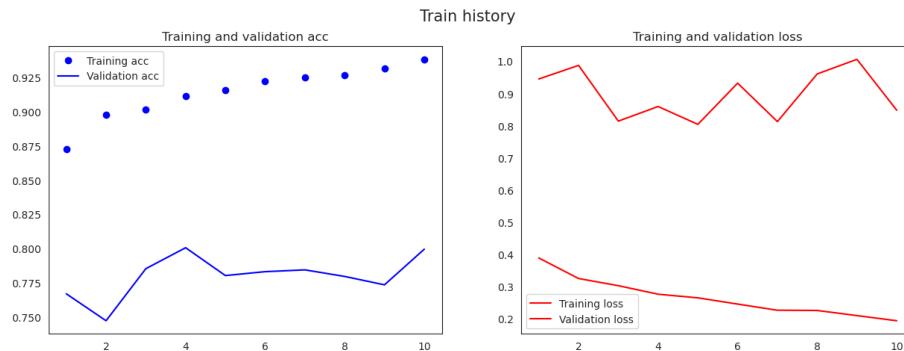
fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(15, 5))
sns.set_style("white")
plt.suptitle('Train history', size = 15)

ax1.plot(epochs, acc, "bo", label = "Training acc")
ax1.plot(epochs, val_acc, "b", label = "Validation acc")
ax1.set_title("Training and validation acc")
ax1.legend()

ax2.plot(epochs, loss, label = "Training loss", color = 'red')
ax2.plot(epochs, val_loss, label = "Validation loss", color = 'red')
ax2.set_title("Training and validation loss")
ax2.legend()

plt.show()

```



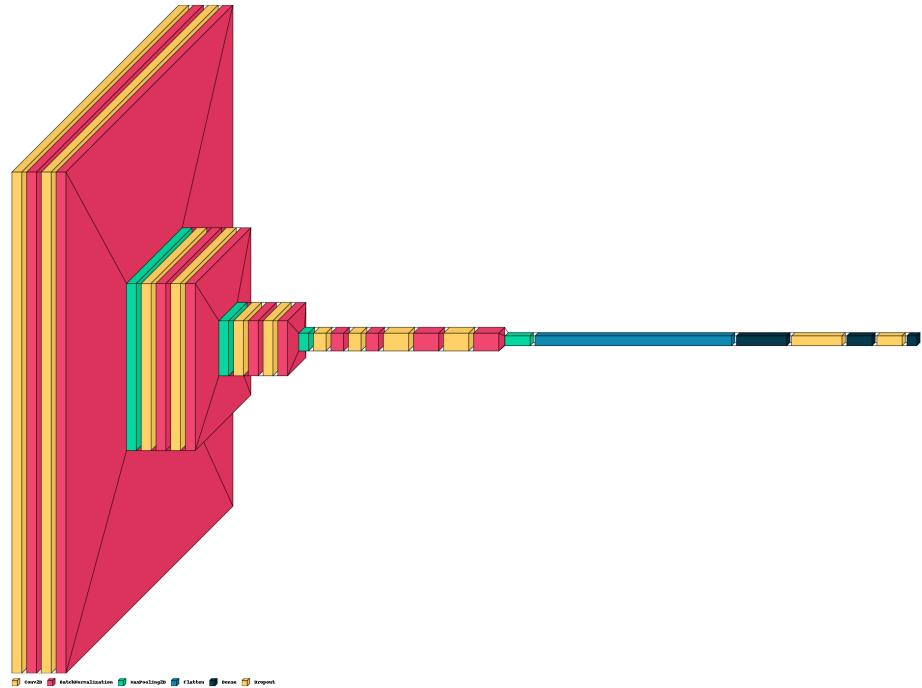
```

convet = tf.lite.TFLiteConverter.from_keras_model(model)
tfile = convet.convert()
with open('modelLite.tflite','wb')as f:
    f.write(tfile)

```

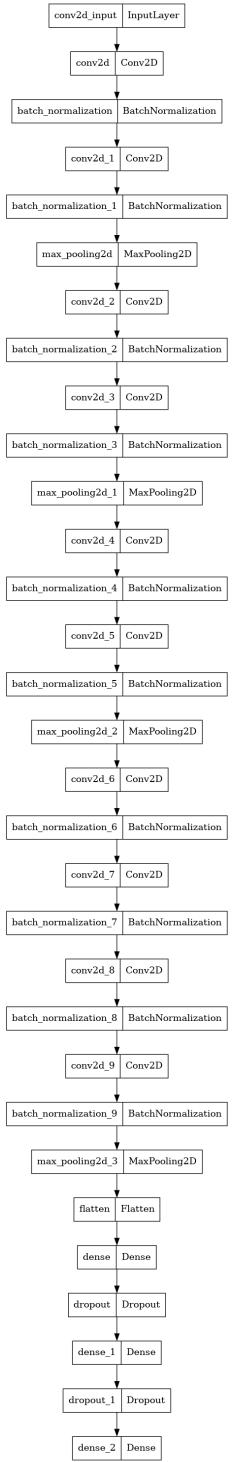
## Visualize the Layered View of the Model

```
import visualkeras  
visualkeras.layered_view(model, legend=True, draw_volume=True)
```



## CNN Layers

```
from keras.utils import plot_model  
plot_model(model, to_file='model.png')
```



```
val_dataset = tf.keras.preprocessing.image_dataset_from_directory(val,seed=123,image_size=(150,150))
class_names = val_dataset.class_names

Found 4585 files belonging to 10 classes.

Prediction of Single Image

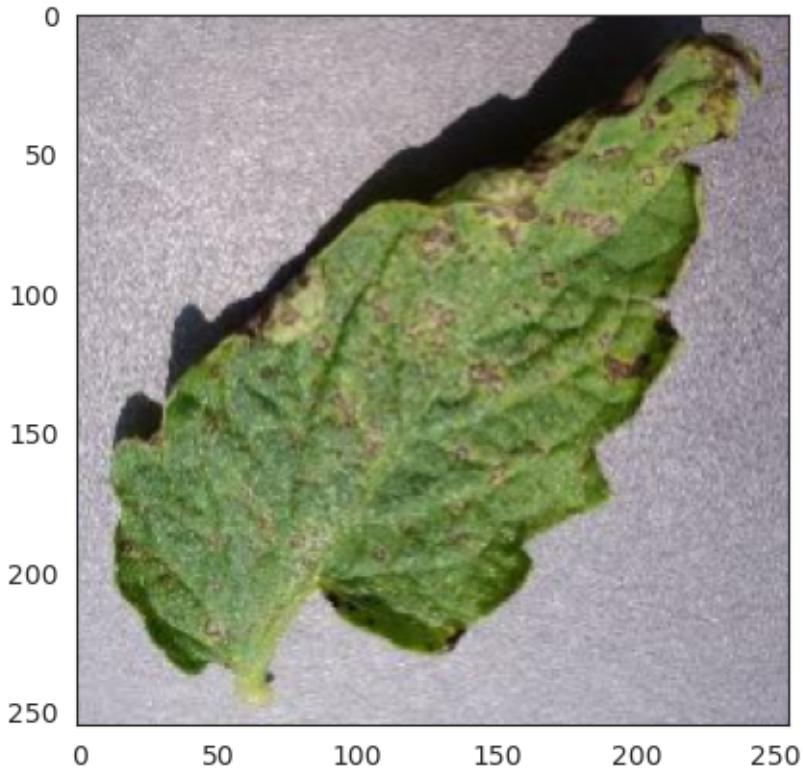
for images_batch, labels_batch in val_dataset.take(1):

    first_image = images_batch[0].numpy().astype('uint8')
    first_label = labels_batch[0].numpy()

    print("first image to predict")
    plt.imshow(first_image)
    print("actual label:",class_names[first_label])

    batch_prediction = model.predict(images_batch)
    print("predicted label:",class_names[np.argmax(batch_prediction[0])])

first image to predict
actual label: Tomato___Septoria_leaf_spot
1/1 [=====] - 0s 34ms/step
predicted label: Tomato___Septoria_leaf_spot
```



### Visualization of CNN intermediate activations

