# LewisRebecca_Assignment_6.1

January 24, 2021

## 1 Assignment 6.1

### 1.1 convnet model on MNIST dataset

#### 1.1.1 Rebecca Lewis

[1]:
```
from keras import layers
from keras import models

#initiate a small convnet

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 clasifier on top of the convnet
model.add(layers.Flatten())
model.add(layers.Dense(64, activation='relu'))
model.add(layers.Dense(10, activation='softmax'))

model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 26, 26, 32)        320
_________________________________________________________________
max_pooling2d (MaxPooling2D) (None, 13, 13, 32)        0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 11, 11, 64)        18496
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 5, 5, 64)          0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 3, 3, 64)          36928
_________________________________________________________________
```

```
flatten (Flatten)            (None, 576)               0
_________________________________________________________________
dense (Dense)                (None, 64)                36928
_________________________________________________________________
dense_1 (Dense)              (None, 10)                650
=================================================================
Total params: 93,322
Trainable params: 93,322
Non-trainable params: 0
_________________________________________________________________
```

[2]:
```
#training the convnet on MNIST images
from keras.datasets import mnist
from keras.utils import to_categorical
import numpy as np

(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)

#shuffle the training set
for _ in range(5):
    indexes = np.random.permutation(len(train_images))

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

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

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

train_images2.shape, val_images.shape
```

[2]:
```
((50000, 28, 28, 1), (10000, 28, 28, 1))
```

[3]:
```
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 [==============================] - 12s 15ms/step - loss: 0.1971 -
accuracy: 0.9378 - val_loss: 0.0859 - val_accuracy: 0.9745
Epoch 2/5
782/782 [==============================] - 13s 16ms/step - loss: 0.0529 -
accuracy: 0.9836 - val_loss: 0.0527 - val_accuracy: 0.9844
Epoch 3/5
782/782 [==============================] - 11s 15ms/step - loss: 0.0364 -
accuracy: 0.9887 - val_loss: 0.0498 - val_accuracy: 0.9859
Epoch 4/5
782/782 [==============================] - 11s 15ms/step - loss: 0.0264 -
accuracy: 0.9917 - val_loss: 0.0385 - val_accuracy: 0.9886
Epoch 5/5
782/782 [==============================] - 11s 14ms/step - loss: 0.0216 -
accuracy: 0.9934 - val_loss: 0.0411 - val_accuracy: 0.9889
```

[4]:
```
history.history.keys()
```

[4]:
```
dict_keys(['loss', 'accuracy', 'val_loss', 'val_accuracy'])
```

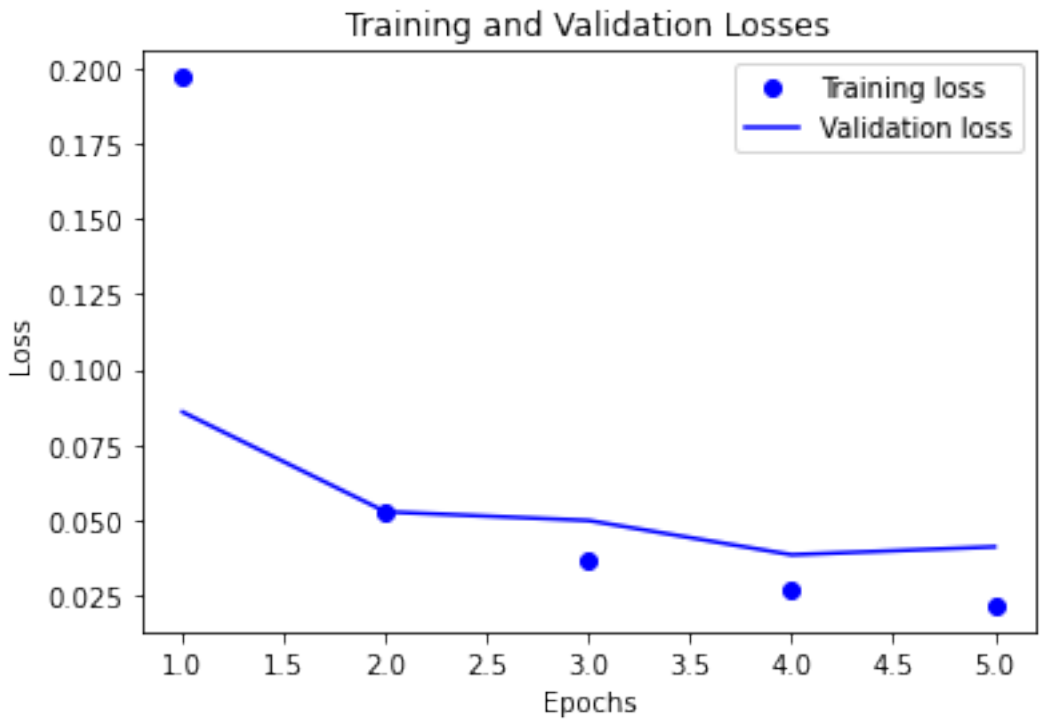
[5]:
```
import matplotlib.pyplot as plt

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 and Validation Losses')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()

plt.show()
plt.savefig('results/lewisrebecca_6_1_lossplot.png')
```

