Spring 2024: CS5720 Neural Networks & Deep Learning – ICP-8

Assignment – 7

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Github Link: https://github.com/mahendrasrirambetha/NN_Assignment7

Video Link: https://drive.google.com/file/d/1Gzh5bhKDVJy4P17simN8s_JHnwa-SYlW/view?usp=drive_link

Use Case Description:

LeNet5, AlexNet, Vgg16, Vgg19
1. Training the model
2. Evaluating the model

Programming elements:

1. About CNN
2. Hyperparameters of CNN
3. Image classification with CNN

In class programming:

1. Tune hyperparameter and make necessary addition to the baseline model to improve validation accuracy and reduce validation loss.
2. Provide logical description of which steps lead to improved response and what was its impact on architecture behavior.
3. Create at least two more visualizations using matplotlib (Other than provided in the source file)
4. Use dataset of your own choice and implement baseline models provided.
5. Apply modified architecture to your own selected dataset and train it.
6. Evaluate your model on testing set.
7. Save the improved model and use it for prediction on testing data
8. Provide plot of confusion matric
9. Provide Training and testing Loss and accuracy plots in one plot using subplot command and history object.
10. Provide at least two more visualizations reflecting your solution.
11. Provide logical description of which steps lead to improved response for new dataset when compared with baseline model and enhance architecture and what was its impact on architecture behavior.

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Run Code

In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import tensorflow as tf
from tensorflow.keras.datasets import cifar100

from tensorflow.keras.optimizers import RMSprop
from keras.preprocessing import image
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.layers import Dense, Flatten, Conv2D, MaxPooling2D, Dropout, BatchNormalization

%matplotlib inline
```

Extract data and train and test dataset

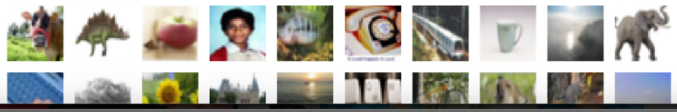
In [2]:
```
#cifar100 = tf.keras.datasets.cifar100
(X_train,Y_train) , (X_test,Y_test) = cifar100.load_data()
```

