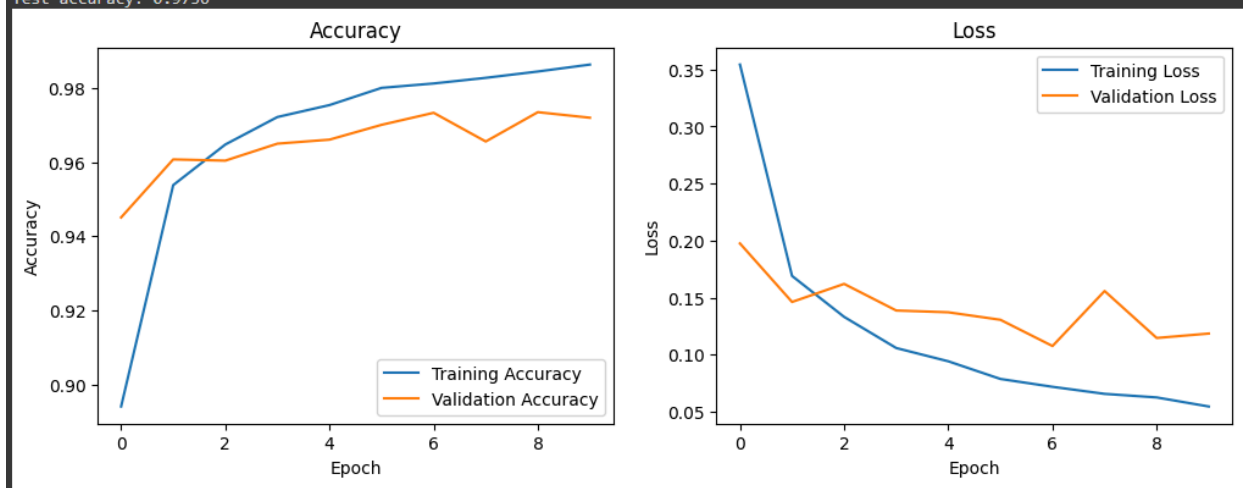


## Homework 5

1. Create a new collab file to train a neural network with 10 dense layers and upload a screenshot of its testing accuracy and training history (plotted history of loss and accuracy).

