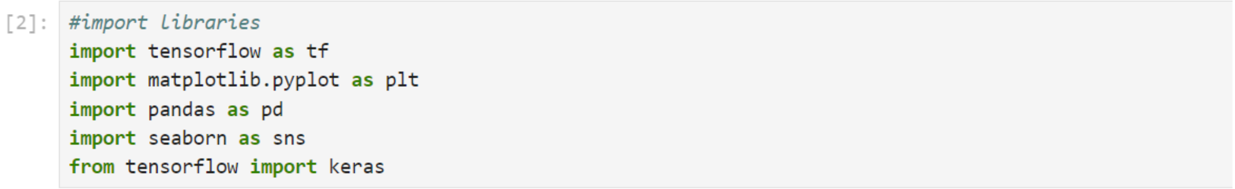
Model Development Phase Template

Date	8 July 2024
Team ID	SWTID1720076593
Project Title	Visual Diagnostics: Detecting Tomato Plant Diseases through Leaf Image Analysis
Maximum Marks	10 Marks

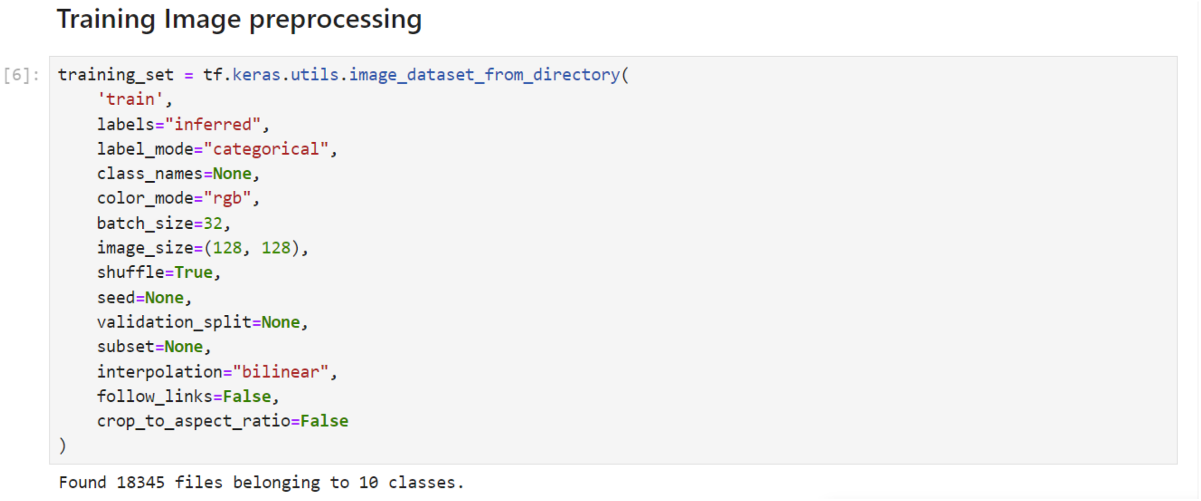
Initial Model Training Code, Model Validation and Evaluation Report

The initial model training code will be showcased in the future through a screenshot. The model validation and evaluation report will include a summary and training and validation performance metrics for multiple models, presented through respective screenshots.

Initial Model Training Code (5 marks):