```
Downloading data from https://www.cs.toronto.edu/~kriz/cifar-100-python.tar.gz
169001437/169001437 [==============================] - 6s 0us/step
```

In [27]:
```
classes = ['apple', 'aquarium_fish', 'baby', 'bear', 'beaver', 'bed', 'bee', 'beetle', 'bicycle', 'bottle',
```

Let's look into the dataset images

In [3]:
```
plt.figure(figsize = (16,16))
for i in range(100):
  plt.subplot(10,10,1+i)
  plt.axis('off')
  plt.imshow(X_train[i], cmap = 'gray')
```



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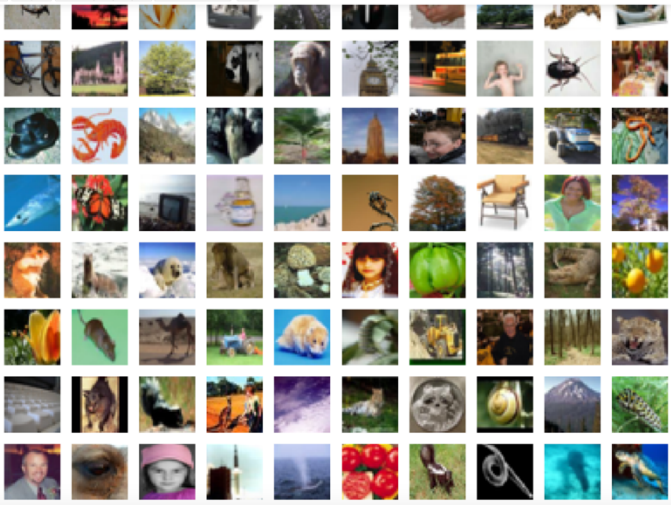

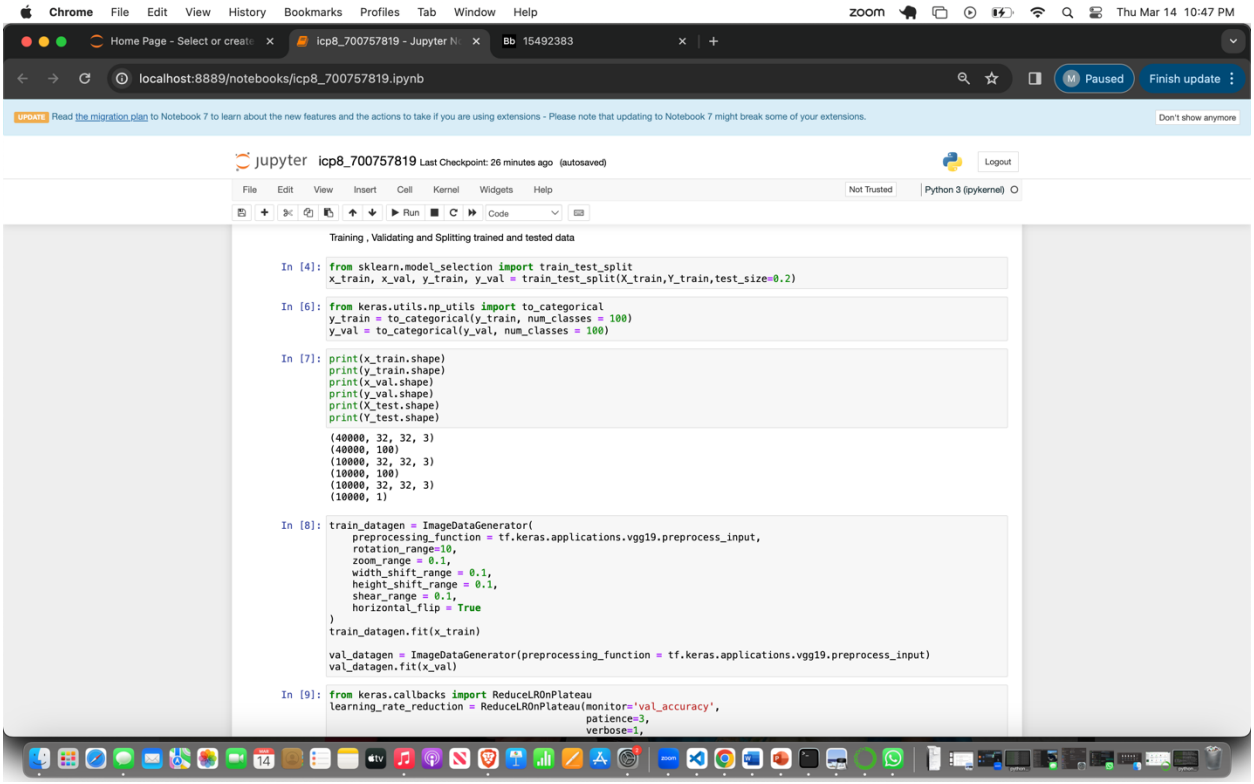
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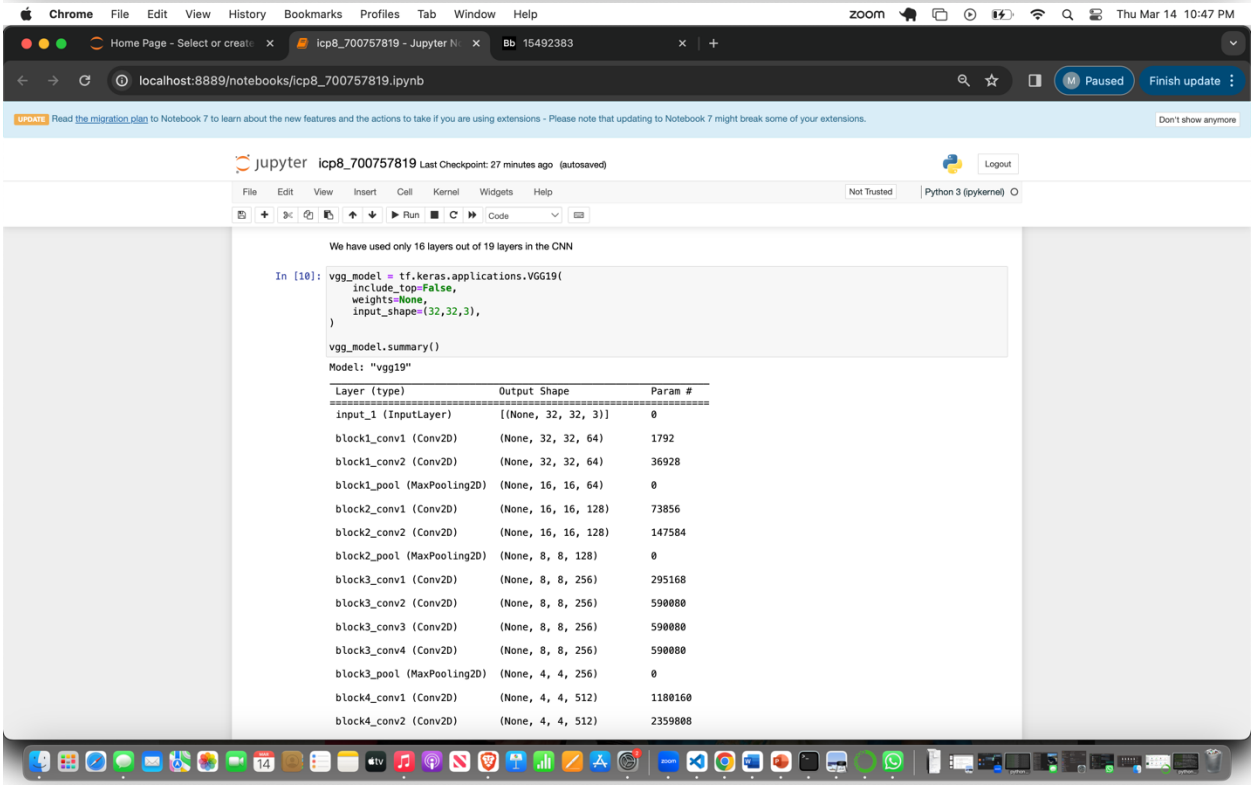
Python 3 (ipykernel)
Run
Code
Training , Validating and Splitting trained and tested data
In [4]:
from sklearn.model_selection import train_test_split
x_train, x_val, y_train, y_val = train_test_split(X_train,Y_train,test_size=0.2)
In [6]:
from keras.utils.np_utils import to_categorical
y_train = to_categorical(y_train, num_classes = 100)
y_val = to_categorical(y_val, num_classes = 100)
In [7]:
print(x_train.shape)
print(y_train.shape)
print(x_val.shape)
print(y_val.shape)
print(X_test.shape)
print(Y_test.shape)
(40000, 32, 32, 3)
(40000, 100)
(10000, 32, 32, 3)
(10000, 100)
(10000, 32, 32, 3)
(10000, 1)
In [8]:
train_datagen = ImageDataGenerator(
preprocessing_function = tf.keras.applications.vgg19.preprocess_input,
rotation_range=10,
zoom_range = 0.1,
width_shift_range = 0.1,
height_shift_range = 0.1,
shear_range = 0.1,
horizontal_flip = True
)
train_datagen.fit(x_train)
val_datagen = ImageDataGenerator(preprocessing_function = tf.keras.applications.vgg19.preprocess_input)
val_datagen.fit(x_val)
In [9]:
from keras.callbacks import ReduceLROnPlateau
learning_rate_reduction = ReduceLROnPlateau(monitor='val_accuracy',
patience=3,
verbose=1,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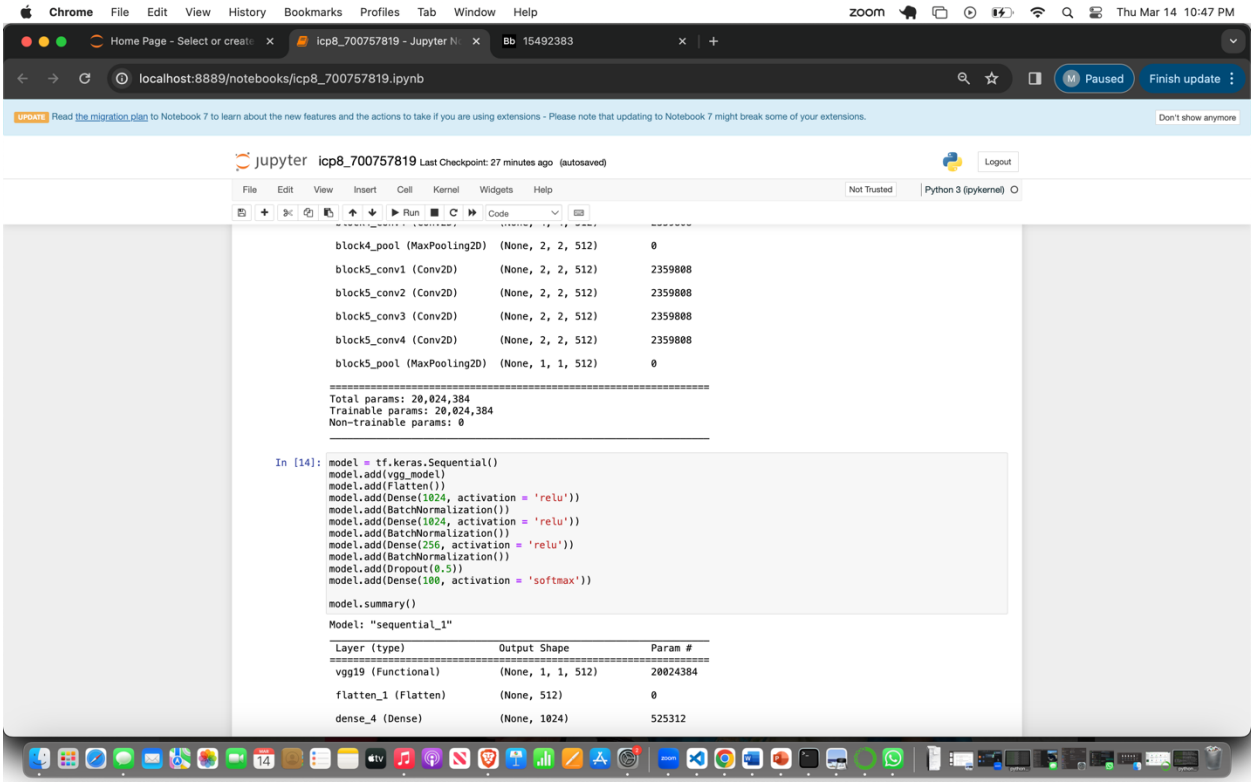
Python 3 (ipykernel)
Run
Code
We have used only 16 layers out of 19 layers in the CNN
In [10]:
vgg_model = tf.keras.applications.VGG19(
include_top=False,
weights=None,
input_shape=(32,32,3),
)
vgg_model.summary()
Model: "vgg19"
Layer (type) Output Shape Param #
input_1 (InputLayer) [(None, 32, 32, 3)] 0
block1_conv1 (Conv2D) (None, 32, 32, 64) 1792
block1_conv2 (Conv2D) (None, 32, 32, 64) 36928
block1_pool (MaxPooling2D) (None, 16, 16, 64) 0
block2_conv1 (Conv2D) (None, 16, 16, 128) 73856
block2_conv2 (Conv2D) (None, 16, 16, 128) 147584
block2_pool (MaxPooling2D) (None, 8, 8, 128) 0
block3_conv1 (Conv2D) (None, 8, 8, 256) 295168
block3_conv2 (Conv2D) (None, 8, 8, 256) 590080
block3_conv3 (Conv2D) (None, 8, 8, 256) 590080
block3_conv4 (Conv2D) (None, 8, 8, 256) 590080
block3_pool (MaxPooling2D) (None, 4, 4, 256) 0
block4_conv1 (Conv2D) (None, 4, 4, 512) 1180160
block4_conv2 (Conv2D) (None, 4, 4, 512) 2359808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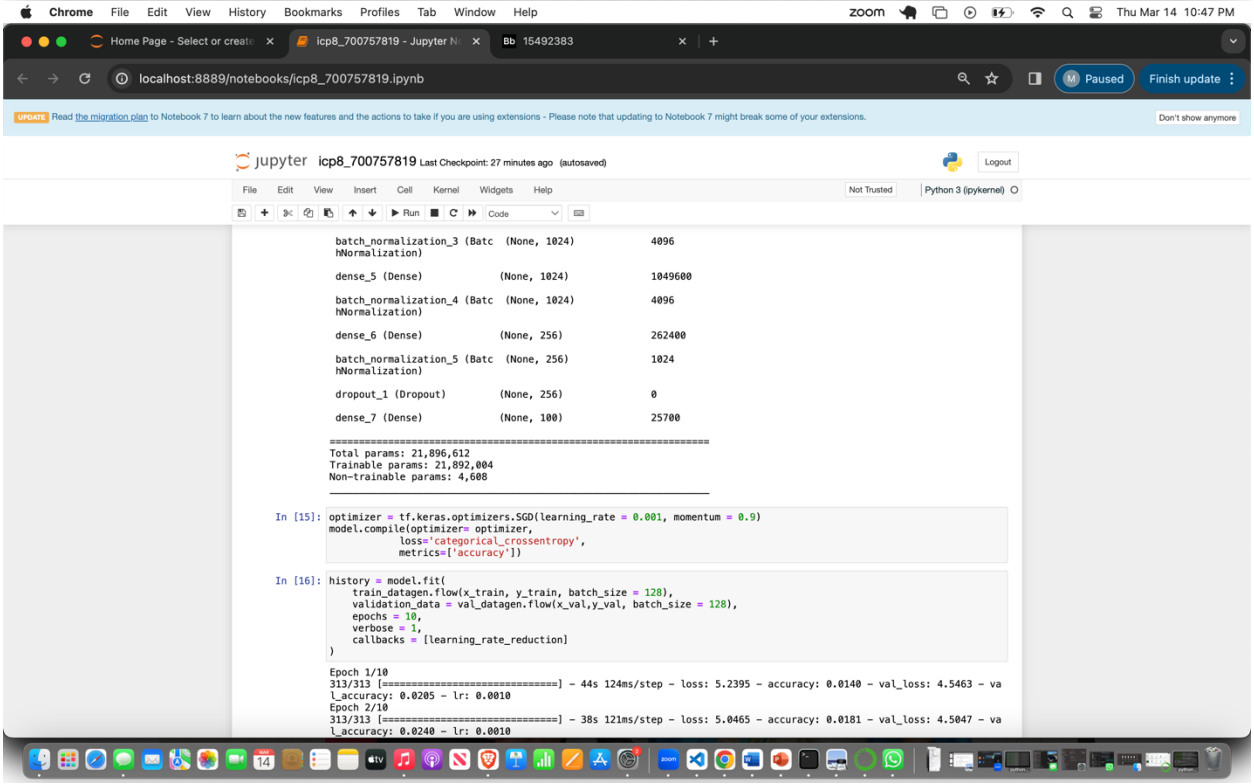
Python 3 (ipykernel)
block4_pool (MaxPooling2D) (None, 2, 2, 512) 0
block5_conv1 (Conv2D) (None, 2, 2, 512) 2359808
block5_conv2 (Conv2D) (None, 2, 2, 512) 2359808
block5_conv3 (Conv2D) (None, 2, 2, 512) 2359808
block5_conv4 (Conv2D) (None, 2, 2, 512) 2359808
block5_pool (MaxPooling2D) (None, 1, 1, 512) 0
Total params: 20,024,384
Trainable params: 20,024,384
Non-trainable params: 0
In [14]:
model = tf.keras.Sequential()
model.add(vgg_model)
model.add(Flatten())