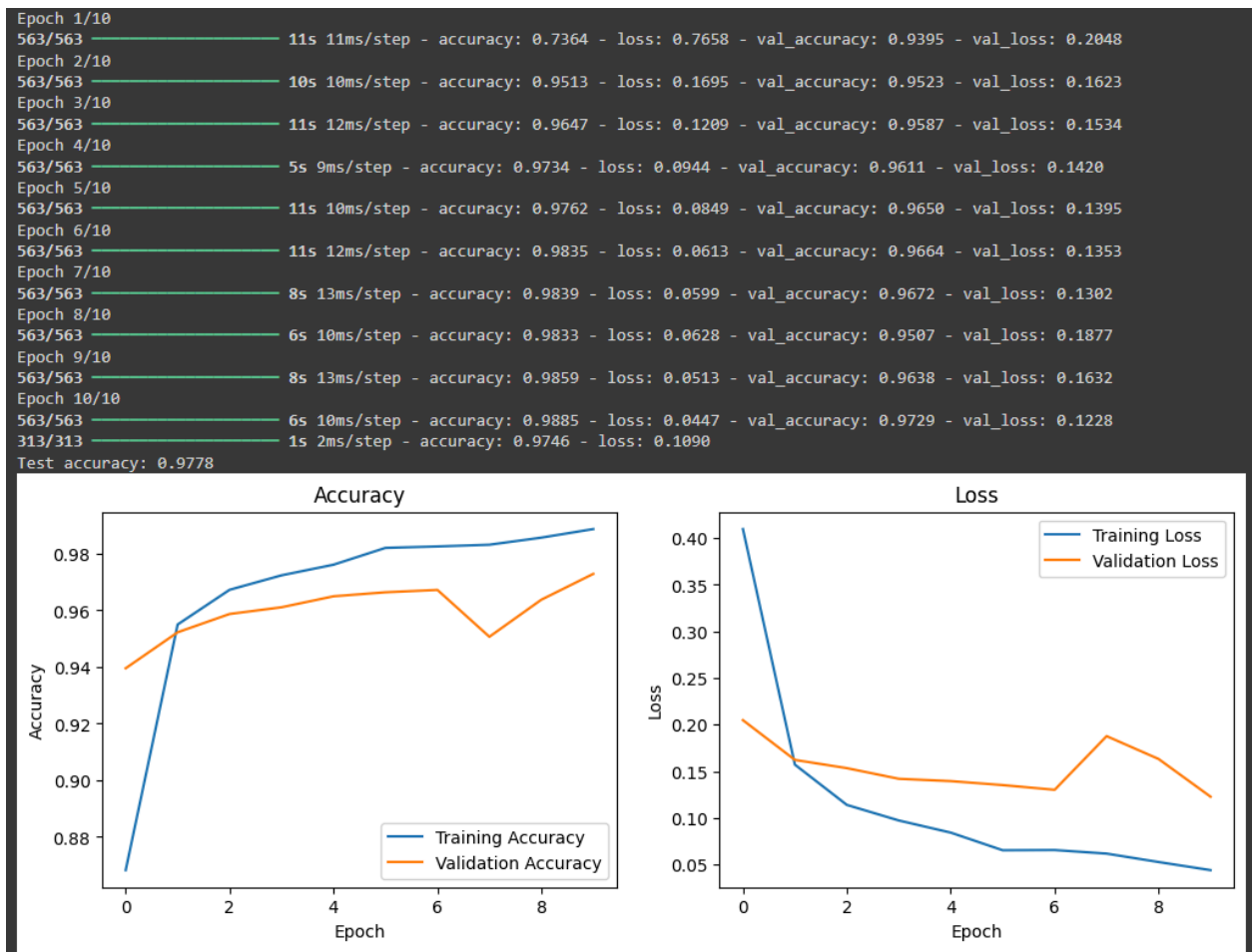
Below is a picture of the results we had from some of our first couple of rounds of training.

```
Epoch 1/10  
1500/1500 — 24s 10ms/step - accuracy: 0.7958 - loss: 0.6210 - val_accuracy: 0.9451 - val_loss: 0.1976  
Epoch 2/10  
1500/1500 — 17s 12ms/step - accuracy: 0.9528 - loss: 0.1723 - val_accuracy: 0.9607 - val_loss: 0.1463  
Epoch 3/10  
1500/1500 — 25s 15ms/step - accuracy: 0.9656 - loss: 0.1281 - val_accuracy: 0.9604 - val_loss: 0.1621  
Epoch 4/10  
1500/1500 — 29s 7ms/step - accuracy: 0.9729 - loss: 0.1041 - val_accuracy: 0.9650 - val_loss: 0.1388  
Epoch 5/10  
1500/1500 — 12s 8ms/step - accuracy: 0.9749 - loss: 0.0967 - val_accuracy: 0.9661 - val_loss: 0.1372  
Epoch 6/10  
1500/1500 — 11s 8ms/step - accuracy: 0.9808 - loss: 0.0747 - val_accuracy: 0.9701 - val_loss: 0.1307  
Epoch 7/10  
1500/1500 — 11s 8ms/step - accuracy: 0.9806 - loss: 0.0752 - val_accuracy: 0.9733 - val_loss: 0.1077  
Epoch 8/10  
1500/1500 — 12s 8ms/step - accuracy: 0.9850 - loss: 0.0570 - val_accuracy: 0.9656 - val_loss: 0.1559  
Epoch 9/10  
1500/1500 — 11s 7ms/step - accuracy: 0.9847 - loss: 0.0620 - val_accuracy: 0.9735 - val_loss: 0.1147  
Epoch 10/10  
1500/1500 — 22s 8ms/step - accuracy: 0.9874 - loss: 0.0499 - val_accuracy: 0.9720 - val_loss: 0.1186  
313/313 — 1s 2ms/step - accuracy: 0.9697 - loss: 0.1215  
Test accuracy: 0.9736
```



2. Try and compare the model's performance (accuracy) by adopting different training parameters such as number of epochs, learning rate, optimizer, etc.\

Below is a picture of the model training with the batch size set to 64 and the Validation split set to 0.4