```
# Choose a random image from the test set
img = tf.keras.preprocessing.image.load_img(
    '/kaggle/input/tomato-plant-dataset/TomatoLeaf/valid/Tomato___Bacterial_spot/03ca5883-e'
    target_size=(image_size, image_size)
)
x = tf.keras.preprocessing.image.img_to_array(img)
x = np.expand_dims(x, axis=0)
x = tf.keras.applications.vgg16.preprocess_input(x)

# Get the model's intermediate layer outputs
layer_outputs = [layer.output for layer in model.layers[:12]]
activation_model = tf.keras.models.Model(inputs=model.input, outputs=layer_outputs)
activations = activation_model.predict(x)

# Visualize the intermediate layer activations
layer_names = []
for layer in model.layers[:12]:
```

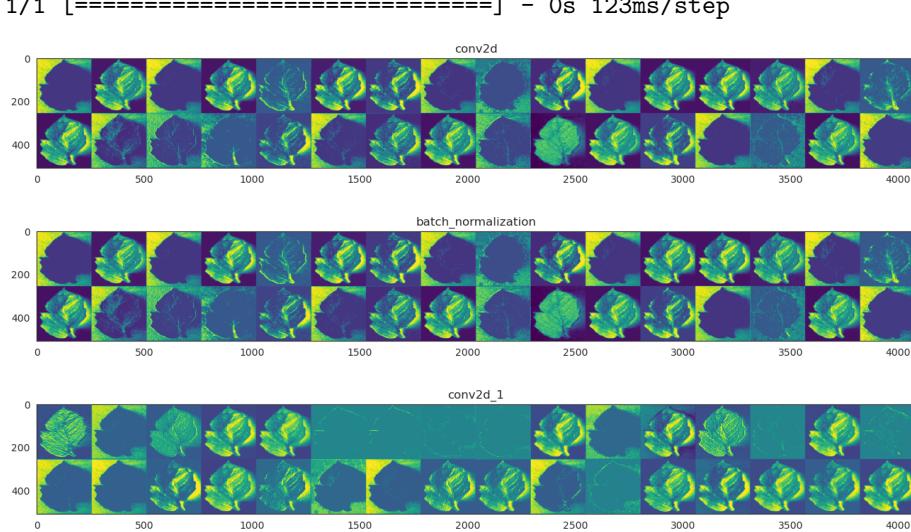
```

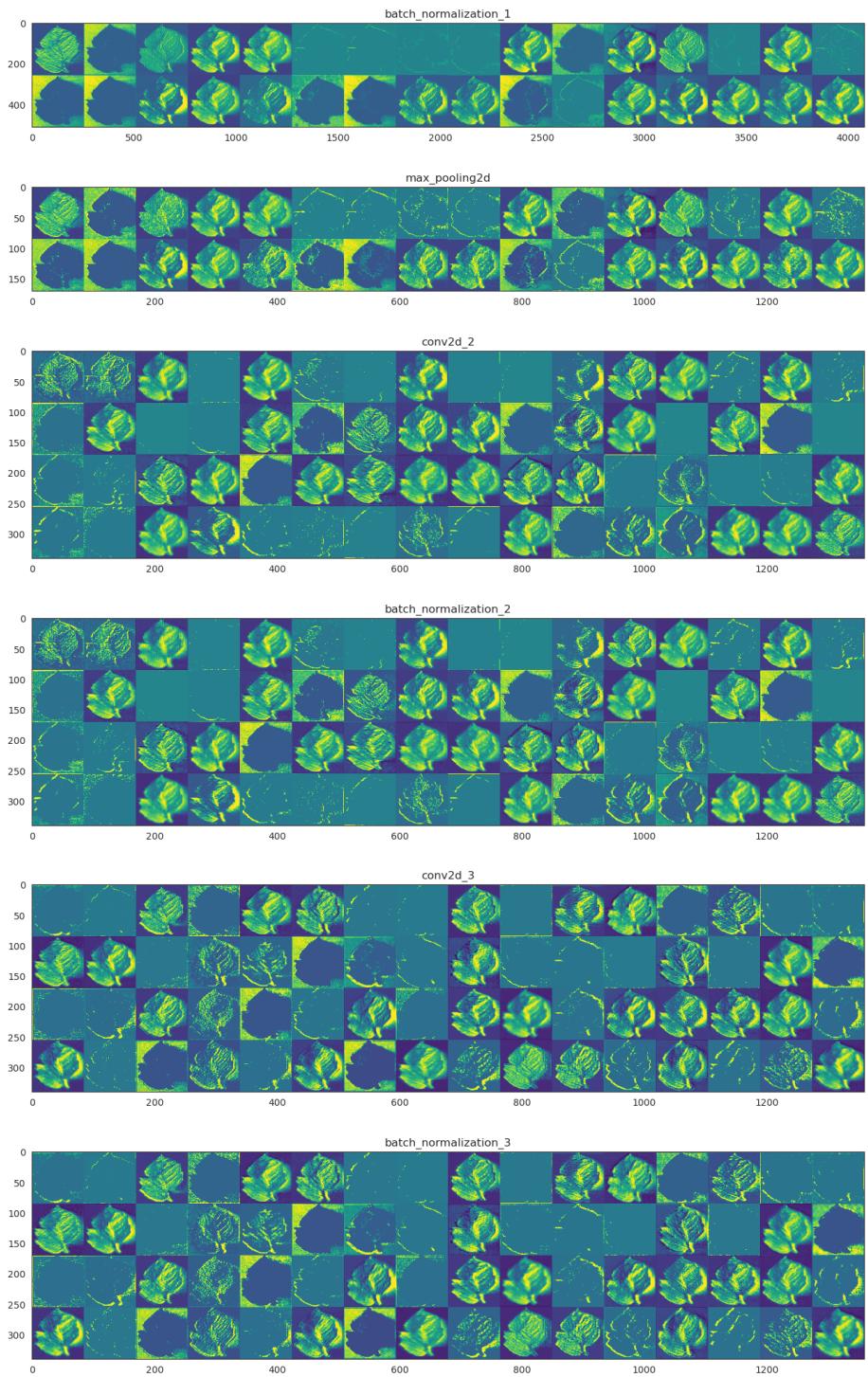
layer_names.append(layer.name)

