In [2]:
```
###Assignment 6
#DSC650  4/23/2023
#Shaquiel Pashtunyar
```

Assignment 6

Using section 5.1 in Deep Learning with Python as a guide (listing 5.3 in particular), create a ConvNet model that classifies images in the MNIST digit dataset. Save the model, predictions, metrics, and validation plots in the dsc650/assignments/assignment06/results directory. If you are using JupyterHub, you can include those plots in your Jupyter notebook.

In [5]:
```
#Importing
```

In [49]:
```
from keras import layers
from keras import models
from keras.datasets import mnist
from keras.utils import to_categorical
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import os
import pandas as pd
```

In [12]:
```
#Minst imported
```

In [13]:
```
# calling a model
model = models.Sequential()
model.add(layers.Conv2D(32, (3,3), activation='relu', input_shape=(28, 28, 1)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(64, (3,3), activation='relu'))
model.add(layers.MaxPooling2D((2,2)))
model.add(layers.Conv2D(64, (3,3), activation='relu'))

# add a classifier on top of Convnet
model.add(layers.Flatten())
model.add(layers.Dense(64, activation='relu'))
model.add(layers.Dense(10, activation = 'softmax'))

# view summary
model.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
 Layer (type)                 Output Shape              Param #
=================================================================
 conv2d_3 (Conv2D)            (None, 26, 26, 32)        320

 max_pooling2d_2 (MaxPooling  (None, 13, 13, 32)       0
 2D)

 conv2d_4 (Conv2D)            (None, 11, 11, 64)        18496

 max_pooling2d_3 (MaxPooling  (None, 5, 5, 64)         0
 2D)

 conv2d_5 (Conv2D)            (None, 3, 3, 64)          36928

 flatten_1 (Flatten)          (None, 576)               0

 dense_2 (Dense)              (None, 64)                36928

 dense_3 (Dense)              (None, 10)                650

=================================================================
Total params: 93,322
Trainable params: 93,322
Non-trainable params: 0
_________________________________________________________________
```

In [14]:
```
#Splitting the data into training and target
```

In [15]:
```
(train_images, train_labels), (test_images, test_labels) = mnist.load_data()

train_images = train_images.reshape((60000, 28, 28, 1))
train_images = train_images.astype('float32') / 255

test_images = test_images.reshape((10000, 28, 28, 1))
test_images = test_images.astype('float32') / 255

train_labels = to_categorical(train_labels)
test_labels = to_categorical(test_labels)
```

In [16]:
```
# shuffle training set
for _ in range(5):
    indexes = np.random.permutation(len(train_images))

train_images = train_images[indexes]
train_labels = train_labels[indexes]

# put 10,000 aside for validation
val_images = train_images[:10000,:]
val_labels = train_labels[:10000,:]

# keep the rest in training set
train_images2 = train_images[10000:,:]
train_labels2 = train_labels[10000:,:]

# view their shape
train_images2.shape, val_images.shape
```

Out[16]:
```
((50000, 28, 28, 1), (10000, 28, 28, 1))
```

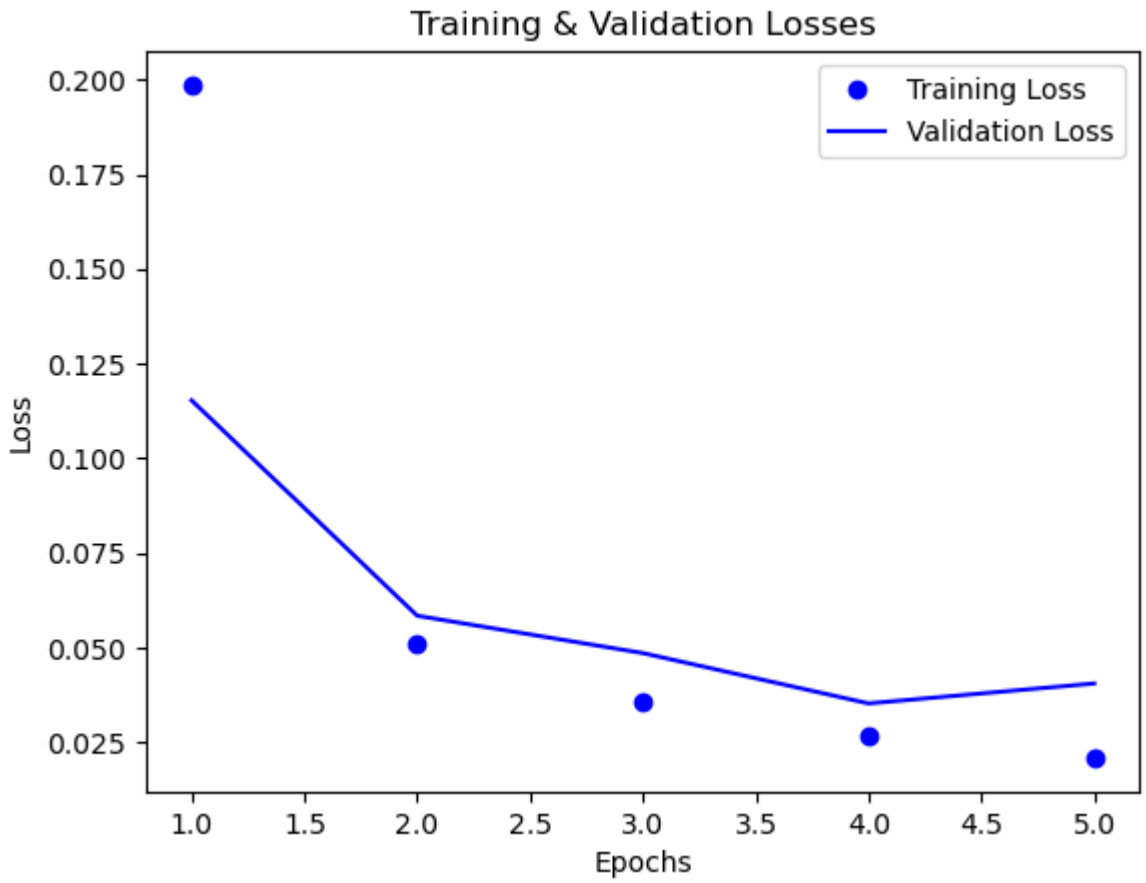
In [18]:
```
#model compiling

model.compile(optimizer='rmsprop',
              loss='categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(train_images2, train_labels2, epochs=5, batch_size=64,
                    validation_data = (val_images, val_labels))
```

```
Epoch 1/5
782/782 [==============================] - 18s 22ms/step - loss: 0.1986 - accuracy:
0.9387 - val_loss: 0.1153 - val_accuracy: 0.9655
Epoch 2/5
782/782 [==============================] - 17s 22ms/step - loss: 0.0510 - accuracy:
0.9840 - val_loss: 0.0584 - val_accuracy: 0.9830
Epoch 3/5
782/782 [==============================] - 20s 26ms/step - loss: 0.0356 - accuracy:
0.9891 - val_loss: 0.0485 - val_accuracy: 0.9852
Epoch 4/5
782/782 [==============================] - 19s 24ms/step - loss: 0.0268 - accuracy:
0.9920 - val_loss: 0.0352 - val_accuracy: 0.9888
Epoch 5/5
782/782 [==============================] - 21s 26ms/step - loss: 0.0209 - accuracy:
0.9935 - val_loss: 0.0405 - val_accuracy: 0.9877
```