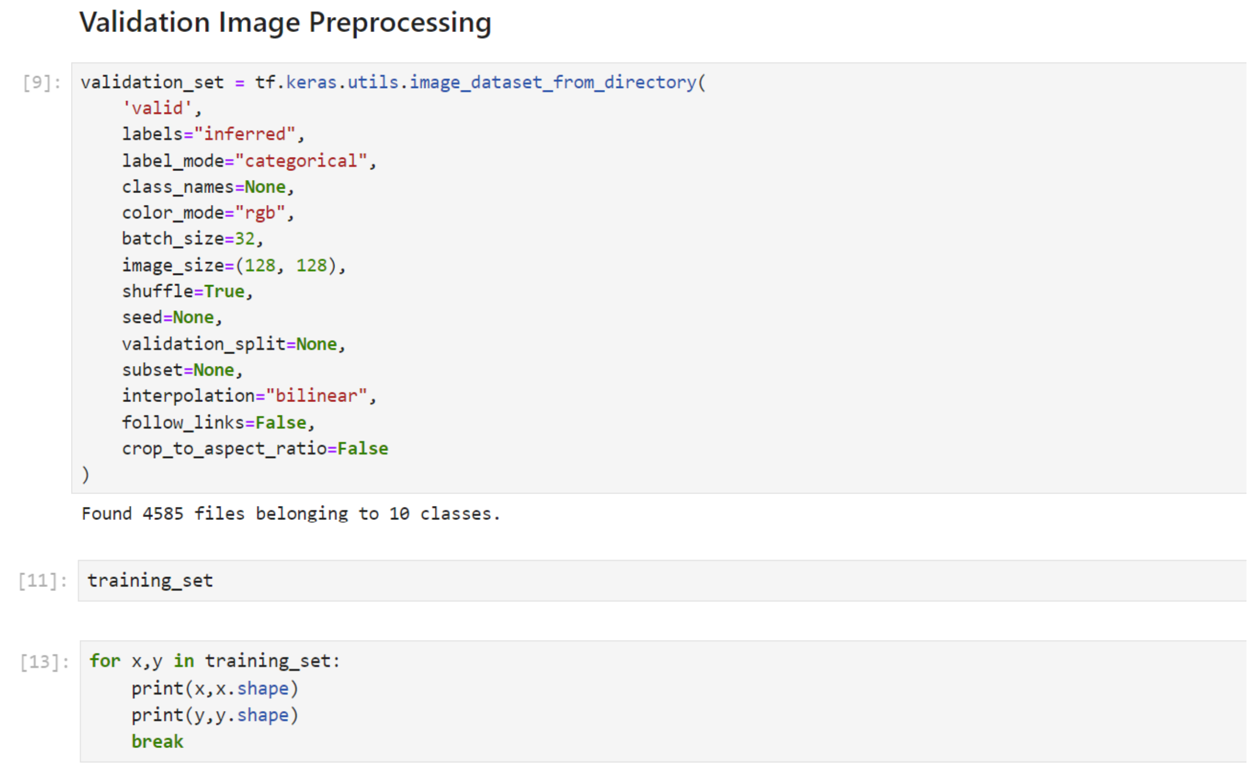
```
[2]: #import libraries
import tensorflow as tf
import matplotlib.pyplot as plt
import pandas as pd
import seaborn as sns
from tensorflow import keras
```



Training Image preprocessing

```
[6]: training_set = tf.keras.utils.image_dataset_from_directory(
    'train',
    labels="inferred",
    label_mode="categorical",
    class_names=None,
    color_mode="rgb",
    batch_size=32,
    image_size=(128, 128),
    shuffle=True,
    seed=None,
    validation_split=None,
    subset=None,
    interpolation="bilinear",
    follow_links=False,
    crop_to_aspect_ratio=False
)
```

```
Found 18345 files belonging to 10 classes.
```