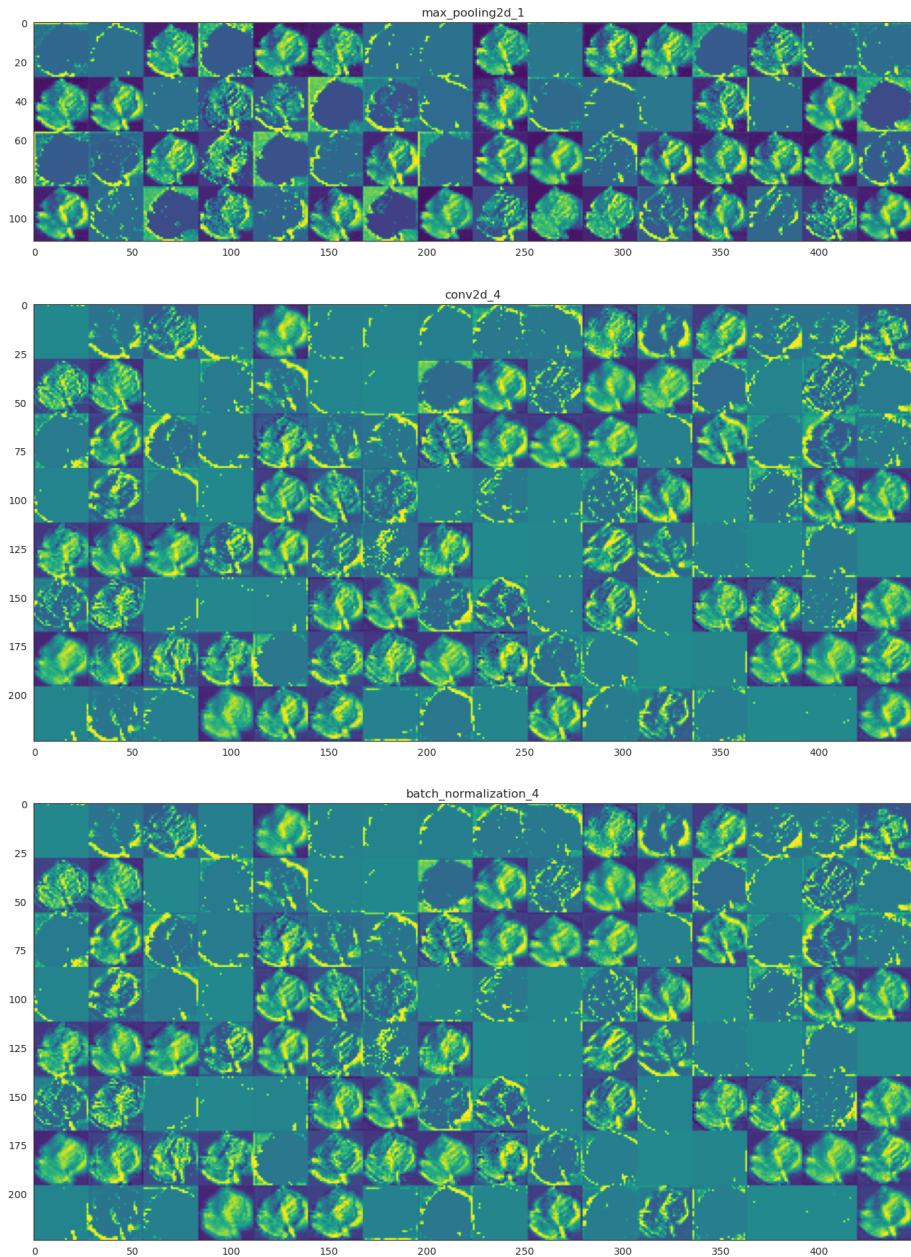
images_per_row = 16
for layer_name, layer_activation in zip(layer_names, activations):
    n_features = layer_activation.shape[-1]
    size = layer_activation.shape[1]
    n_cols = n_features // images_per_row
    display_grid = np.zeros((size * n_cols, images_per_row * size))
    for col in range(n_cols):
        for row in range(images_per_row):
            channel_image = layer_activation[0, :, :, col * images_per_row + row]
            channel_image -= channel_image.mean()
            channel_image /= channel_image.std()
            channel_image *= 64
            channel_image += 128
            channel_image = np.clip(channel_image, 0, 255).astype('uint8')
            display_grid[col * size : (col + 1) * size,
                         row * size : (row + 1) * size] = channel_image
    scale = 1. / size
    plt.figure(figsize=(scale * display_grid.shape[1],
                        scale * display_grid.shape[0]))
    plt.title(layer_name)
    plt.grid(False)
    plt.imshow(display_grid, aspect='auto', cmap='viridis')

plt.show()
1/1 [=====] - 0s 123ms/step

```







## F1 Score

```
from sklearn.metrics import classification_report

y_pred = model.predict(test_datagenerator)
y_true = test_datagenerator.classes
```

```

y_pred = tf.argmax(y_pred, axis=1)

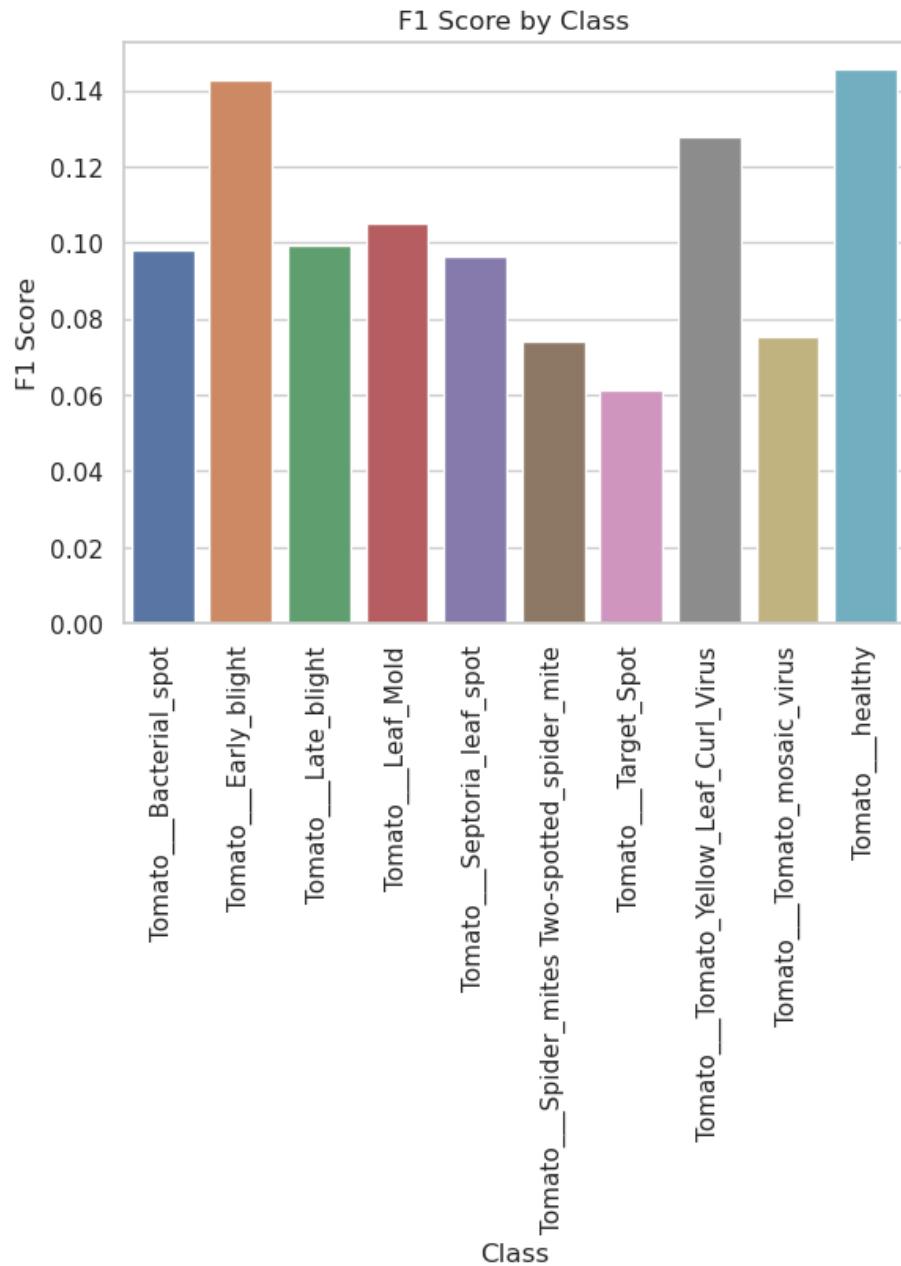
# Calculate F1 score
f1_score = classification_report(y_true, y_pred, target_names=test_datagenerator.class_indices)
f1_scores = [f1_score[label]['f1-score'] for label in test_datagenerator.class_indices.keys()]

# Create dataframe with class names and F1 scores
df = pd.DataFrame({'class': test_datagenerator.class_indices.keys(), 'f1_score': f1_scores})

# Plot F1 score using a bar plot
sns.set(style='whitegrid')
ax = sns.barplot(x='class', y='f1_score', data=df)
ax.set_title('F1 Score by Class')
ax.set_xlabel('Class')
ax.set_ylabel('F1 Score')
plt.xticks(rotation=90)
plt.show()