model.add(Dense(1024, activation = 'relu'))
model.add(BatchNormalization())
model.add(Dense(1024, activation = 'relu'))
model.add(BatchNormalization())
model.add(Dense(256, activation = 'relu'))
model.add(BatchNormalization())
model.add(Dropout(0.5))
model.add(Dense(100, activation = 'softmax'))
model.summary()
Model: "sequential_1"
Layer (type) Output Shape Param #
vgg19 (Functional) (None, 1, 1, 512) 20024384
flatten_1 (Flatten) (None, 512) 0
dense_4 (Dense) (None, 1024) 525312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Python 3 (ipykernel)
batch_normalization_3 (Batch Normalization) (None, 1024) 4096
dense_5 (Dense) (None, 1024) 1049600
batch_normalization_4 (Batch Normalization) (None, 1024) 4096
dense_6 (Dense) (None, 256) 262400
batch_normalization_5 (Batch Normalization) (None, 256) 1024
dropout_1 (Dropout) (None, 256) 0
dense_7 (Dense) (None, 100) 25700
Total params: 21,896,612
Trainable params: 21,892,004
Non-trainable params: 4,608
In [15]:
optimizer = tf.keras.optimizers.SGD(learning_rate = 0.001, momentum = 0.9)
model.compile(optimizer= optimizer,
loss='categorical_crossentropy',
metrics=['accuracy'])
In [16]:
history = model.fit(
train_datagen.flow(x_train, y_train, batch_size = 128),
validation_data = val_datagen.flow(x_val,y_val, batch_size = 128),
epochs = 10,
verbose = 1,
callbacks = [learning_rate_reduction]
)
Epoch 1/10
313/313 [==============================] - 44s 124ms/step - loss: 5.2395 - accuracy: 0.0140 - val_loss: 4.5463 - val_accuracy: 0.0205 - lr: 0.0010
Epoch 2/10
313/313 [==============================] - 38s 121ms/step - loss: 5.0465 - accuracy: 0.0181 - val_loss: 4.5047 - val_accuracy: 0.0240 - lr: 0.0010

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Run Code

```
    callbacks = [learning_rate_reduction]
)
```

```
Epoch 1/10
313/313 [==============================] - 44s 124ms/step - loss: 5.2395 - accuracy: 0.0140 - val_loss: 4.5463 - va
l_accuracy: 0.0205 - lr: 0.0010
Epoch 2/10
313/313 [==============================] - 38s 121ms/step - loss: 5.0465 - accuracy: 0.0181 - val_loss: 4.5047 - va
l_accuracy: 0.0240 - lr: 0.0010
Epoch 3/10
313/313 [==============================] - 36s 116ms/step - loss: 4.9621 - accuracy: 0.0179 - val_loss: 4.7844 - va
l_accuracy: 0.0117 - lr: 0.0010
Epoch 4/10
313/313 [==============================] - 36s 115ms/step - loss: 4.8896 - accuracy: 0.0191 - val_loss: 4.5794 - va
l_accuracy: 0.0206 - lr: 0.0010
Epoch 5/10
313/313 [==============================] - 36s 116ms/step - loss: 4.7757 - accuracy: 0.0202 - val_loss: 4.4016 - va
l_accuracy: 0.0302 - lr: 0.0010
Epoch 6/10
313/313 [==============================] - 36s 116ms/step - loss: 4.6797 - accuracy: 0.0253 - val_loss: 4.3797 - va
l_accuracy: 0.0325 - lr: 0.0010
Epoch 7/10
313/313 [==============================] - 35s 113ms/step - loss: 4.6021 - accuracy: 0.0245 - val_loss: 4.3531 - va
l_accuracy: 0.0295 - lr: 0.0010
Epoch 8/10
313/313 [==============================] - 36s 115ms/step - loss: 4.5665 - accuracy: 0.0258 - val_loss: 4.3573 - va
l_accuracy: 0.0308 - lr: 0.0010
Epoch 9/10
313/313 [==============================] - 36s 116ms/step - loss: 4.5199 - accuracy: 0.0262 - val_loss: 4.3059 - va
l_accuracy: 0.0348 - lr: 0.0010
Epoch 10/10
313/313 [==============================] - 36s 113ms/step - loss: 4.4793 - accuracy: 0.0281 - val_loss: 4.3472 - va
l_accuracy: 0.0322 - lr: 0.0010
```

In [17]:
```
acc = history.history['accuracy']
val_acc = history.history['val_accuracy']

plt.figure()
plt.plot(acc,color = 'purple',label = 'Training Acuracy')
plt.plot(val_acc,color = 'blue',label = 'Validation Accuracy')
plt.legend()
```

Out[17]: `<matplotlib.legend.Legend at 0x7f82e645a190>`

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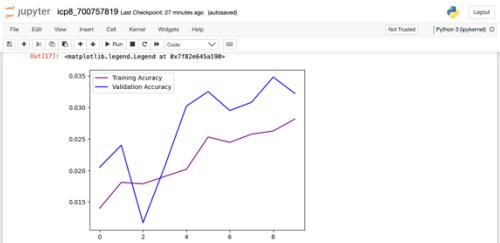
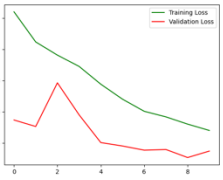


In [18]:
```
loss = history.history['loss']
val_loss = history.history['val_loss']

plt.figure()
plt.plot(loss,color = 'green',label = 'Training Loss')
plt.plot(val_loss,color = 'red',label = 'Validation Loss')
plt.legend()
```

Out[18]: `<matplotlib.legend.Legend at 0x7f82e61622e8>`



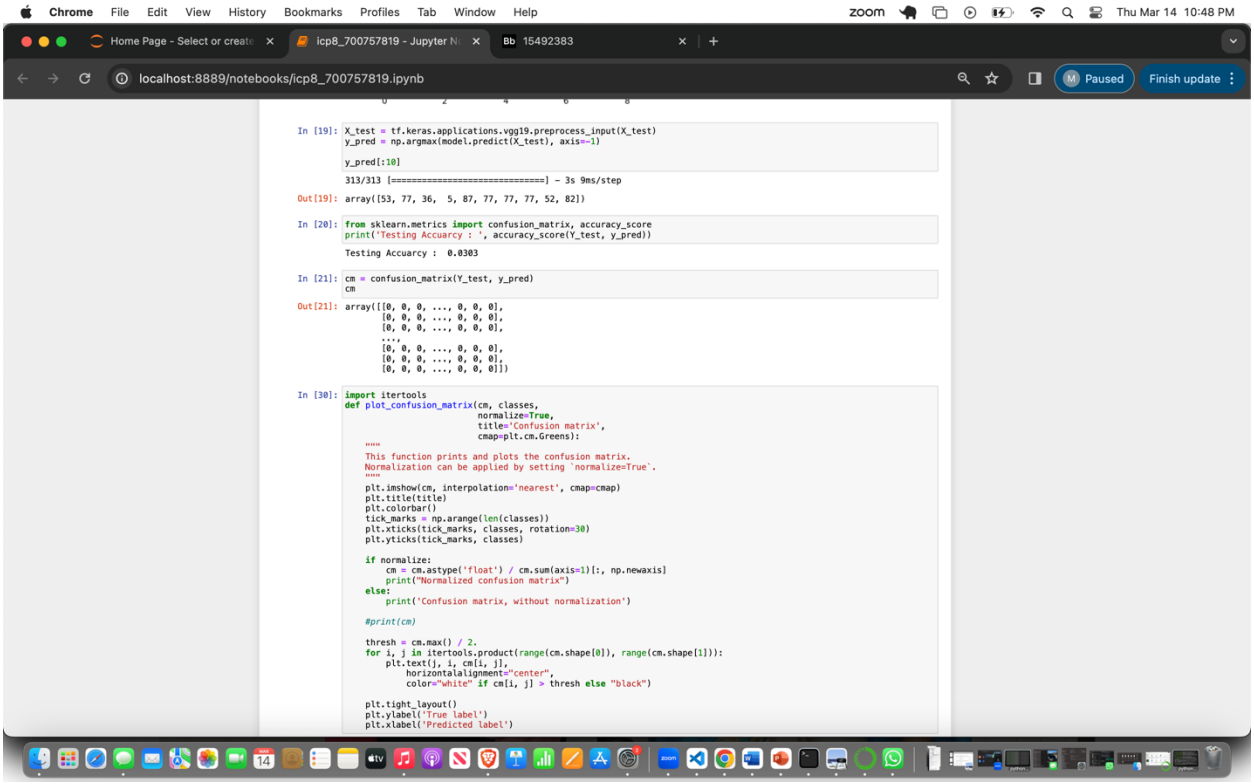
In [19]:
```
X_test = tf.keras.applications.vgg19.preprocess_input(X_test)
y_pred = np.argmax(model.predict(X_test), axis=-1)

y_pred[:10]
```

```
313/313 [==============================] - 3s 9ms/step
```

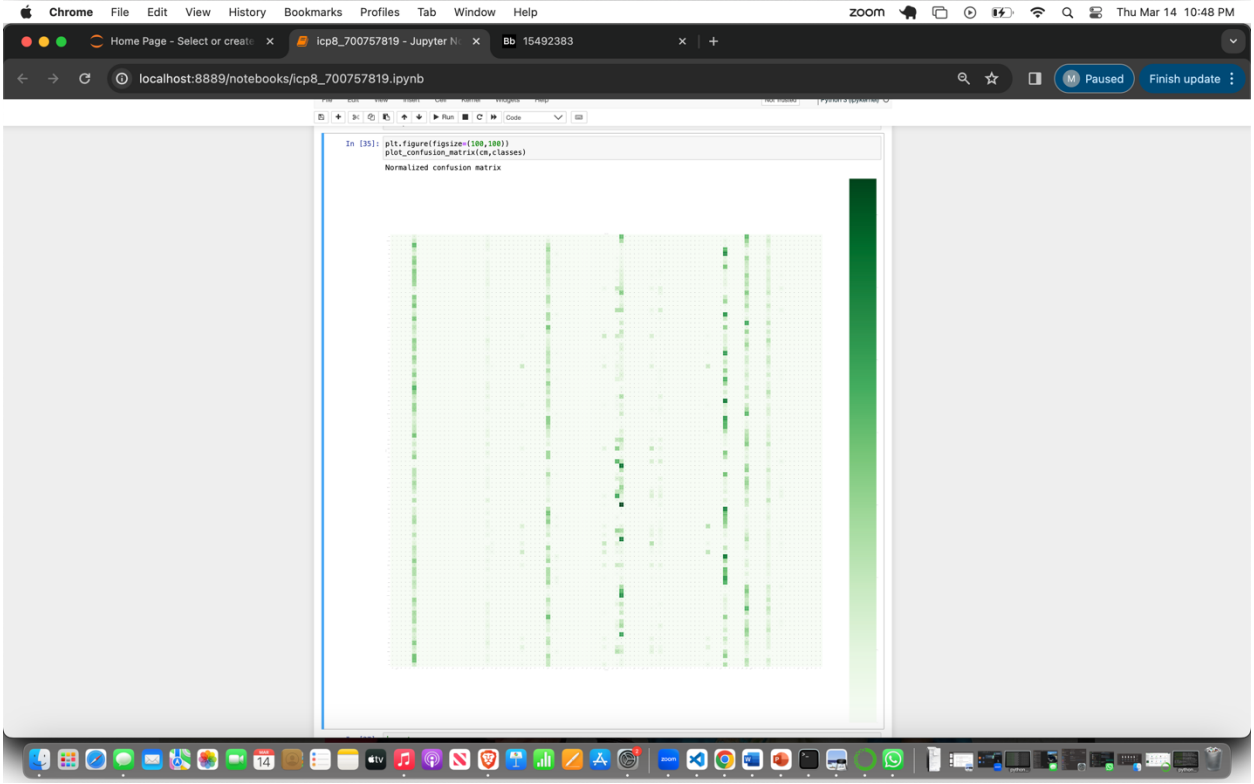
Out[19]: `array([53, 77, 36,  5, 87, 77, 77, 77, 52, 82])`

In [20]:
```
from sklearn.metrics import confusion_matrix, accuracy_score
print('Testing Accuracy : ', accuracy_score(Y_test, y_pred))
```

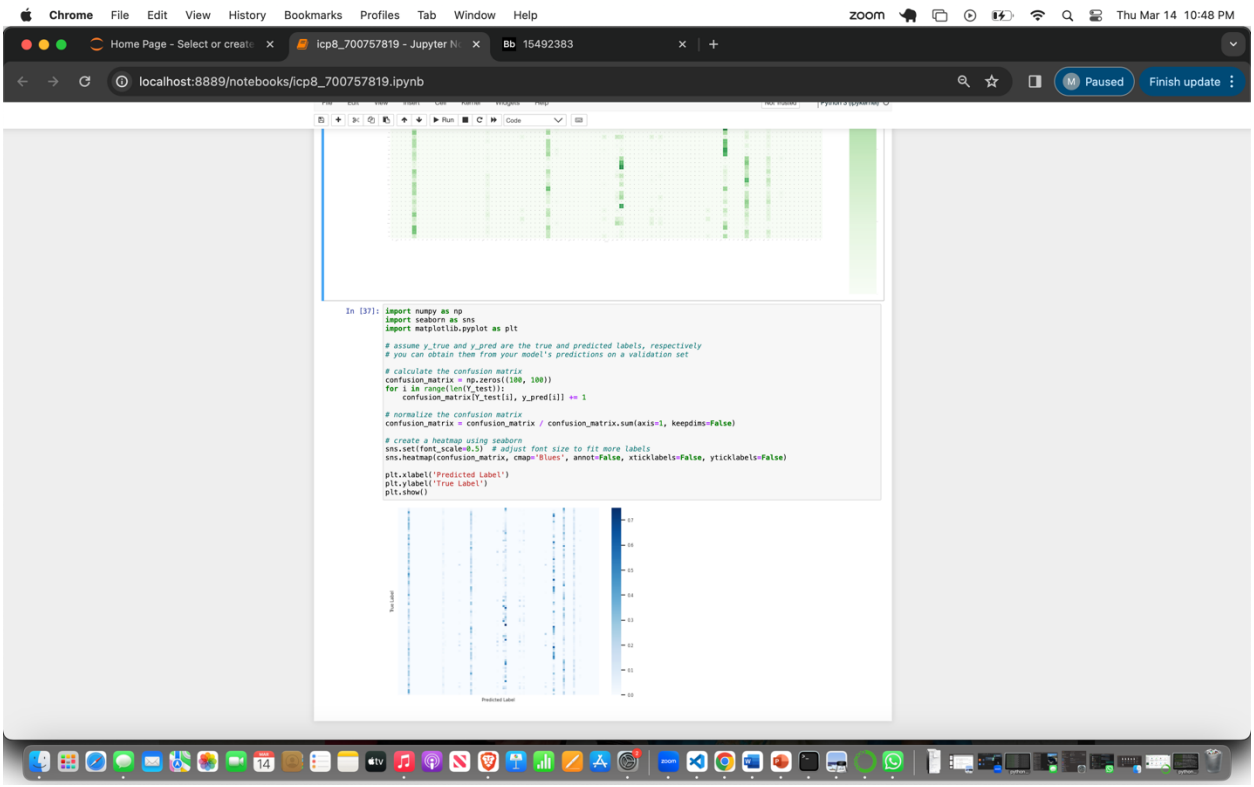
```
Testing Accuracy :  0.0303
```



```
In [19]: X_test = tf.keras.applications.vgg19.preprocess_input(X_test)
         y_pred = np.argmax(model.predict(X_test), axis=1)

         y_pred[:10]

         313/313 [==============================] - 3s 9ms/step

Out[19]: array([53, 77, 36,  5, 87, 77, 77, 77, 52, 82])

In [20]: from sklearn.metrics import confusion_matrix, accuracy_score
         print('Testing Accuarcy : ', accuracy_score(Y_test, y_pred))

         Testing Accuarcy :  0.0303

In [21]: cm = confusion_matrix(Y_test, y_pred)
         cm

Out[21]: array([[[0, 0, 0, ..., 0, 0, 0],
                 [0, 0, 0, ..., 0, 0, 0],
                 [0, 0, 0, ..., 0, 0, 0],
                 ...,
                 [0, 0, 0, ..., 0, 0, 0],
                 [0, 0, 0, ..., 0, 0, 0],
                 [0, 0, 0, ..., 0, 0, 0]]])

In [30]: import itertools
         def plot_confusion_matrix(cm, classes,
                                   normalize=True,
                                   title='Confusion matrix',
                                   cmap=plt.cm.Greens):
             """
             This function prints and plots the confusion matrix.
             Normalization can be applied by setting `normalize=True`.
             """
             plt.imshow(cm, interpolation='nearest', cmap=cmap)
             plt.title(title)
             plt.colorbar()
             tick_marks = np.arange(len(classes))
             plt.xticks(tick_marks, classes, rotation=30)
             plt.yticks(tick_marks, classes)

             if normalize:
                 cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
                 print("Normalized confusion matrix")
             else:
                 print('Confusion matrix, without normalization')

             #print(cm)

             thresh = cm.max() / 2.
             for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
                 plt.text(j, i, cm[i, j],
                     horizontalalignment="center",
                     color="white" if cm[i, j] > thresh else "black")

             plt.tight_layout()
             plt.ylabel('True label')
             plt.xlabel('Predicted label')
```



```
In [35]: plt.figure(figsize=(100,100))
         plot_confusion_matrix(cm,classes)

         Normalized confusion matrix
```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In [37]:
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
# assume y_true and y_pred are the true and predicted labels, respectively
# you can obtain them from your model's predictions on a validation set
# calculate the confusion matrix
confusion_matrix = np.zeros((100, 100))
for i in range(len(Y_test)):
confusion_matrix[Y_test[i], y_pred[i]] += 1
# normalize the confusion matrix
confusion_matrix = confusion_matrix / confusion_matrix.sum(axis=1, keepdims=False)
# create a heatmap using seaborn
sns.set(font_scale=0.5) # adjust font size to fit more labels
sns.heatmap(confusion_matrix, cmap='Blues', annot=False, xticklabels=False, yticklabels=False)
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
True Label
Predicted Label