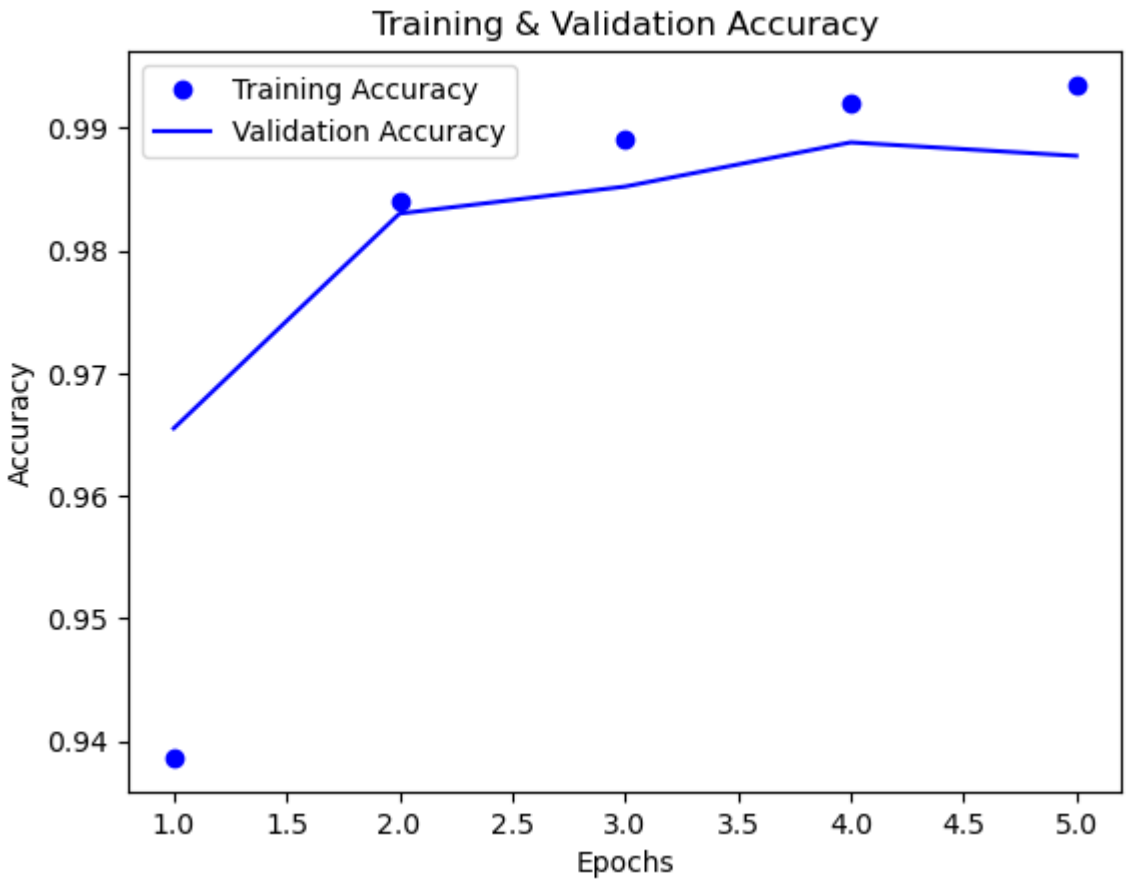
In [20]:
```
#file path needed for download
os.getcwd()
```

Out[20]:
```
'C:\\Users\\spashtunyar\\Documents\\School\\dsc650\\dsc650\\assignments\\assignment0
6'
```

In [37]:
```
train_loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(history.history['loss']) + 1)

plt.plot(epochs, train_loss, 'bo', label = 'Training Loss')
plt.plot(epochs, val_loss, 'b', label = 'Validation Loss')
plt.title('Training & Validation Losses')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.savefig(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignme
plt.show()
```



In [36]:
```
#Accuracy
train_acc = history.history['accuracy']
val_acc = history.history['val_accuracy']

epcohs = range(1, len(history.history['accuracy']) + 1)

plt.plot(epochs, train_acc, 'bo', label = 'Training Accuracy')
plt.plot(epochs, val_acc, 'b', label = 'Validation Accuracy')
plt.title('Training & Validation Accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.savefig(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignme
plt.show()
```



In [39]:
```
# retrain model & evaluate for 3 epochs
model.compile(optimizer='rmsprop',
              loss='categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(train_images, train_labels, epochs = 3, batch_size = 64)
results = model.evaluate(test_images, test_labels)
```

```
Epoch 1/3
938/938 [==============================] - 25s 25ms/step - loss: 0.0116 - accuracy:
0.9965
Epoch 2/3
938/938 [==============================] - 25s 26ms/step - loss: 0.0092 - accuracy:
0.9973
Epoch 3/3
938/938 [==============================] - 25s 26ms/step - loss: 0.0076 - accuracy:
0.9980
313/313 [==============================] - 2s 5ms/step - loss: 0.0435 - accuracy: 0.9
911
```

In [40]:
```
results
```

Out[40]:
```
[0.043479882180690765, 0.991100013256073]
```

In [42]:
```
#Loss and accuracy
history.history
```

Out[42]:
```
{'loss': [0.011624673381447792, 0.009243286214768887, 0.007589162793010473],
 'accuracy': [0.9964666962623596, 0.9973499774932861, 0.9979833364486694]}
```

In [43]:
```
model.save(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignmer
```

In [44]:
```
prediction_results = model.predict(test_images)
```

```
313/313 [==============================] - 2s 5ms/step
```