115/115 [=====] - 11s 96ms/step

```

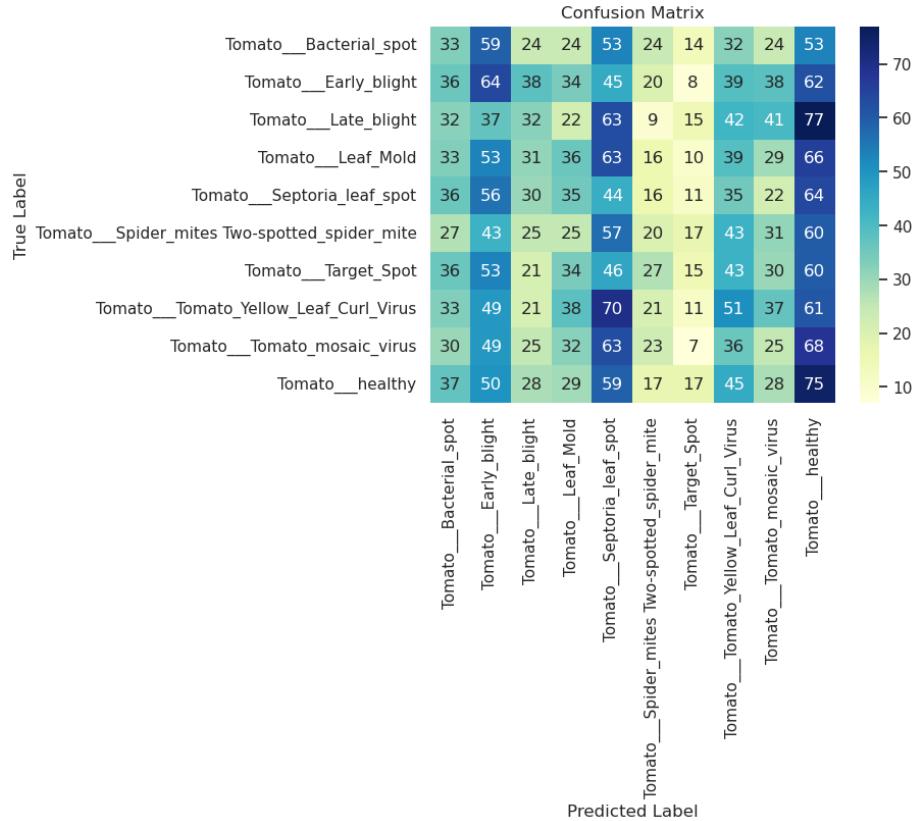


#### Confusion Matrix

```
from sklearn.metrics import confusion_matrix

conf_matrix = confusion_matrix(y_true, y_pred, labels=range(len(test_datagenerator.class_in
```

```
# Display confusion matrix using heatmap
sns.set()
ax = sns.heatmap(conf_matrix, annot=True, cmap="YlGnBu", xticklabels=test_datagenerator.class_indices.keys(),
                  yticklabels=test_datagenerator.class_indices.keys())
ax.set_title('Confusion Matrix')
ax.set_xlabel('Predicted Label')
ax.set_ylabel('True Label')
plt.show()
```



### Distribution of training and validation data

```
train_size = len(train_datagenerator.filenames)
val_size = len(validation_datagenerator.filenames)
test_size = len(test_datagenerator.filenames)

fig, ax = plt.subplots()
x = ['Train', 'Validation', 'Test']
bar_width = 0.35
opacity = 0.8
```

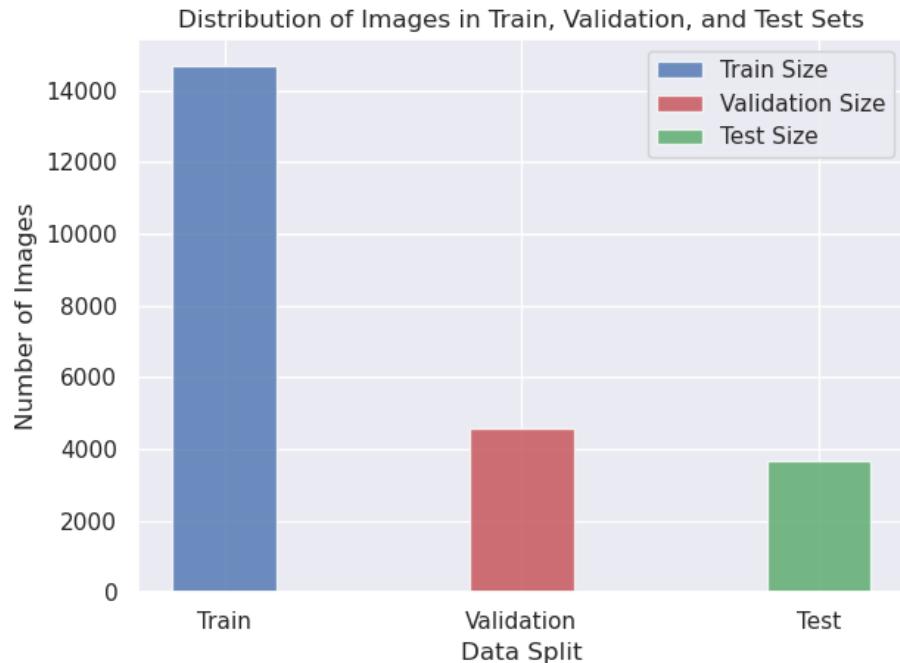
```

train_bars = ax.bar(x[0], train_size, bar_width, alpha=opacity, color='b', label='Train Size')
val_bars = ax.bar(x[1], val_size, bar_width, alpha=opacity, color='r', label='Validation Size')
test_bars = ax.bar(x[2], test_size, bar_width, alpha=opacity, color='g', label='Test Size')

ax.set_xlabel('Data Split')
ax.set_ylabel('Number of Images')
ax.set_title('Distribution of Images in Train, Validation, and Test Sets')
ax.legend()

plt.tight_layout()
plt.show()

```



### Class activation maps

### Training Result Representation

```

train_acc = history.history['accuracy'][-1]*100
val_acc = history.history['val_accuracy'][-1]*100
train_loss = history.history['loss'][-1]*100
val_loss = history.history['val_loss'][-1]*100

labels = ['Train Accuracy', 'Validation Accuracy', 'Train Loss', 'Validation Loss']
values = [train_acc, val_acc, train_loss, val_loss]

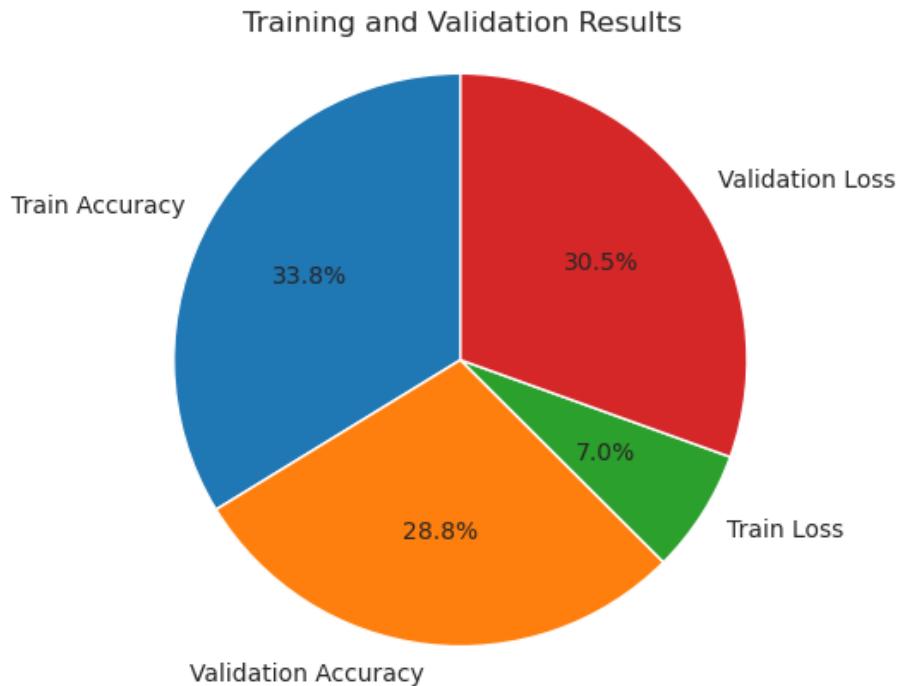
```

```

fig, ax = plt.subplots()
ax.pie(values, labels=labels, autopct='%.1f%%', startangle=90)
ax.axis('equal')

plt.title("Training and Validation Results")
plt.show()

```



## Data Representation