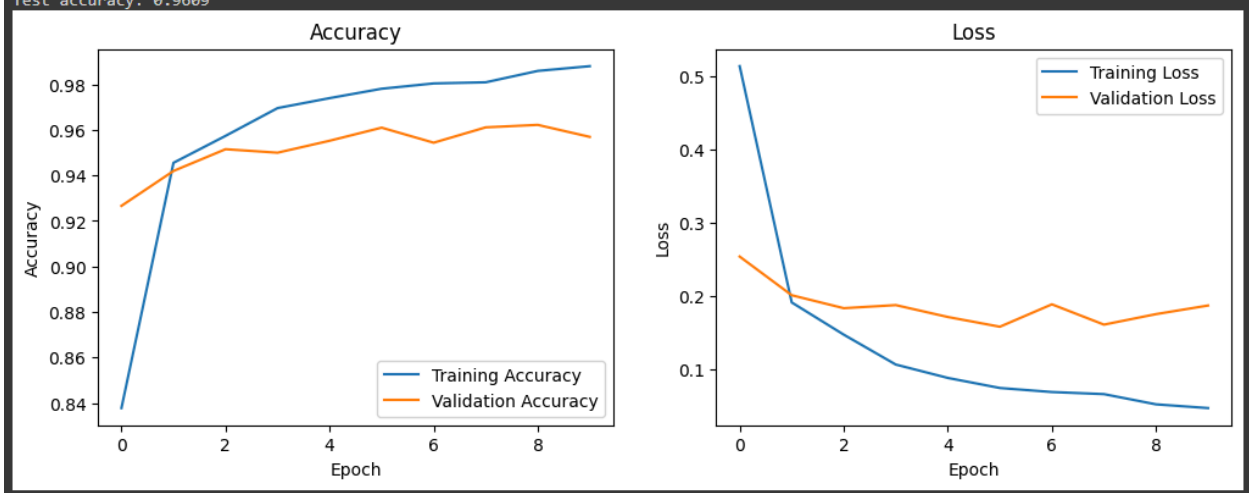


Below is another picture with the same batch size but a different Validation split, which is 0.6.

```

Epoch 1/10
375/375 ————— 10s 17ms/step - accuracy: 0.6900 - loss: 0.9106 - val_accuracy: 0.9266 - val_loss: 0.2542
Epoch 2/10
375/375 ————— 4s 11ms/step - accuracy: 0.9436 - loss: 0.1964 - val_accuracy: 0.9419 - val_loss: 0.2016
Epoch 3/10
375/375 ————— 6s 15ms/step - accuracy: 0.9578 - loss: 0.1430 - val_accuracy: 0.9515 - val_loss: 0.1839
Epoch 4/10
375/375 ————— 5s 12ms/step - accuracy: 0.9711 - loss: 0.1006 - val_accuracy: 0.9499 - val_loss: 0.1881
Epoch 5/10
375/375 ————— 6s 15ms/step - accuracy: 0.9758 - loss: 0.0829 - val_accuracy: 0.9552 - val_loss: 0.1719
Epoch 6/10
375/375 ————— 7s 18ms/step - accuracy: 0.9797 - loss: 0.0692 - val_accuracy: 0.9609 - val_loss: 0.1586
Epoch 7/10
375/375 ————— 5s 13ms/step - accuracy: 0.9813 - loss: 0.0648 - val_accuracy: 0.9543 - val_loss: 0.1892
Epoch 8/10
375/375 ————— 9s 24ms/step - accuracy: 0.9815 - loss: 0.0609 - val_accuracy: 0.9611 - val_loss: 0.1615
Epoch 9/10
375/375 ————— 6s 14ms/step - accuracy: 0.9881 - loss: 0.0460 - val_accuracy: 0.9622 - val_loss: 0.1758
Epoch 10/10
375/375 ————— 6s 16ms/step - accuracy: 0.9892 - loss: 0.0423 - val_accuracy: 0.9569 - val_loss: 0.1875
313/313 ————— 1s 2ms/step - accuracy: 0.9576 - loss: 0.1919
Test accuracy: 0.9609

```



We also tried the extreme examples of setting the validation split to 0.1 and 0.9, and they gave bad results, so there is a good middle ground. We also tried higher and lower batch sizes ranging from 8 to 2048, and around 32 to 100 gave the best results.

3. Based on the findings of steps 1 and 2, train a model with the highest possible accuracy. This step's grade will be proportional to the testing precision.

After tinkering with the numbers, we came up with our highest-accuracy Test, which had a batch size of 64 and a Validation split of 0.4.

```

Epoch 1/10
563/563 — 11s 11ms/step - accuracy: 0.7364 - loss: 0.7658 - val_accuracy: 0.9395 - val_loss: 0.2048
Epoch 2/10
563/563 — 10s 10ms/step - accuracy: 0.9513 - loss: 0.1695 - val_accuracy: 0.9523 - val_loss: 0.1623
Epoch 3/10
563/563 — 11s 12ms/step - accuracy: 0.9647 - loss: 0.1209 - val_accuracy: 0.9587 - val_loss: 0.1534
Epoch 4/10
563/563 — 5s 9ms/step - accuracy: 0.9734 - loss: 0.0944 - val_accuracy: 0.9611 - val_loss: 0.1420
Epoch 5/10
563/563 — 11s 10ms/step - accuracy: 0.9762 - loss: 0.0849 - val_accuracy: 0.9650 - val_loss: 0.1395
Epoch 6/10
563/563 — 11s 12ms/step - accuracy: 0.9835 - loss: 0.0613 - val_accuracy: 0.9664 - val_loss: 0.1353
Epoch 7/10
563/563 — 8s 13ms/step - accuracy: 0.9839 - loss: 0.0599 - val_accuracy: 0.9672 - val_loss: 0.1302
Epoch 8/10
563/563 — 6s 10ms/step - accuracy: 0.9833 - loss: 0.0628 - val_accuracy: 0.9507 - val_loss: 0.1877
Epoch 9/10
563/563 — 8s 13ms/step - accuracy: 0.9859 - loss: 0.0513 - val_accuracy: 0.9638 - val_loss: 0.1632
Epoch 10/10
563/563 — 6s 10ms/step - accuracy: 0.9885 - loss: 0.0447 - val_accuracy: 0.9729 - val_loss: 0.1228
313/313 — 1s 2ms/step - accuracy: 0.9746 - loss: 0.1090
Test accuracy: 0.9778

```