In [45]:
```
prediction_results
```

Out[45]:
```
array([[8.4818215e-13, 1.4013637e-12, 7.9418064e-13, ..., 1.0000000e+00,
        7.1448720e-14, 8.8554679e-13],
       [1.0670370e-12, 3.0961589e-13, 1.0000000e+00, ..., 6.2001581e-20,
        6.3564592e-16, 4.9383507e-21],
       [3.2855095e-15, 1.0000000e+00, 1.3975719e-14, ..., 2.2907494e-10,
        2.7650401e-12, 3.6749812e-15],
       ...,
       [1.0209669e-26, 6.3787823e-16, 4.9082052e-22, ..., 2.7280451e-16,
        3.5719909e-18, 1.6070612e-15],
       [2.5390151e-14, 3.2301263e-19, 7.8710421e-22, ..., 3.7945682e-18,
        2.5481697e-07, 1.1942707e-15],
       [2.1948858e-13, 5.9157579e-20, 4.1198930e-18, ..., 8.3996679e-24,
        2.9717780e-16, 5.2695157e-21]], dtype=float32)
```

In [46]:
```
with open(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignment
    f.write('Training Loss: {}'.format(str(history.history['loss'])))
    f.write('\nTraining Accuracy: {}'.format(str(history.history['accuracy'])))
    f.write('\nTest Loss: {}'.format(results[0]))
    f.write('\nTest Accuracy: {}'.format(results[1]))
```

In [47]:
```
preds = pd.DataFrame(prediction_results,
                     columns = ['0','1','2','3','4','5','6','7','8','9'])

preds.to_csv(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignm
```

Assignment part 2

In [48]:
```
#importing cifar10
from keras.datasets import cifar10
```

In [50]:
```
#Splitting data
(x_train, y_train), (x_test, y_test) = cifar10.load_data()
```

```
Downloading data from https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz
170498071/170498071 [==============================] - 8s 0us/step
```

In [51]:
```
# preprocess data
x_train = x_train.astype('float32') / 255
x_test = x_test.astype('float32') / 255
y_train = to_categorical(y_train)
y_test = to_categorical(y_test)

# put 10,000 aside for validation
x_val = x_train[-10000:]
y_val = y_train[-10000:]
x_train = x_train[:-10000]
y_train = y_train[:-10000]
```

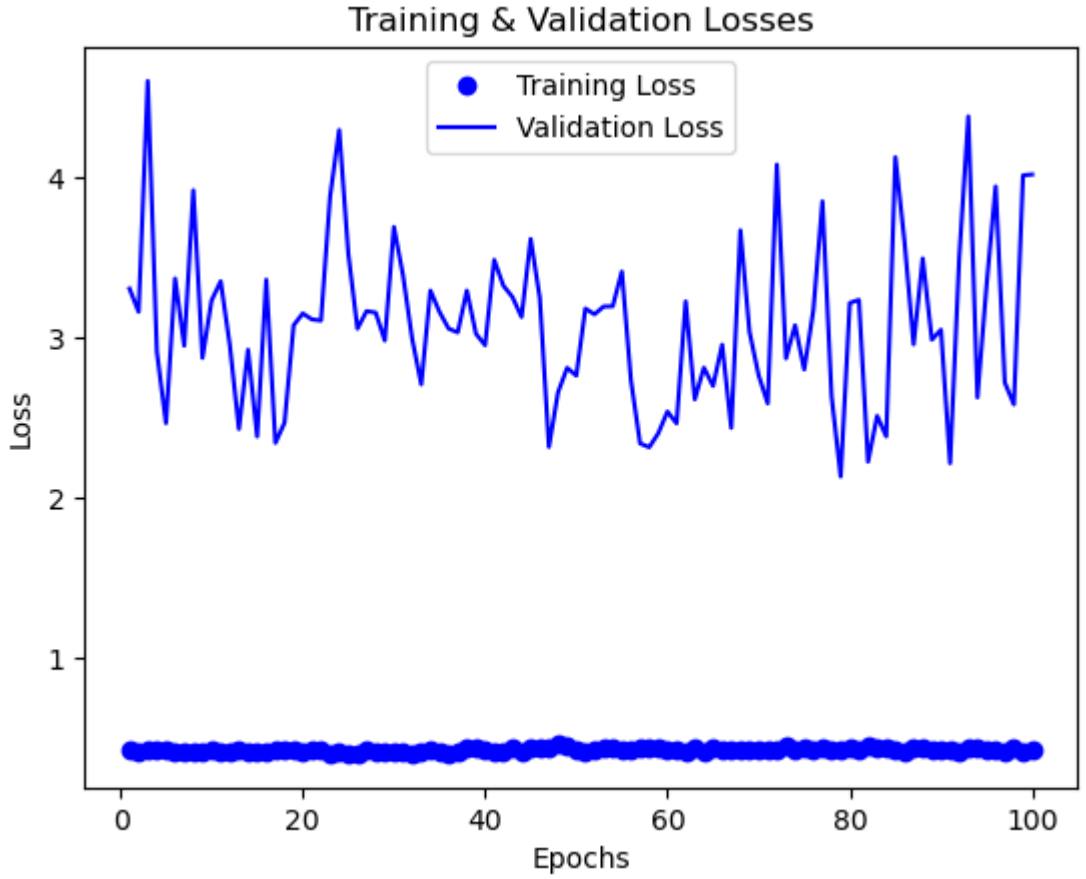
In [52]:
```
# Create the model
model = models.Sequential()
model.add(layers.Conv2D(32, (3,3), activation='relu', input_shape=(32, 32, 3)))
model.add(layers.MaxPooling2D((2, 2)))
model.add(layers.Conv2D(64, (3,3), activation='relu'))
model.add(layers.MaxPooling2D((2,2)))
model.add(layers.Conv2D(64, (3,3), activation='relu'))
model.add(layers.MaxPooling2D((2,2)))
model.add(layers.Flatten())
model.add(layers.Dense(64, activation='relu'))
model.add(layers.Dense(10, activation = 'softmax'))

# view summary
model.summary()
```

```
Model: "sequential_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d_6 (Conv2D)           (None, 30, 30, 32)        896

 max_pooling2d_4 (MaxPooling  (None, 15, 15, 32)       0
 2D)

 conv2d_7 (Conv2D)           (None, 13, 13, 64)        18496

 max_pooling2d_5 (MaxPooling  (None, 6, 6, 64)         0
 2D)

 conv2d_8 (Conv2D)           (None, 4, 4, 64)          36928

 max_pooling2d_6 (MaxPooling  (None, 2, 2, 64)         0
 2D)

 flatten_2 (Flatten)         (None, 256)               0

 dense_4 (Dense)             (None, 64)                16448

 dense_5 (Dense)             (None, 10)                650

=================================================================
Total params: 73,418
Trainable params: 73,418
Non-trainable params: 0
_________________________________________________________________
```