```

import os
# Get a list of all the folders (i.e. disease types) in the dataset
disease_folders = os.listdir(train)

# Create a figure and axes object
fig, axes = plt.subplots(nrows=len(disease_folders), ncols=3, figsize=(12, 3*len(disease_folders)))

# Loop over each disease folder and plot a sample of three images
for i, folder in enumerate(disease_folders):
    folder_path = os.path.join(train, folder)
    image_files = os.listdir(folder_path)
    sample_images = image_files[:3]

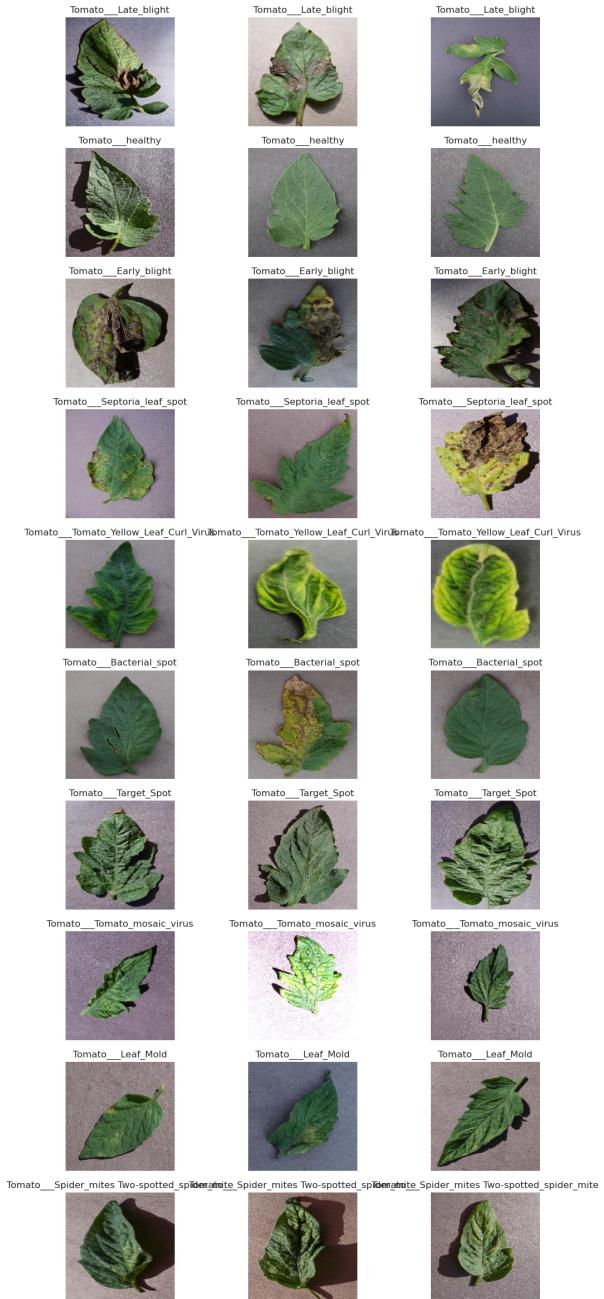
    for j, image_file in enumerate(sample_images):
        image_path = os.path.join(folder_path, image_file)

```

```
image = plt.imread(image_path)
axes[i,j].imshow(image)
axes[i,j].axis('off')
axes[i,j].set_title(folder)

# Set the overall plot title and show the plot
plt.suptitle("Leaf Plant Disease Samples")
plt.show()
```

Leaf Plant Disease Samples



```

# Define the path to the dataset
dataset_path = train
# Get a list of all the folders (i.e. disease types) in the dataset
disease_folders = os.listdir(dataset_path)

# Count the number of images in each disease folder
image_counts = []
for folder in disease_folders:
    folder_path = os.path.join(dataset_path, folder)
    image_count = len(os.listdir(folder_path))
    image_counts.append(image_count)

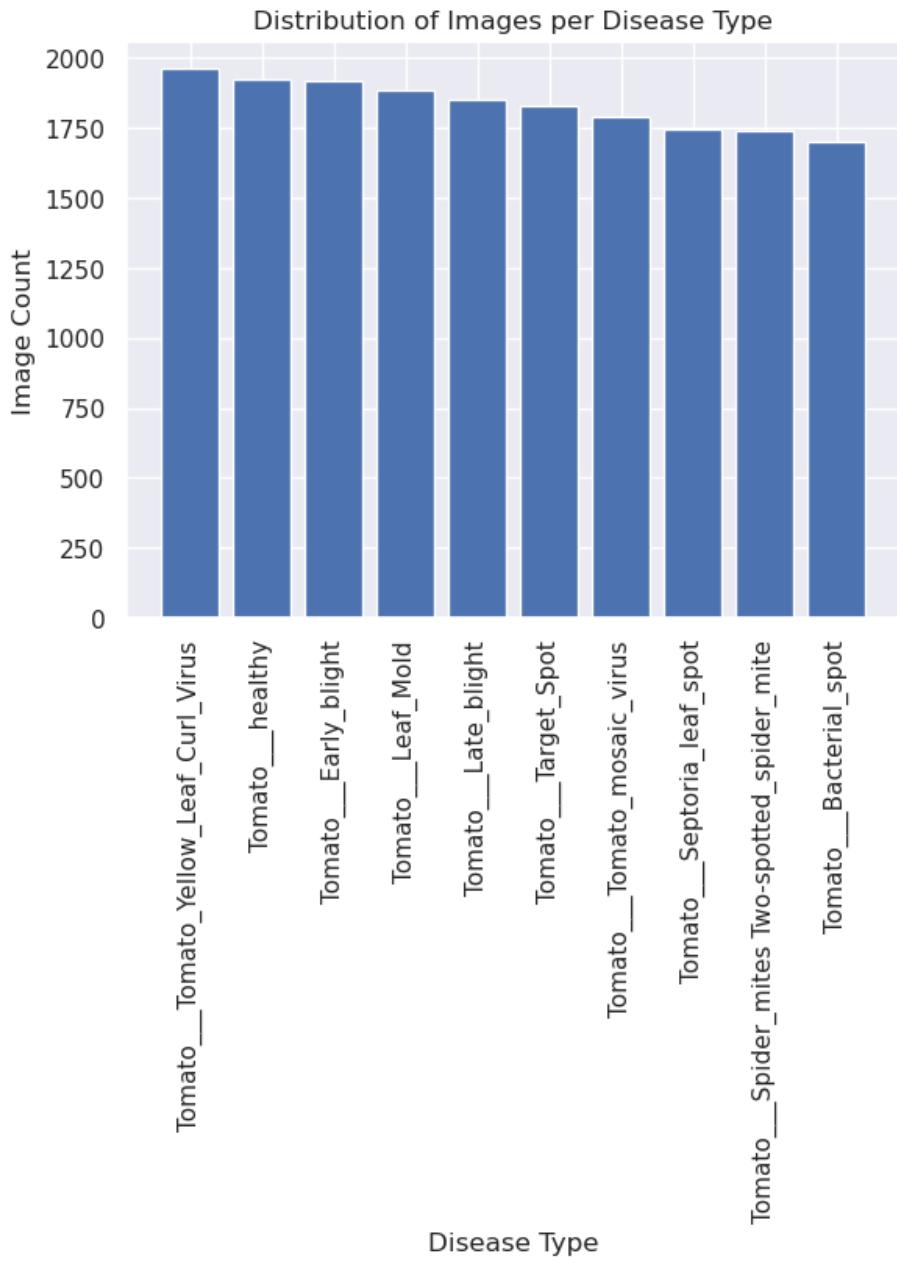
# Create a Pandas DataFrame to hold the image counts
df = pd.DataFrame({
    'Disease Type': disease_folders,
    'Image Count': image_counts
})