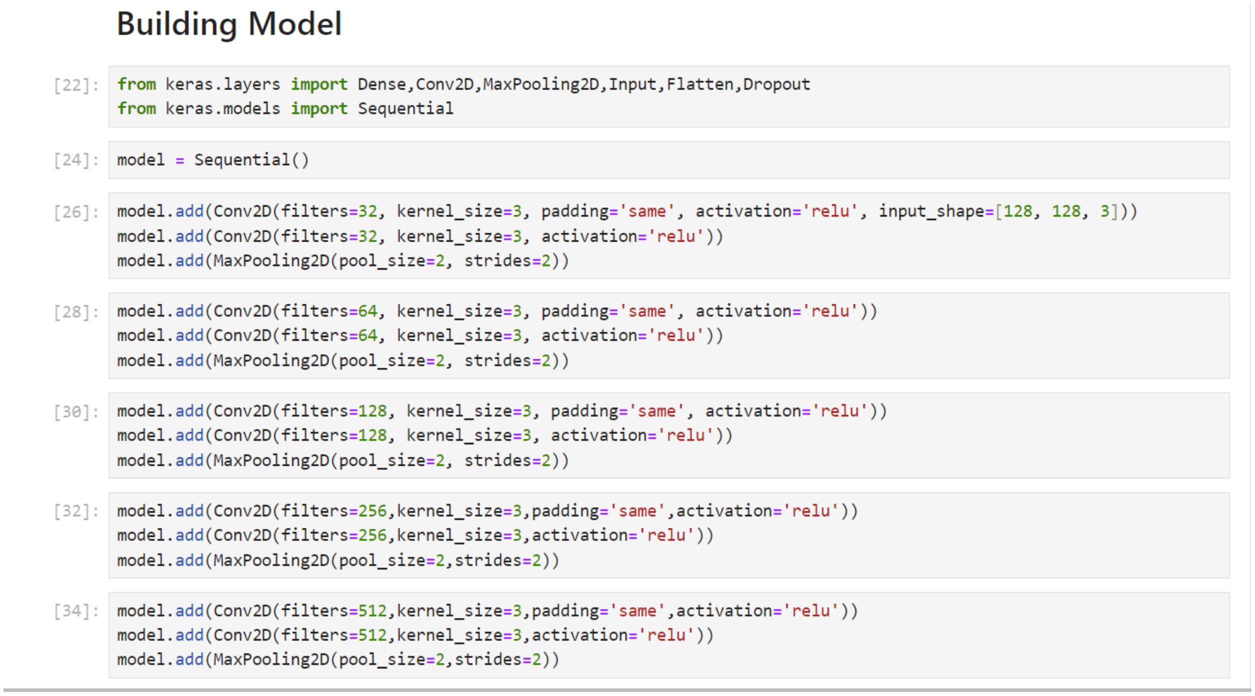
Validation Image Preprocessing

[9]:
```
validation_set = tf.keras.utils.image_dataset_from_directory(
    'valid',
    labels="inferred",
    label_mode="categorical",
    class_names=None,
    color_mode="rgb",
    batch_size=32,
    image_size=(128, 128),
    shuffle=True,
    seed=None,
    validation_split=None,
    subset=None,
    interpolation="bilinear",
    follow_links=False,
    crop_to_aspect_ratio=False
)
```

```
Found 4585 files belonging to 10 classes.
```

[11]:
```
training_set
```

[13]:
```
for x,y in training_set:
    print(x,x.shape)
    print(y,y.shape)
    break
```



Building Model

[22]:
```
from keras.layers import Dense,Conv2D,MaxPooling2D,Input,Flatten,Dropout
from keras.models import Sequential
```