In [54]:
```
model.compile(optimizer='rmsprop',
              loss='categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(x_train, y_train, epochs=100,
                    validation_data = (x_val, y_val), verbose=0)
```

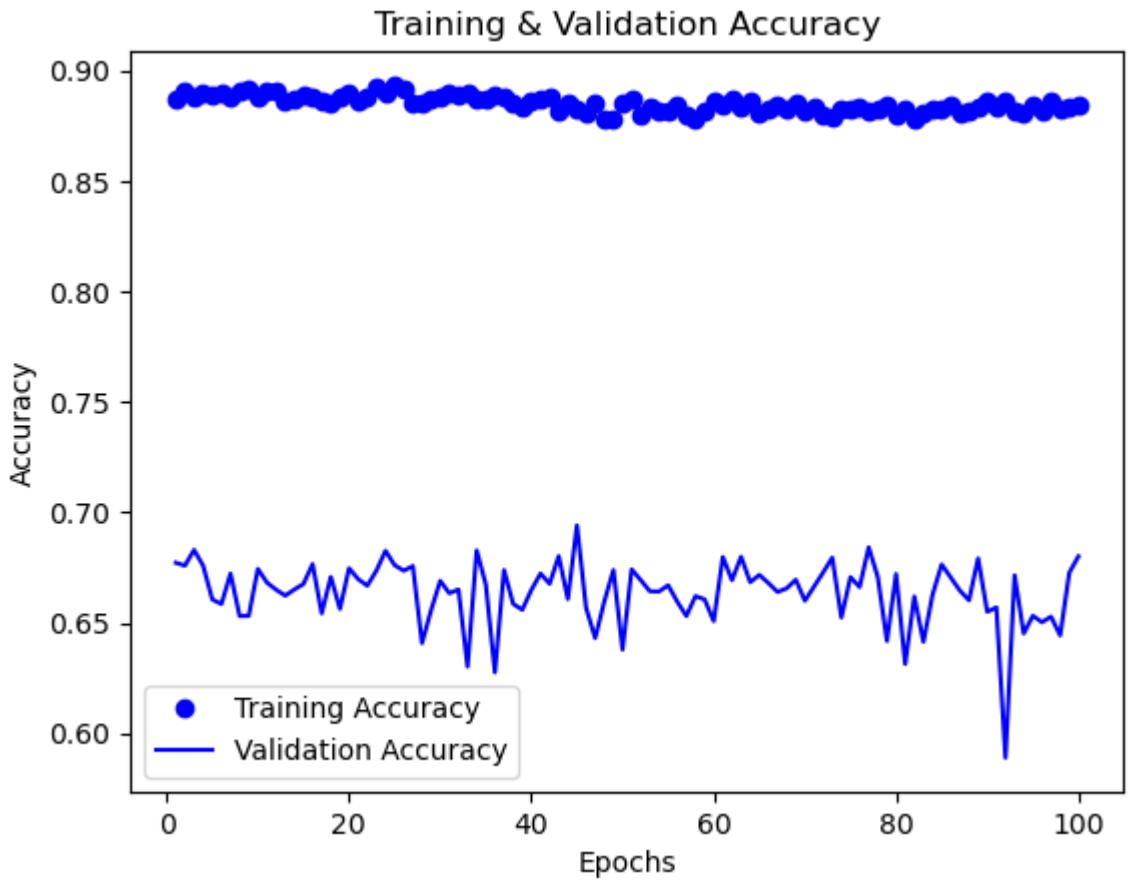
In [55]:
```
train_loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(history.history['loss']) + 1)

plt.plot(epochs, train_loss, 'bo', label = 'Training Loss')
```

```
plt.plot(epochs, val_loss, 'b', label = 'Validation Loss')
plt.title('Training & Validation Losses')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.savefig(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignme
plt.show()
```



In [56]:

```
train_acc = history.history['accuracy']
val_acc = history.history['val_accuracy']
epcohs = range(1, len(history.history['accuracy']) + 1)
plt.plot(epochs, train_acc, 'bo', label = 'Training Accuracy')
plt.plot(epochs, val_acc, 'b', label = 'Validation Accuracy')
plt.title('Training & Validation Accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.savefig(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignme
plt.show()
```



In [57]:
```
# retrain model & evaluate
(x_train, y_train), (x_test, y_test) = cifar10.load_data()

# preprocess data
x_train = x_train.astype('float32') / 255
x_test = x_test.astype('float32') / 255
y_train = to_categorical(y_train)
y_test = to_categorical(y_test)

model.compile(optimizer='rmsprop',
              loss='categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit(x_train, y_train, epochs=10)
results = model.evaluate(x_test, y_test)
```

```
Epoch 1/10
1563/1563 [==============================] - 39s 24ms/step - loss: 0.8312 - accuracy:
0.7800
Epoch 2/10
1563/1563 [==============================] - 37s 24ms/step - loss: 0.7477 - accuracy:
0.7891
Epoch 3/10
1563/1563 [==============================] - 40s 26ms/step - loss: 0.7026 - accuracy:
0.7936
Epoch 4/10
1563/1563 [==============================] - 47s 30ms/step - loss: 0.6806 - accuracy:
0.7970
Epoch 5/10
1563/1563 [==============================] - 42s 27ms/step - loss: 0.6500 - accuracy:
0.8025
Epoch 6/10
1563/1563 [==============================] - 44s 28ms/step - loss: 0.6398 - accuracy:
0.8050
Epoch 7/10
1563/1563 [==============================] - 41s 26ms/step - loss: 0.6412 - accuracy:
0.8010
Epoch 8/10
1563/1563 [==============================] - 39s 25ms/step - loss: 0.6225 - accuracy:
0.8078
Epoch 9/10
1563/1563 [==============================] - 39s 25ms/step - loss: 0.6123 - accuracy:
0.8088
Epoch 10/10
1563/1563 [==============================] - 37s 24ms/step - loss: 0.6165 - accuracy:
0.8118
313/313 [==============================] - 3s 8ms/step - loss: 1.2173 - accuracy: 0.6
453
```

In [59]:
```
model.save(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignmer
```

In [60]:
```
prediction_results = model.predict(x_test)
```

```
313/313 [==============================] - 3s 8ms/step
```