# Sort the DataFrame by the image counts
df = df.sort_values(by=['Image Count'], ascending=False)

# Create a bar plot of the image counts per disease type
plt.bar(df['Disease Type'], df['Image Count'])
plt.xticks(rotation=90)

plt.title("Distribution of Images per Disease Type")
plt.xlabel("Disease Type")
plt.ylabel("Image Count")
plt.show()

```



### Model Comparing with Lite Version

```
# Define the path to the model files
model_h5_path = "best_model.h5"
```

```

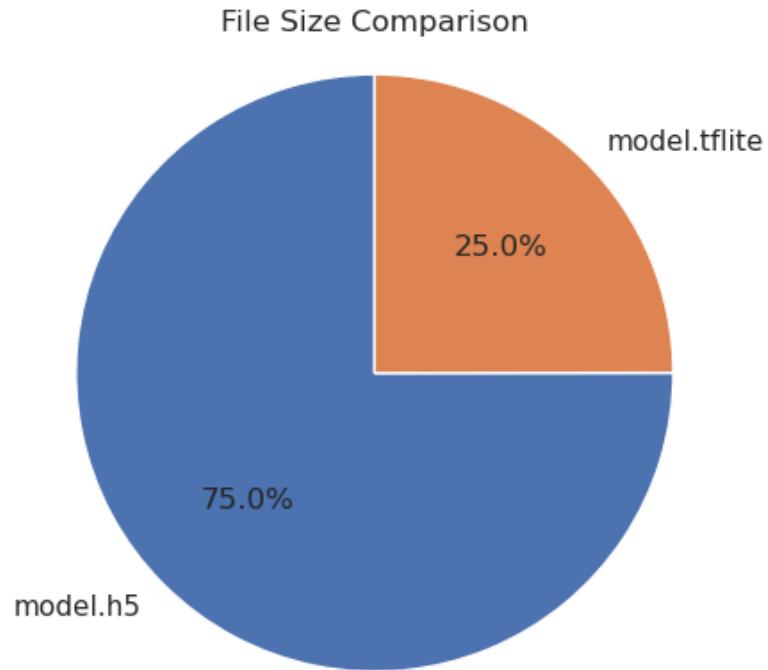
model_tflite_path = "modelLite.tflite"

# Get the file sizes of the model files
model_h5_size = os.path.getsize(model_h5_path)
model_tflite_size = os.path.getsize(model_tflite_path)

# Create a pie chart comparing the file sizes
labels = ['model.h5', 'model.tflite']
sizes = [model_h5_size, model_tflite_size]
plt.pie(sizes, labels=labels, autopct='%.1f%%', startangle=90)

plt.title("File Size Comparison")
plt.axis('equal')
plt.show()

```



```

import time
# Load the models and compare their inference speed
# Load the model.h5 file
model_h5 = tf.keras.models.load_model(model_h5_path)

# Load the model.tflite file
interpreter = tf.lite.Interpreter(model_path=model_tflite_path)

```

```

interpreter.allocate_tensors()
input_details = interpreter.get_input_details()
output_details = interpreter.get_output_details()

# Create a random input tensor
input_shape = input_details[0]['shape']
input_tensor = tf.random.uniform(input_shape)

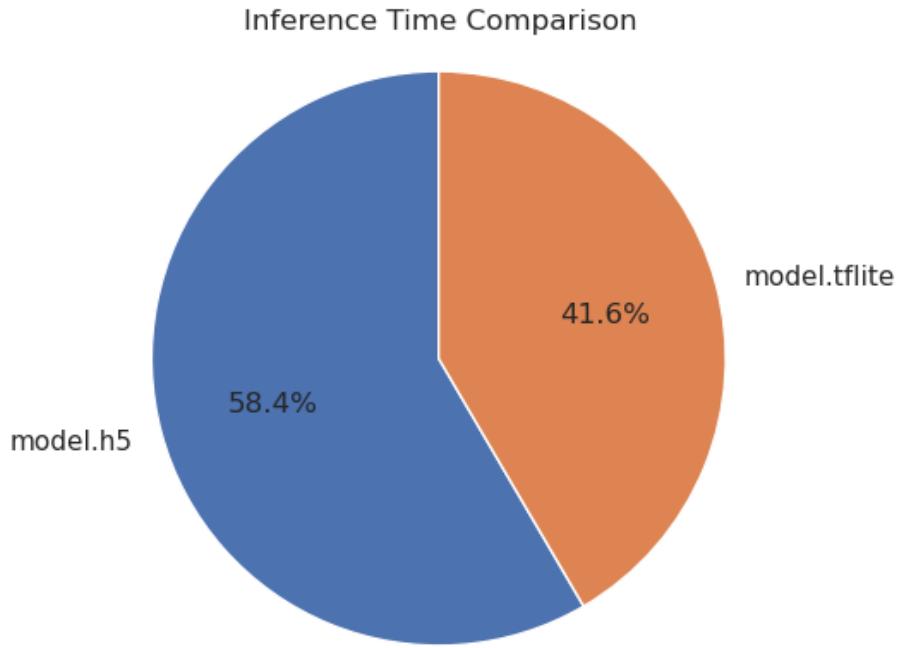
# Time the inference of the model.h5 file
start_time = time.time()
output_h5 = model_h5(input_tensor)
end_time = time.time()
inference_time_h5 = end_time - start_time

# Time the inference of the model.tflite file
start_time = time.time()
interpreter.set_tensor(input_details[0]['index'], input_tensor)
interpreter.invoke()
output_tflite = interpreter.get_tensor(output_details[0]['index'])
end_time = time.time()
inference_time_tflite = end_time - start_time

# Create a pie chart comparing the inference time of the models
labels = ['model.h5', 'model.tflite']
sizes = [inference_time_h5, inference_time_tflite]
plt.pie(sizes, labels=labels, autopct='%.1f%%', startangle=90)

plt.title("Inference Time Comparison")
plt.axis('equal')
plt.show()

```



```

def all_activations_vis(img, layers = 10):
    layer_outputs = [layer.output for layer in model.layers[:layers]]
    activation_model = models.Model(inputs = model.input, outputs = layer_outputs)
    activations = activation_model.predict(img)

    layer_names = []
    for layer in model.layers[:layers]:
        layer_names.append(layer.name)

    images_per_row = 3
    for layer_name, layer_activation in zip(layer_names, activations):
        n_features = layer_activation.shape[-1]

        size = layer_activation.shape[1]

        n_cols = n_features // images_per_row
        display_grid = np.zeros((size * n_cols, images_per_row * size))

        for col in range(n_cols):
            for row in range(images_per_row):
                channel_image = layer_activation[0, :, :, col * images_per_row + row]
                channel_image -= channel_image.mean()
                channel_image /= channel_image.std()

```

```

channel_image *= 64
channel_image += 128
channel_image = np.clip(channel_image, 0, 255).astype('uint8')
display_grid[col * size : (col + 1) * size,
             row * size : (row + 1) * size] = channel_image
scale = 1. / size
plt.figure(figsize=(scale * 5 * display_grid.shape[1],
                   scale * 5 * display_grid.shape[0]))
plt.title(layer_name)
plt.grid(False)
plt.axis('off')
plt.imshow(display_grid, aspect = 'auto', cmap = 'viridis')

img_path = "/kaggle/input/tomato-plant-dataset/TomattoLeaf/valid/Tomato___Bacterial_spot/01"
img = tf.keras.preprocessing.image.load_img(img_path, target_size = (image_size,image_size))
img_tensor = tf.keras.preprocessing.image.img_to_array(img)
img_tensor = np.expand_dims(img_tensor, axis = 0)
img_tensor /= 255.