[24]:
```
model = Sequential()
```

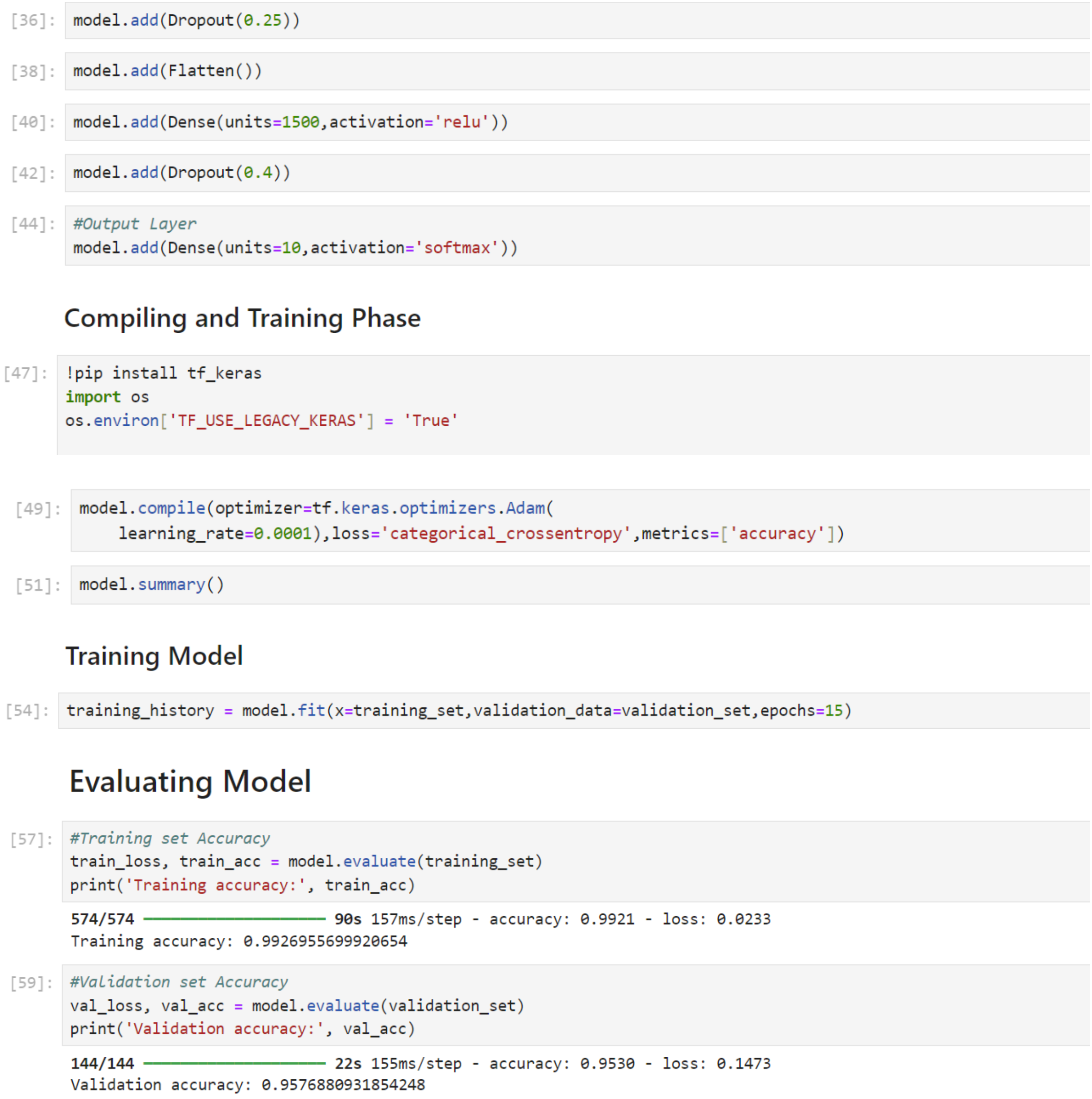
[26]:
```
model.add(Conv2D(filters=32, kernel_size=3, padding='same', activation='relu', input_shape=[128, 128, 3]))
model.add(Conv2D(filters=32, kernel_size=3, activation='relu'))
model.add(MaxPooling2D(pool_size=2, strides=2))
```

[28]:
```
model.add(Conv2D(filters=64, kernel_size=3, padding='same', activation='relu'))
model.add(Conv2D(filters=64, kernel_size=3, activation='relu'))
model.add(MaxPooling2D(pool_size=2, strides=2))
```

[30]:
```
model.add(Conv2D(filters=128, kernel_size=3, padding='same', activation='relu'))
model.add(Conv2D(filters=128, kernel_size=3, activation='relu'))
model.add(MaxPooling2D(pool_size=2, strides=2))
```

[32]:
```
model.add(Conv2D(filters=256,kernel_size=3,padding='same',activation='relu'))
model.add(Conv2D(filters=256,kernel_size=3,activation='relu'))
model.add(MaxPooling2D(pool_size=2,strides=2))
```

[34]:
```
model.add(Conv2D(filters=512,kernel_size=3,padding='same',activation='relu'))
model.add(Conv2D(filters=512,kernel_size=3,activation='relu'))
model.add(MaxPooling2D(pool_size=2,strides=2))
```



```
[36]: model.add(Dropout(0.25))
```

```
[38]: model.add(Flatten())
```

```
[40]: model.add(Dense(units=1500,activation='relu'))
```

```
[42]: model.add(Dropout(0.4))
```

```
[44]: #Output Layer
      model.add(Dense(units=10,activation='softmax'))
```