In [61]:
```
prediction_results
```

Out[61]:
```
array([[4.21460310e-04, 1.52559573e-04, 2.89890799e-03, ...,
        1.02881808e-04, 2.96914834e-03, 1.25233841e-04],
       [6.28627837e-04, 3.70398047e-04, 3.56287654e-16, ...,
        1.48146096e-14, 9.99000967e-01, 1.30031585e-08],
       [5.94272576e-02, 1.90348569e-02, 2.61096051e-04, ...,
        8.35009923e-05, 9.08882439e-01, 8.88891425e-03],
       ...,
       [3.65121878e-07, 4.80077063e-08, 3.01973009e-03, ...,
        1.10382631e-01, 4.64879292e-07, 1.73881290e-05],
       [9.73920669e-06, 3.36405193e-03, 1.74554007e-03, ...,
        7.68269529e-04, 3.40715123e-09, 3.31380056e-06],
       [4.94112008e-11, 1.59739350e-18, 7.89580952e-08, ...,
        9.99655366e-01, 5.83787319e-19, 4.79023188e-18]], dtype=float32)
```

In [62]:
```
#Writing results in text file
with open(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignment
    f.write('Training Loss: {}'.format(str(history.history['loss'])))
    f.write('\nTraining Accuracy: {}'.format(str(history.history['accuracy'])))
```

```
    f.write('\nTest Loss: {}'.format(results[0]))
    f.write('\nTest Accuracy: {}'.format(results[1]))
```

In [63]:
```
preds = pd.DataFrame(prediction_results,
                     columns = ['0','1','2','3','4','5','6','7','8','9'])

preds.to_csv(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignm
```

In [1]:
```
#Part 2 B
```

In [2]:
```
from keras.datasets import cifar10
from keras.utils import to_categorical
from keras.preprocessing.image import ImageDataGenerator
import pandas as pd
import matplotlib.pyplot as plt
```

In [3]:
```
(x_train, y_train), (x_test, y_test) = cifar10.load_data()
```

In [5]:
```
x_train.shape, y_train.shape
```

Out[5]:
```
((50000, 32, 32, 3), (50000, 1))
```

In [6]:
```
# preprocess data
x_train = x_train.astype('float32')
x_test = x_test.astype('float32')
y_train = to_categorical(y_train)
y_test = to_categorical(y_test)

# put 10,000 aside for validation
x_val = x_train[-10000:]
y_val = y_train[-10000:]
x_train2 = x_train[:-10000]
y_train2 = y_train[:-10000]
```

In [7]:
```
train_datagen = ImageDataGenerator(rescale=1./255,
                                   rotation_range=40,
                                   width_shift_range=0.2,
                                   height_shift_range=0.2,
                                   shear_range=0.2,
                                   zoom_range=0.2,
                                   horizontal_flip=True)

test_datagen = ImageDataGenerator(rescale=1./255)

train_generator = train_datagen.flow(x_train2, y_train2, batch_size=32)

validation_generator = train_datagen.flow(x_val, y_val, batch_size=32)
```

In [8]:
```
from keras import models
from keras import layers
```

In [9]:
```
# instantiate the model
# add dropout layer
model = models.Sequential()
model.add(layers.Conv2D(32, (3,3), activation='relu', input_shape=(32, 32, 3)))
model.add(layers.MaxPooling2D((2, 2)))
```

```
model.add(layers.Conv2D(64, (3,3), activation='relu'))
model.add(layers.MaxPooling2D((2,2)))
model.add(layers.Conv2D(64, (3,3), activation='relu'))
model.add(layers.MaxPooling2D((2,2)))
model.add(layers.Flatten())
model.add(layers.Dropout(0.5))
model.add(layers.Dense(64, activation='relu'))
model.add(layers.Dense(10, activation = 'softmax'))

# view summary
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 30, 30, 32)        896

 max_pooling2d (MaxPooling2D  (None, 15, 15, 32)       0
 )

 conv2d_1 (Conv2D)           (None, 13, 13, 64)        18496

 max_pooling2d_1 (MaxPooling  (None, 6, 6, 64)         0
 2D)

 conv2d_2 (Conv2D)           (None, 4, 4, 64)          36928

 max_pooling2d_2 (MaxPooling  (None, 2, 2, 64)         0
 2D)

 flatten (Flatten)           (None, 256)               0

 dropout (Dropout)           (None, 256)               0

 dense (Dense)               (None, 64)                16448

 dense_1 (Dense)             (None, 10)                650

=================================================================
Total params: 73,418
Trainable params: 73,418
Non-trainable params: 0
_________________________________________________________________
```

In [11]:
```
from keras import optimizers
```

In [12]:
```
model.compile(optimizer=optimizers.RMSprop(lr=1e-4),
              loss='categorical_crossentropy',
              metrics=['accuracy'])
```

```
C:\Users\spashtunyar\Anaconda3\lib\site-packages\keras\optimizers\optimizer_v2\rmspro
p.py:140: UserWarning: The `lr` argument is deprecated, use `learning_rate` instead.
  super().__init__(name, **kwargs)
```

In [13]:
```
history = model.fit_generator(train_generator,
                              steps_per_epoch=len(x_train2) / 32,
                              epochs = 30,
                              validation_data=validation_generator,
                              validation_steps=len(x_val) / 32)
```