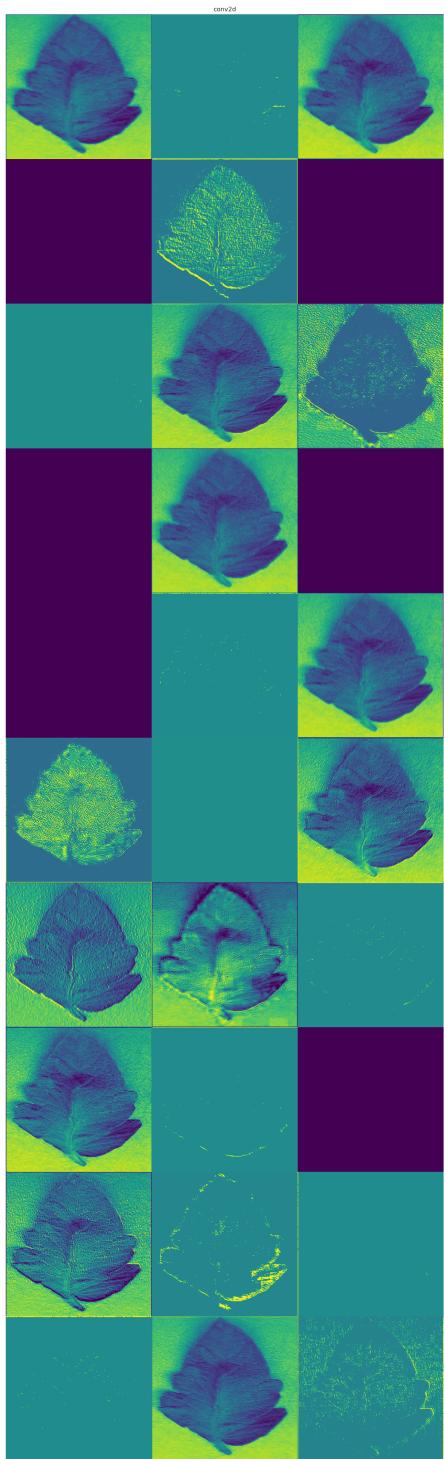
plt.imshow(img_tensor[0])
plt.axis('off')
plt.show()

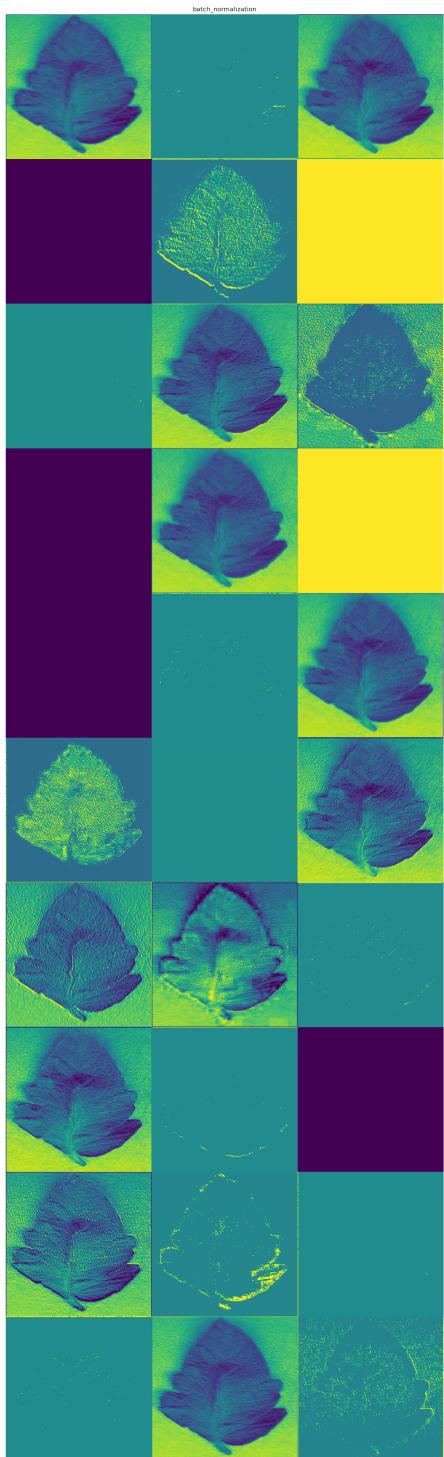
```

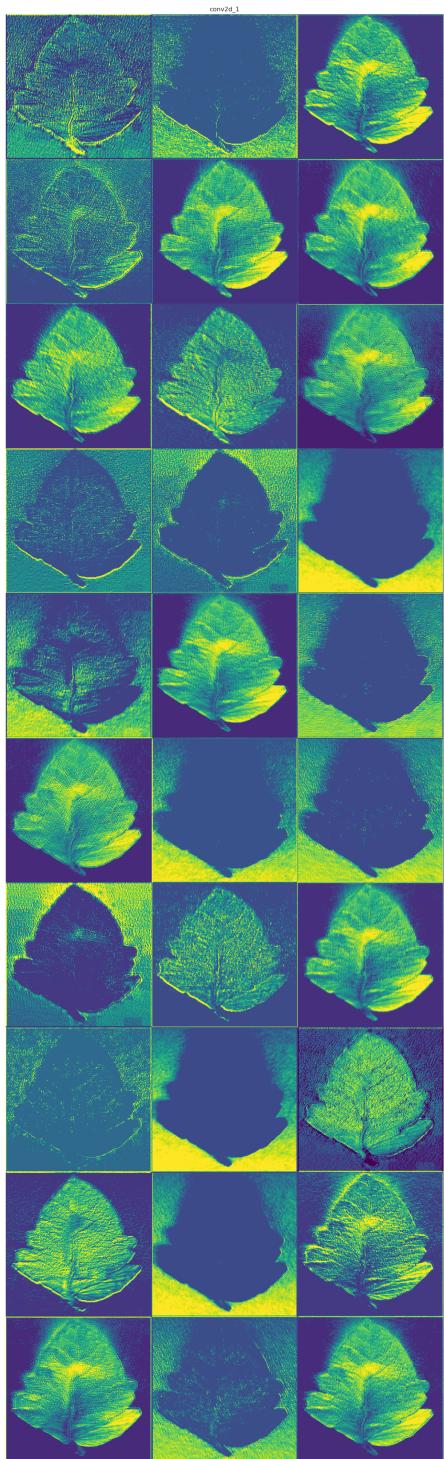


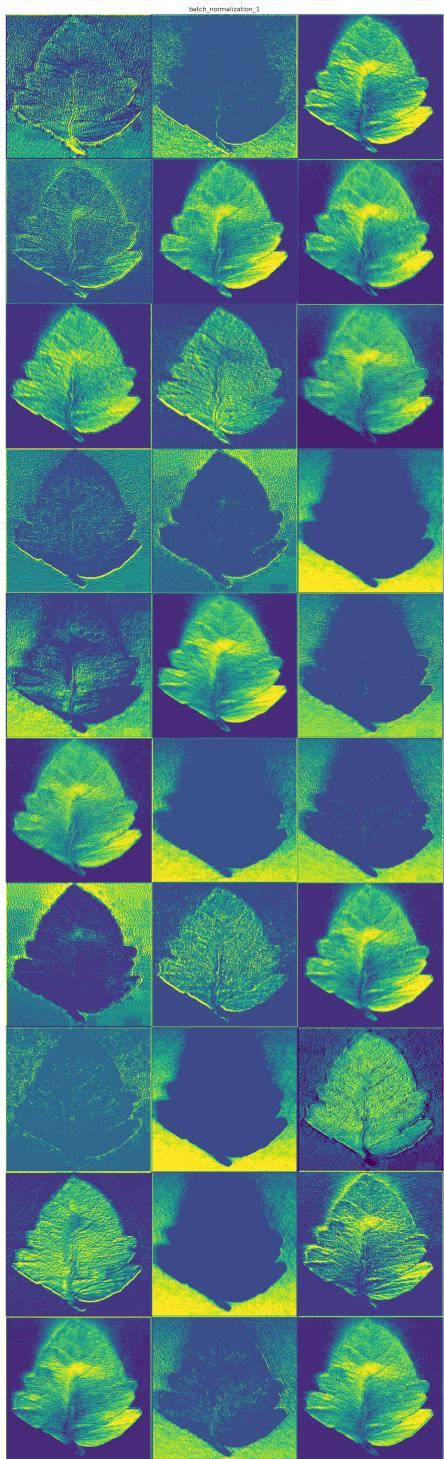
**Layer of Model to Show How procees the image**

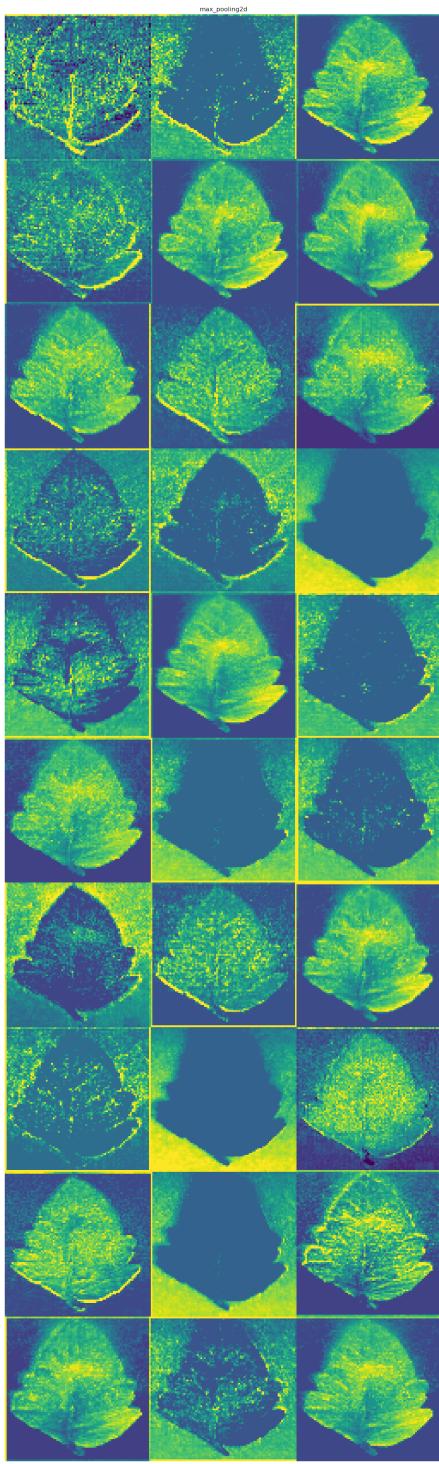
```
all_activations_vis(img_tensor, 5)
1/1 [=====] - 0s 72ms/step
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:23: RuntimeWarning: invalid value encountered in divide
/opt/conda/lib/python3.7/site-packages/ipykernel_launcher.py:23: RuntimeWarning: divide by zero
```











```

model.summary()
Model: "sequential"
-----
Layer (type)          Output Shape         Param #
=====
conv2d (Conv2D)       (None, 255, 255, 32)    896
batch_normalization (BatchN (None, 255, 255, 32)    128
ormalization)

conv2d_1 (Conv2D)     (None, 255, 255, 32)    9248
batch_normalization_1 (Bac (None, 255, 255, 32)    128
hNormalization)

max_pooling2d (MaxPooling2D (None, 85, 85, 32)    0
)

conv2d_2 (Conv2D)     (None, 85, 85, 64)      18496
batch_normalization_2 (Bac (None, 85, 85, 64)    256
hNormalization)

conv2d_3 (Conv2D)     (None, 85, 85, 64)      36928
batch_normalization_3 (Bac (None, 85, 85, 64)    256
hNormalization)

max_pooling2d_1 (MaxPooling (None, 28, 28, 64)    0
2D)

conv2d_4 (Conv2D)     (None, 28, 28, 128)     73856
batch_normalization_4 (Bac (None, 28, 28, 128)    512
hNormalization)

conv2d_5 (Conv2D)     (None, 28, 28, 128)     147584
batch_normalization_5 (Bac (None, 28, 28, 128)    512
hNormalization)

max_pooling2d_2 (MaxPooling (None, 9, 9, 128)    0
2D)

conv2d_6 (Conv2D)     (None, 9, 9, 256)       295168

```

batch_normalization_6 (BatchNormalization)	(None, 9, 9, 256)	1024
conv2d_7 (Conv2D)	(None, 9, 9, 256)	590080
batch_normalization_7 (BatchNormalization)	(None, 9, 9, 256)	1024
conv2d_8 (Conv2D)	(None, 9, 9, 512)	3277312
batch_normalization_8 (BatchNormalization)	(None, 9, 9, 512)	2048
conv2d_9 (Conv2D)	(None, 9, 9, 512)	6554112
batch_normalization_9 (BatchNormalization)	(None, 9, 9, 512)	2048
max_pooling2d_3 (MaxPooling2D)	(None, 3, 3, 512)	0
flatten (Flatten)	(None, 4608)	0
dense (Dense)	(None, 1024)	4719616
dropout (Dropout)	(None, 1024)	0
dense_1 (Dense)	(None, 512)	524800
dropout_1 (Dropout)	(None, 512)	0
dense_2 (Dense)	(None, 10)	5130

---

Total params: 16,261,162  
Trainable params: 16,257,194  
Non-trainable params: 3,968

---

```
!jupyter nbconvert --to pdf /content/notebook.ipynb
[NbConvertApp] Converting notebook /content/notebook.ipynb to pdf
Traceback (most recent call last):
  File "/usr/local/lib/python3.9/dist-packages/nbformat/reader.py", line 20, in parse_json
    nb_dict = json.loads(s, **kwargs)
  File "/usr/lib/python3.9/json/_json.py", line 346, in loads
```

```

        return _default_decoder.decode(s)
File "/usr/lib/python3.9/json/decoder.py", line 337, in decode
    obj, end = self.raw_decode(s, idx=_w(s, 0).end())
File "/usr/lib/python3.9/json/decoder.py", line 353, in raw_decode
    obj, end = self.scan_once(s, idx)
json.decoder.JSONDecodeError: Unterminated string starting at: line 1 column 13119737 (char

```

The above exception was the direct cause of the following exception:

```

Traceback (most recent call last):
  File "/usr/local/bin/jupyter-nbconvert", line 8, in <module>
    sys.exit(main())
  File "/usr/local/lib/python3.9/dist-packages/jupyter_core/application.py", line 277, in la
    return super().launch_instance(argv=argv, **kwargs)
  File "/usr/local/lib/python3.9/dist-packages/traitlets/config/application.py", line 992, i
    app.start()
  File "/usr/local/lib/python3.9/dist-packages/nbconvert/nbconvertapp.py", line 423, in sta
    self.convert_notebooks()
  File "/usr/local/lib/python3.9/dist-packages/nbconvert/nbconvertapp.py", line 597, in conv
    self.convert_single_notebook(notebook_filename)
  File "/usr/local/lib/python3.9/dist-packages/nbconvert/nbconvertapp.py", line 560, in conv
    output, resources = self.export_single_notebook(
  File "/usr/local/lib/python3.9/dist-packages/nbconvert/nbconvertapp.py", line 488, in exp
    output, resources = self.exporter.from_filename(
  File "/usr/local/lib/python3.9/dist-packages/nbconvert/exporters/exporter.py", line 189, i
    return self.from_file(f, resources=resources, **kw)
  File "/usr/local/lib/python3.9/dist-packages/nbconvert/exporters/exporter.py", line 207, i
    nbformat.read(file_stream, as_version=4), resources=resources, **kw
  File "/usr/local/lib/python3.9/dist-packages/nbformat/__init__.py", line 171, in read
    return reads(buf, as_version, capture_validation_error, **kwargs)
  File "/usr/local/lib/python3.9/dist-packages/nbformat/__init__.py", line 89, in reads
    nb = reader.reads(s, **kwargs)
  File "/usr/local/lib/python3.9/dist-packages/nbformat/reader.py", line 76, in reads
    nb_dict = parse_json(s, **kwargs)
  File "/usr/local/lib/python3.9/dist-packages/nbformat/reader.py", line 26, in parse_json
    raise NotJSONError(message) from e
nbformat.reader.NotJSONError: Notebook does not appear to be JSON: '{"metadata": {"kernelspec":
```