Compiling and Training Phase

```
[47]: !pip install tf_keras
      import os
      os.environ['TF_USE_LEGACY_KERAS'] = 'True'
```

```
[49]: model.compile(optimizer=tf.keras.optimizers.Adam(
          learning_rate=0.0001),loss='categorical_crossentropy',metrics=['accuracy'])
```

```
[51]: model.summary()
```

Training Model

```
[54]: training_history = model.fit(x=training_set,validation_data=validation_set,epochs=15)
```

Evaluating Model

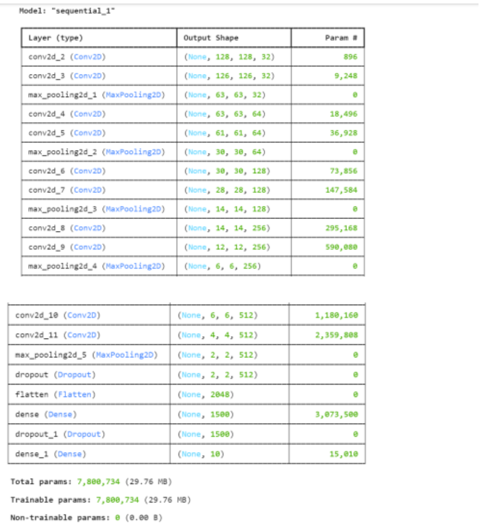
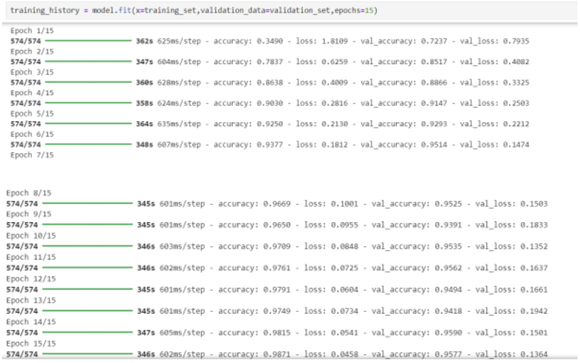
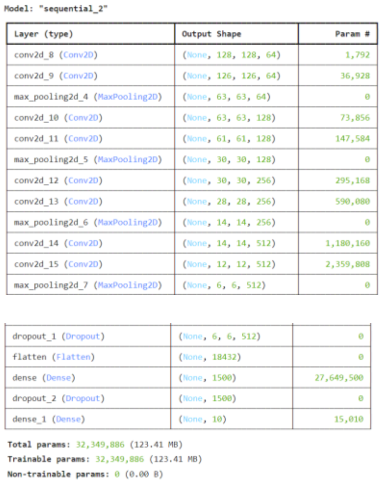
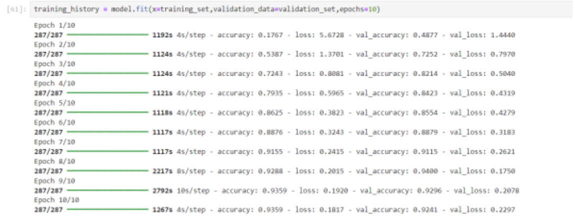
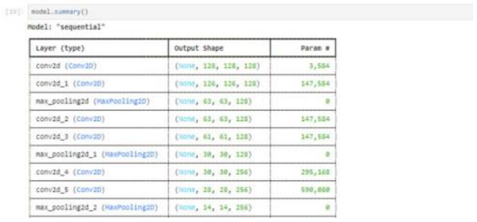
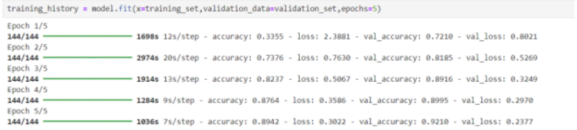
```
[57]: #Training set Accuracy
      train_loss, train_acc = model.evaluate(training_set)
      print('Training accuracy:', train_acc)
```

```
574/574 ━━━━━━━━━━━━━━━━━━━━ 90s 157ms/step - accuracy: 0.9921 - loss: 0.0233
Training accuracy: 0.9926955699920654
```

```
[59]: #Validation set Accuracy
      val_loss, val_acc = model.evaluate(validation_set)
      print('Validation accuracy:', val_acc)
```

```
144/144 ━━━━━━━━━━━━━━━━━━━━ 22s 155ms/step - accuracy: 0.9530 - loss: 0.1473
Validation accuracy: 0.9576880931854248
```