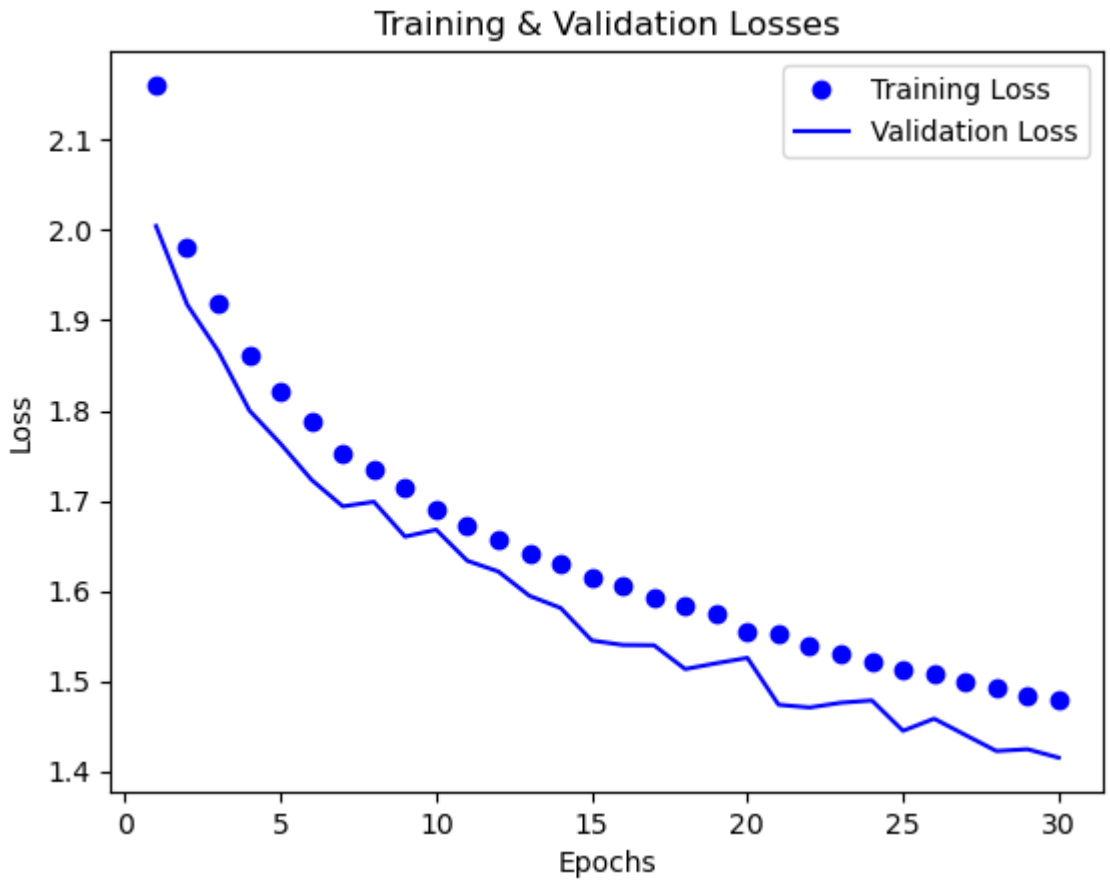
```
C:\Users\spashtunyar\AppData\Local\Temp\ipykernel_17548\7325378.py:1: UserWarning: `M
odel.fit_generator` is deprecated and will be removed in a future version. Please use
`Model.fit`, which supports generators.
  history = model.fit_generator(train_generator,
```

```
Epoch 1/30
1250/1250 [==============================] - 120s 94ms/step - loss: 2.1608 - accurac
y: 0.1845 - val_loss: 2.0044 - val_accuracy: 0.2605
Epoch 2/30
1250/1250 [==============================] - 93s 74ms/step - loss: 1.9819 - accuracy:
0.2599 - val_loss: 1.9174 - val_accuracy: 0.2897
Epoch 3/30
1250/1250 [==============================] - 68s 54ms/step - loss: 1.9184 - accuracy:
0.2846 - val_loss: 1.8656 - val_accuracy: 0.3120
Epoch 4/30
1250/1250 [==============================] - 65s 52ms/step - loss: 1.8616 - accuracy:
0.3105 - val_loss: 1.8000 - val_accuracy: 0.3407
Epoch 5/30
1250/1250 [==============================] - 57s 45ms/step - loss: 1.8219 - accuracy:
0.3250 - val_loss: 1.7632 - val_accuracy: 0.3502
Epoch 6/30
1250/1250 [==============================] - 52s 42ms/step - loss: 1.7886 - accuracy:
0.3350 - val_loss: 1.7230 - val_accuracy: 0.3763
Epoch 7/30
1250/1250 [==============================] - 51s 41ms/step - loss: 1.7531 - accuracy:
0.3530 - val_loss: 1.6938 - val_accuracy: 0.3790
Epoch 8/30
1250/1250 [==============================] - 54s 43ms/step - loss: 1.7335 - accuracy:
0.3632 - val_loss: 1.6988 - val_accuracy: 0.3836
Epoch 9/30
1250/1250 [==============================] - 52s 41ms/step - loss: 1.7138 - accuracy:
0.3702 - val_loss: 1.6602 - val_accuracy: 0.4011
Epoch 10/30
1250/1250 [==============================] - 51s 41ms/step - loss: 1.6899 - accuracy:
0.3823 - val_loss: 1.6678 - val_accuracy: 0.3956
Epoch 11/30
1250/1250 [==============================] - 50s 40ms/step - loss: 1.6726 - accuracy:
0.3854 - val_loss: 1.6334 - val_accuracy: 0.4088
Epoch 12/30
1250/1250 [==============================] - 51s 40ms/step - loss: 1.6576 - accuracy:
0.3959 - val_loss: 1.6215 - val_accuracy: 0.4082
Epoch 13/30
1250/1250 [==============================] - 51s 40ms/step - loss: 1.6406 - accuracy:
0.3982 - val_loss: 1.5945 - val_accuracy: 0.4242
Epoch 14/30
1250/1250 [==============================] - 51s 41ms/step - loss: 1.6312 - accuracy:
0.4073 - val_loss: 1.5811 - val_accuracy: 0.4315
Epoch 15/30
1250/1250 [==============================] - 50s 40ms/step - loss: 1.6145 - accuracy:
0.4147 - val_loss: 1.5450 - val_accuracy: 0.4426
Epoch 16/30
1250/1250 [==============================] - 51s 40ms/step - loss: 1.6048 - accuracy:
0.4162 - val_loss: 1.5401 - val_accuracy: 0.4425
Epoch 17/30
1250/1250 [==============================] - 50s 40ms/step - loss: 1.5919 - accuracy:
0.4244 - val_loss: 1.5398 - val_accuracy: 0.4463
Epoch 18/30
1250/1250 [==============================] - 51s 41ms/step - loss: 1.5847 - accuracy:
0.4245 - val_loss: 1.5134 - val_accuracy: 0.4678
Epoch 19/30
1250/1250 [==============================] - 50s 40ms/step - loss: 1.5737 - accuracy:
0.4310 - val_loss: 1.5199 - val_accuracy: 0.4492
Epoch 20/30
1250/1250 [==============================] - 50s 40ms/step - loss: 1.5555 - accuracy:
0.4404 - val_loss: 1.5258 - val_accuracy: 0.4523
```