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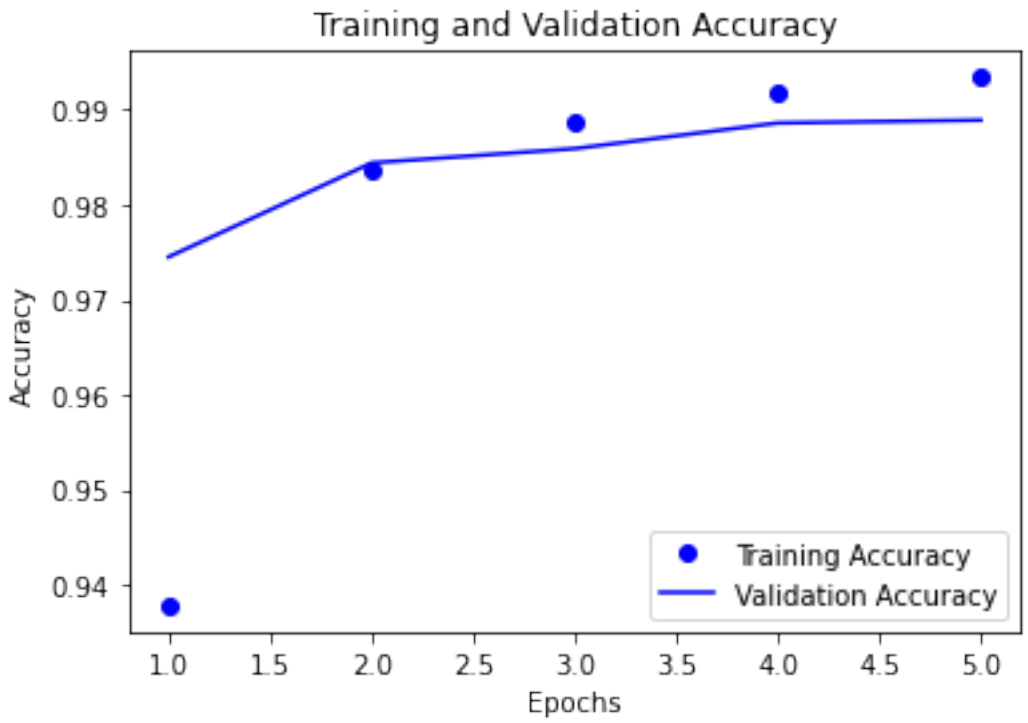
[6]:
```
train_acc = history.history['accuracy']
val_acc = history.history['val_accuracy']

epochs = 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 and Validation Accuracy')
plt.xlabel('Epochs')
plt.ylabel('Accuracy')
plt.legend()

plt.show()
plt.savefig('results/lewisrebecca_6_1_accplot.png')
```




```
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```

[7]:
```
#retrain and 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 [==============================] - 12s 13ms/step - loss: 0.0217 -
accuracy: 0.9934
Epoch 2/3
938/938 [==============================] - 12s 13ms/step - loss: 0.0162 -
accuracy: 0.9952
Epoch 3/3
938/938 [==============================] - 12s 13ms/step - loss: 0.0129 -
accuracy: 0.9962
313/313 [==============================] - 1s 4ms/step - loss: 0.0294 -
accuracy: 0.9915
```

[8]:
```
results
```

[8]:
```
[0.02942630648612976, 0.9915000200271606]
```

[9]:
```
history.history
```

[9]:
```
{'loss': [0.021696971729397774, 0.016194459050893784, 0.012945333495736122],
 'accuracy': [0.9934499859809875, 0.9952333569526672, 0.9962499737739563]}
```

[10]:
```
model.save('results/lewisrebecca_6_1_model.h5')
```

[11]:
```
prediction_results = model.predict(test_images)
```

[12]:
```
#write metrics to file
with open('results/lewisrebecca_6_1_metrics.txt', 'w') as f:
    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]))
```

[13]:
```
import pandas as pd

predictions = pd.DataFrame(prediction_results,␣
 ↪columns=['0','1','2','3','4','5','6','7','8','9'])
predictions.to_csv('results/lewisrebecca_6_1_predictions.csv', index=False)
```