Model Validation and Evaluation Report (5 marks):

Model	Summary	Training and Validation Performance Metrics
Model 1		
Model 2		
Model 3		

Model: "sequential_1"

Layer (type)	Output Shape	Param #
conv2d_2 (Conv2D)	(None, 128, 128, 32)	896
conv2d_3 (Conv2D)	(None, 126, 126, 32)	9,248
max_pooling2d_1 (MaxPooling2D)	(None, 63, 63, 32)	0
conv2d_4 (Conv2D)	(None, 63, 63, 64)	18,496
conv2d_5 (Conv2D)	(None, 61, 61, 64)	36,928
max_pooling2d_2 (MaxPooling2D)	(None, 30, 30, 64)	0
conv2d_6 (Conv2D)	(None, 30, 30, 128)	73,856
conv2d_7 (Conv2D)	(None, 28, 28, 128)	147,584
max_pooling2d_3 (MaxPooling2D)	(None, 14, 14, 128)	0
conv2d_8 (Conv2D)	(None, 14, 14, 256)	295,168
conv2d_9 (Conv2D)	(None, 12, 12, 256)	590,080
max_pooling2d_4 (MaxPooling2D)	(None, 6, 6, 256)	0
conv2d_10 (Conv2D)	(None, 6, 6, 512)	1,180,160
conv2d_11 (Conv2D)	(None, 4, 4, 512)	2,359,808
max_pooling2d_5 (MaxPooling2D)	(None, 2, 2, 512)	0
dropout (Dropout)	(None, 2, 2, 512)	0
flatten (Flatten)	(None, 2048)	0
dense (Dense)	(None, 1500)	3,073,500
dropout_1 (Dropout)	(None, 1500)	0
dense_1 (Dense)	(None, 10)	15,010

```
Total params: 7,800,734 (29.76 MB)
Trainable params: 7,800,734 (29.76 MB)
Non-trainable params: 0 (0.00 B)
```

```
training_history = model.fit(x=training_set,validation_data=validation_set,epochs=15)
```

```
Epoch 1/15
574/574 ━━━━━━━━━━━━━━━━━━━━ 362s 625ms/step - accuracy: 0.3490 - loss: 1.8109 - val_accuracy: 0.7237 - val_loss: 0.7935
Epoch 2/15
574/574 ━━━━━━━━━━━━━━━━━━━━ 347s 604ms/step - accuracy: 0.7837 - loss: 0.6259 - val_accuracy: 0.8517 - val_loss: 0.4082
Epoch 3/15
574/574 ━━━━━━━━━━━━━━━━━━━━ 360s 628ms/step - accuracy: 0.8638 - loss: 0.4009 - val_accuracy: 0.8866 - val_loss: 0.3325
Epoch 4/15
574/574 ━━━━━━━━━━━━━━━━━━━━ 358s 624ms/step - accuracy: 0.9030 - loss: 0.2816 - val_accuracy: 0.9147 - val_loss: 0.2503
Epoch 5/15
574/574 ━━━━━━━━━━━━━━━━━━━━ 364s 635ms/step - accuracy: 0.9250 - loss: 0.2130 - val_accuracy: 0.9293 - val_loss: 0.2212
Epoch 6/15
574/574 ━━━━━━━━━━━━━━━━━━━━ 348s 607ms/step - accuracy: 0.9377 - loss: 0.1812 - val_accuracy: 0.9514 - val_loss: 0.1474
Epoch 7/15


Epoch 8/15
574/574 ━━━━━━━━━━━━━━━━━━━━ 345s 601ms/step - accuracy: 0.9669 - loss: 0.1001 - val_accuracy: 0.9525 - val_loss: 0.1503
Epoch 9/15
574/574 ━━━━━━━━━━━━━━━━━━━━ 345s 601ms/step - accuracy: 0.9650 - loss: 0.0955 - val_accuracy: 0.9391 - val_loss: 0.1833
Epoch 10/15
574/574 ━━━━━━━━━━━━━━━━━━━━ 346s 603ms/step - accuracy: 0.9709 - loss: 0.0848 - val_accuracy: 0.9535 - val_loss: 0.1352
Epoch 11/15
574/574 ━━━━━━━━━━━━━━━━━━━━ 346s 602ms/step - accuracy: 0.9761 - loss: 0.0725 - val_accuracy: 0.9562 - val_loss: 0.1637
Epoch 12/15
574/574 ━━━━━━━━━━━━━━━━━━━━ 345s 601ms/step - accuracy: 0.9791 - loss: 0.0604 - val_accuracy: 0.9494 - val_loss: 0.1661
Epoch 13/15
574/574 ━━━━━━━━━━━━━━━━━━━━ 345s 601ms/step - accuracy: 0.9749 - loss: 0.0734 - val_accuracy: 0.9418 - val_loss: 0.1942
Epoch 14/15
574/574 ━━━━━━━━━━━━━━━━━━━━ 347s 605ms/step - accuracy: 0.9815 - loss: 0.0541 - val_accuracy: 0.9590 - val_loss: 0.1501
Epoch 15/15
574/574 ━━━━━━━━━━━━━━━━━━━━ 346s 602ms/step - accuracy: 0.9871 - loss: 0.0458 - val_accuracy: 0.9577 - val_loss: 0.1364
```

Model: "sequential_2"

Layer (type)	Output Shape	Param #
conv2d_8 (Conv2D)	(None, 128, 128, 64)	1,792
conv2d_9 (Conv2D)	(None, 126, 126, 64)	36,928
max_pooling2d_4 (MaxPooling2D)	(None, 63, 63, 64)	0
conv2d_10 (Conv2D)	(None, 63, 63, 128)	73,856
conv2d_11 (Conv2D)	(None, 61, 61, 128)	147,584
max_pooling2d_5 (MaxPooling2D)	(None, 30, 30, 128)	0
conv2d_12 (Conv2D)	(None, 30, 30, 256)	295,168
conv2d_13 (Conv2D)	(None, 28, 28, 256)	590,080
max_pooling2d_6 (MaxPooling2D)	(None, 14, 14, 256)	0
conv2d_14 (Conv2D)	(None, 14, 14, 512)	1,180,160
conv2d_15 (Conv2D)	(None, 12, 12, 512)	2,359,808
max_pooling2d_7 (MaxPooling2D)	(None, 6, 6, 512)	0
dropout_1 (Dropout)	(None, 6, 6, 512)	0
flatten (Flatten)	(None, 18432)	0
dense (Dense)	(None, 1500)	27,649,500
dropout_2 (Dropout)	(None, 1500)	0
dense_1 (Dense)	(None, 10)	15,010

```
Total params: 32,349,886 (123.41 MB)
Trainable params: 32,349,886 (123.41 MB)
Non-trainable params: 0 (0.00 B)
```

```
[61]: training_history = model.fit(x=training_set,validation_data=validation_set,epochs=10)
```

```
Epoch 1/10
287/287 ━━━━━━━━━━━━━━━━━━━━ 1192s 4s/step - accuracy: 0.1767 - loss: 5.6728 - val_accuracy: 0.4877 - val_loss: 1.4440
Epoch 2/10
287/287 ━━━━━━━━━━━━━━━━━━━━ 1124s 4s/step - accuracy: 0.5387 - loss: 1.3701 - val_accuracy: 0.7252 - val_loss: 0.7970
Epoch 3/10
287/287 ━━━━━━━━━━━━━━━━━━━━ 1124s 4s/step - accuracy: 0.7243 - loss: 0.8081 - val_accuracy: 0.8214 - val_loss: 0.5040
Epoch 4/10
287/287 ━━━━━━━━━━━━━━━━━━━━ 1121s 4s/step - accuracy: 0.7935 - loss: 0.5965 - val_accuracy: 0.8423 - val_loss: 0.4319
Epoch 5/10
287/287 ━━━━━━━━━━━━━━━━━━━━ 1118s 4s/step - accuracy: 0.8625 - loss: 0.3823 - val_accuracy: 0.8554 - val_loss: 0.4279
Epoch 6/10
287/287 ━━━━━━━━━━━━━━━━━━━━ 1117s 4s/step - accuracy: 0.8876 - loss: 0.3243 - val_accuracy: 0.8879 - val_loss: 0.3183
Epoch 7/10
287/287 ━━━━━━━━━━━━━━━━━━━━ 1117s 4s/step - accuracy: 0.9155 - loss: 0.2415 - val_accuracy: 0.9115 - val_loss: 0.2621
Epoch 8/10
287/287 ━━━━━━━━━━━━━━━━━━━━ 2217s 8s/step - accuracy: 0.9288 - loss: 0.2015 - val_accuracy: 0.9400 - val_loss: 0.1750
Epoch 9/10
287/287 ━━━━━━━━━━━━━━━━━━━━ 2792s 10s/step - accuracy: 0.9359 - loss: 0.1920 - val_accuracy: 0.9296 - val_loss: 0.2078
Epoch 10/10
287/287 ━━━━━━━━━━━━━━━━━━━━ 1267s 4s/step - accuracy: 0.9359 - loss: 0.1817 - val_accuracy: 0.9241 - val_loss: 0.2297
```

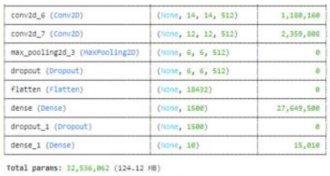
```
[19]: model.summary()
```

Model: "sequential"

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 128, 128, 128)	3,584
conv2d_1 (Conv2D)	(None, 126, 126, 128)	147,584
max_pooling2d (MaxPooling2D)	(None, 63, 63, 128)	0
conv2d_2 (Conv2D)	(None, 63, 63, 128)	147,584
conv2d_3 (Conv2D)	(None, 61, 61, 128)	147,584
max_pooling2d_1 (MaxPooling2D)	(None, 30, 30, 128)	0
conv2d_4 (Conv2D)	(None, 30, 30, 256)	295,168
conv2d_5 (Conv2D)	(None, 28, 28, 256)	590,080
max_pooling2d_2 (MaxPooling2D)	(None, 14, 14, 256)	0

```
training_history = model.fit(x=training_set,validation_data=validation_set,epochs=5)
```

```
Epoch 1/5
144/144 ━━━━━━━━━━━━━━━━━━━━ 1698s 12s/step - accuracy: 0.3355 - loss: 2.3881 - val_accuracy: 0.7210 - val_loss: 0.8021
Epoch 2/5
144/144 ━━━━━━━━━━━━━━━━━━━━ 2974s 20s/step - accuracy: 0.7376 - loss: 0.7630 - val_accuracy: 0.8185 - val_loss: 0.5269
Epoch 3/5
144/144 ━━━━━━━━━━━━━━━━━━━━ 1914s 13s/step - accuracy: 0.8237 - loss: 0.5067 - val_accuracy: 0.8916 - val_loss: 0.3249
Epoch 4/5
144/144 ━━━━━━━━━━━━━━━━━━━━ 1284s 9s/step - accuracy: 0.8764 - loss: 0.3586 - val_accuracy: 0.8995 - val_loss: 0.2970
Epoch 5/5
144/144 ━━━━━━━━━━━━━━━━━━━━ 1036s 7s/step - accuracy: 0.8942 - loss: 0.3022 - val_accuracy: 0.9210 - val_loss: 0.2377
```

	 conv2d_6 (Conv2D) (None, 14, 14, 512) 1,180,160 conv2d_7 (Conv2D) (None, 12, 12, 512) 2,359,808 max_pooling2d_3 (MaxPooling2D) (None, 6, 6, 512) 0 dropout (Dropout) (None, 6, 6, 512) 0 flatten (Flatten) (None, 18432) 0 dense (Dense) (None, 1500) 27,649,500 dropout_1 (Dropout) (None, 1500) 0 dense_1 (Dense) (None, 10) 15,010 Total params: 32,536,062 (124.12 MB)	