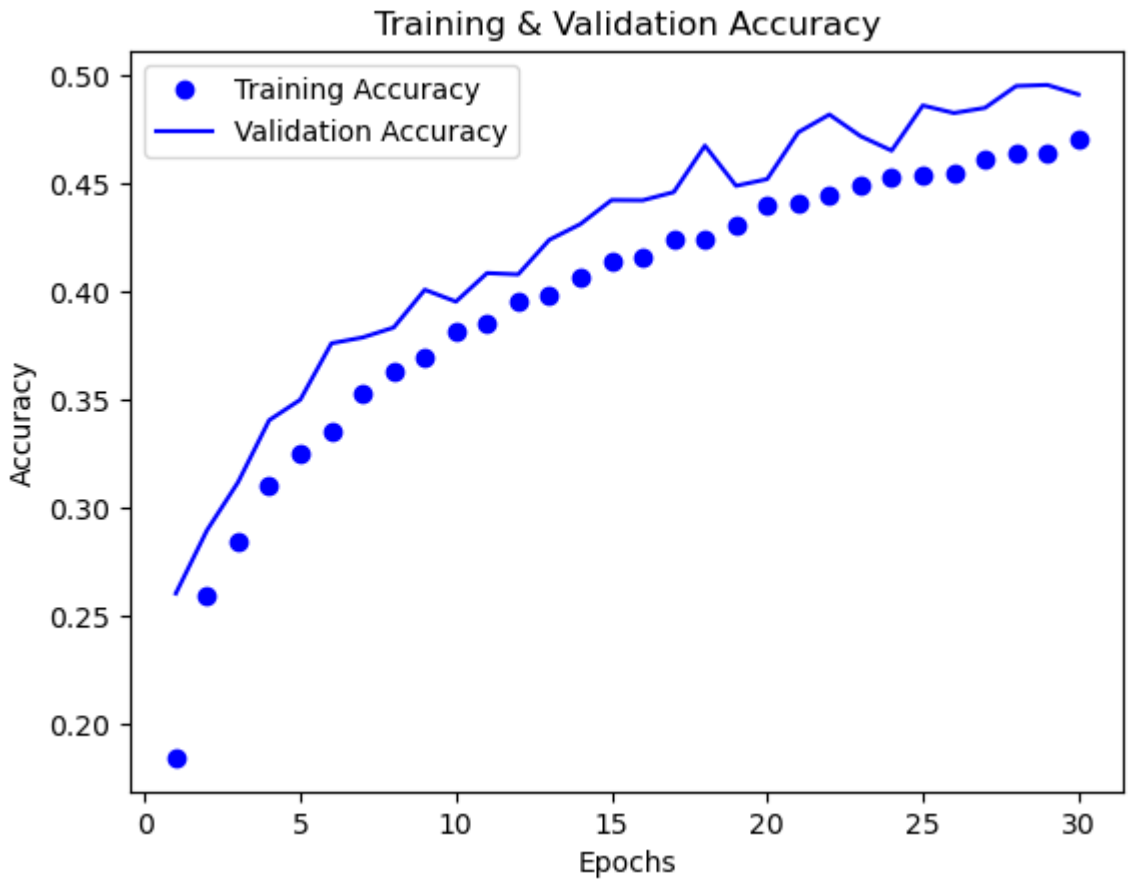
```
Epoch 21/30
1250/1250 [==============================] - 52s 42ms/step - loss: 1.5516 - accuracy:
0.4408 - val_loss: 1.4739 - val_accuracy: 0.4740
Epoch 22/30
1250/1250 [==============================] - 51s 41ms/step - loss: 1.5387 - accuracy:
0.4451 - val_loss: 1.4708 - val_accuracy: 0.4822
Epoch 23/30
1250/1250 [==============================] - 50s 40ms/step - loss: 1.5315 - accuracy:
0.4492 - val_loss: 1.4761 - val_accuracy: 0.4722
Epoch 24/30
1250/1250 [==============================] - 51s 41ms/step - loss: 1.5206 - accuracy:
0.4529 - val_loss: 1.4786 - val_accuracy: 0.4655
Epoch 25/30
1250/1250 [==============================] - 50s 40ms/step - loss: 1.5118 - accuracy:
0.4539 - val_loss: 1.4450 - val_accuracy: 0.4864
Epoch 26/30
1250/1250 [==============================] - 52s 41ms/step - loss: 1.5075 - accuracy:
0.4549 - val_loss: 1.4584 - val_accuracy: 0.4829
Epoch 27/30
1250/1250 [==============================] - 52s 41ms/step - loss: 1.5004 - accuracy:
0.4611 - val_loss: 1.4404 - val_accuracy: 0.4853
Epoch 28/30
1250/1250 [==============================] - 51s 41ms/step - loss: 1.4937 - accuracy:
0.4640 - val_loss: 1.4226 - val_accuracy: 0.4954
Epoch 29/30
1250/1250 [==============================] - 50s 40ms/step - loss: 1.4840 - accuracy:
0.4648 - val_loss: 1.4246 - val_accuracy: 0.4959
Epoch 30/30
1250/1250 [==============================] - 51s 41ms/step - loss: 1.4802 - accuracy:
0.4709 - val_loss: 1.4152 - val_accuracy: 0.4915
```

In [16]:

```
train_loss = history.history['loss']
val_loss = history.history['val_loss']

epochs = range(1, len(history.history['loss']) + 1)

plt.plot(epochs, train_loss, 'bo', label = 'Training Loss')
plt.plot(epochs, val_loss, 'b', label = 'Validation Loss')
plt.title('Training & Validation Losses')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.savefig(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignme
plt.show()
```



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

epcohs = range(1, len(history.history['accuracy']) + 1)

plt.plot(epochs, train_acc, 'bo', label = 'Training Accuracy')
plt.plot(epochs, val_acc, 'b', label = 'Validation Accuracy')
plt.title('Training & Validation Accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()
plt.savefig(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignme
plt.show()
```



In [18]:
```
# retrain model & evaluate
train_generator = train_datagen.flow(x_train, y_train, batch_size=32)

model.compile(optimizer=optimizers.RMSprop(lr=1e-4),
              loss='categorical_crossentropy',
              metrics=['accuracy'])

history = model.fit_generator(train_generator,
                              steps_per_epoch=len(x_train) / 32,
                              epochs = 16)

results = model.evaluate(x_test, y_test)
```

```
Epoch 1/16
C:\Users\spashtunyar\AppData\Local\Temp\ipykernel_17548\740027706.py:8: UserWarning:
`Model.fit_generator` is deprecated and will be removed in a future version. Please u
se `Model.fit`, which supports generators.
  history = model.fit_generator(train_generator,
```

```
1562/1562 [==============================] - 40s 25ms/step - loss: 1.4771 - accuracy:
0.4714
Epoch 2/16
1562/1562 [==============================] - 44s 28ms/step - loss: 1.4708 - accuracy:
0.4739
Epoch 3/16
1562/1562 [==============================] - 47s 30ms/step - loss: 1.4596 - accuracy:
0.4778
Epoch 4/16
1562/1562 [==============================] - 47s 30ms/step - loss: 1.4533 - accuracy:
0.4809
Epoch 5/16
1562/1562 [==============================] - 48s 31ms/step - loss: 1.4405 - accuracy:
0.4825
Epoch 6/16
1562/1562 [==============================] - 51s 33ms/step - loss: 1.4372 - accuracy:
0.4871
Epoch 7/16
1562/1562 [==============================] - 54s 34ms/step - loss: 1.4341 - accuracy:
0.4861
Epoch 8/16
1562/1562 [==============================] - 54s 35ms/step - loss: 1.4223 - accuracy:
0.4940
Epoch 9/16
1562/1562 [==============================] - 55s 35ms/step - loss: 1.4236 - accuracy:
0.4905
Epoch 10/16
1562/1562 [==============================] - 55s 35ms/step - loss: 1.4146 - accuracy:
0.4976
Epoch 11/16
1562/1562 [==============================] - 55s 35ms/step - loss: 1.4116 - accuracy:
0.4969
Epoch 12/16
1562/1562 [==============================] - 57s 36ms/step - loss: 1.4000 - accuracy:
0.4995
Epoch 13/16
1562/1562 [==============================] - 55s 35ms/step - loss: 1.4008 - accuracy:
0.5003
Epoch 14/16
1562/1562 [==============================] - 59s 38ms/step - loss: 1.3937 - accuracy:
0.5051
Epoch 15/16
1562/1562 [==============================] - 88s 56ms/step - loss: 1.3886 - accuracy:
0.5054
Epoch 16/16
1562/1562 [==============================] - 61s 39ms/step - loss: 1.3816 - accuracy:
0.5086
313/313 [==============================] - 3s 9ms/step - loss: 216.5171 - accuracy:
0.3698
```

In [19]:
```
model.save(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignmer
```

In [20]:
```
prediction_results = model.predict(x_test)
```

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

In [21]:
```
prediction_results
```

Out[21]:
```
array([[9.0042595e-13, 0.0000000e+00, 0.0000000e+00, ..., 0.0000000e+00,
        1.0000000e+00, 0.0000000e+00],
       [0.0000000e+00, 1.0000000e+00, 0.0000000e+00, ..., 0.0000000e+00,
        0.0000000e+00, 0.0000000e+00],
       [0.0000000e+00, 1.0000000e+00, 0.0000000e+00, ..., 0.0000000e+00,
        0.0000000e+00, 1.8758386e-21],
       ...,
       [0.0000000e+00, 0.0000000e+00, 0.0000000e+00, ..., 0.0000000e+00,
        0.0000000e+00, 0.0000000e+00],
       [1.2673316e-34, 1.0000000e+00, 0.0000000e+00, ..., 0.0000000e+00,
        0.0000000e+00, 0.0000000e+00],
       [0.0000000e+00, 0.0000000e+00, 0.0000000e+00, ..., 1.0000000e+00,
        0.0000000e+00, 0.0000000e+00]], dtype=float32)
```

In [22]:
```
with open(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignment
    f.write('Training Loss: {}'.format(str(history.history['loss'])))
    f.write('\nTraining Accuracy: {}'.format(str(history.history['accuracy'])))
    f.write('\nTest Loss: {}'.format(results[0]))
    f.write('\nTest Accuracy: {}'.format(results[1]))
```

In [23]:
```
preds = pd.DataFrame(prediction_results,
                     columns = ['0','1','2','3','4','5','6','7','8','9'])

preds.to_csv(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignm
```

Part 3

In [24]:
```
!pip install opencv-python
```

```
Collecting opencv-python
  Downloading opencv_python-4.7.0.72-cp37-abi3-win_amd64.whl (38.2 MB)
     ---------------------------------------- 38.2/38.2 MB 23.4 MB/s eta 0:00:00
Requirement already satisfied: numpy>=1.17.3 in c:\users\spashtunyar\anaconda3\lib\si
te-packages (from opencv-python) (1.23.5)
Installing collected packages: opencv-python
Successfully installed opencv-python-4.7.0.72
```

In [47]:
```
from tensorflow.keras.applications.resnet50 import ResNet50
from tensorflow.keras.preprocessing import image
from tensorflow.keras.applications.resnet50 import preprocess_input, decode_predictior
import numpy as np
import os, cv2
import matplotlib.pyplot as plt
```

In [48]:
```
# Load Model
model = ResNet50(weights = 'imagenet')
```

In [49]:
```
img_path = r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\assignmer
```

In [50]:
```
images = os.listdir(img_path)
```

In [51]:
```
# Get the filename for each image
for i, name in enumerate(images):
    print(name)
```

```
6-1-metrics.txt
6-1-model.h5
6-1-predicitons.csv
6-2A-Accuracy.png
6-2A-Loss.png
6-2A-metrics.txt
6-2A-model.h5
6-2A-predicitons.csv
6-2B-Accuracy.png
6-2B-Loss.png
6-2B-metrics.txt
6-2B-predicitons.csv
6-2B_model.h5
accuracyPNG.png
assignment06PNG.png
image.txt
```

In [54]:
```
# Write the predictions into a file
for i,name in enumerate(images):

    if name != '.ipynb_checkpoints':
        img = cv2.imread(img_path + '/' + name)
        img = cv2.resize(img, (224,224))
        x = image.img_to_array(img)
        x = np.expand_dims(x, axis=0)
        x = preprocess_input(x)

        preds = model.predict(x)

        decpr = name, decode_predictions(preds, top=3)[0]

        print(decpr)

        with open(r'C:\Users\spashtunyar\Documents\School\dsc650\dsc650\assignments\as
            f.write(decpr[0])
    else:
        pass
```

```
---------------------------------------------------------------------------
error                                     Traceback (most recent call last)
Cell In[54], line 6
      4 if name != '.ipynb_checkpoints':
      5     img = cv2.imread(img_path + '/' + name)
----> 6     img = cv2.resize(img, (224,224))
      7     x = image.img_to_array(img)
      8     x = np.expand_dims(x, axis=0)

error: OpenCV(4.7.0) D:\a\opencv-python\opencv-python\opencv\modules\imgproc\src\resi
ze.cpp:4062: error: (-215:Assertion failed) !ssize.empty() in function 'cv::resize'
```

In [55]:
```
#unsure here
```

In [ ]: