

Handwritten Digit Classification In Action With TensorFlow

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CSC580-1: Applying Machine Learning and Neural Networks - Capstone

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Handwritten Digit Classification In Action With TensorFlow

This is a paper on a neural network model that was developed and tuned to recognize the MNIST handwritten digit dataset. These are the results of the model and the results of the tuning I have done with its hyperparameters.

What Is The Accuracy of The Model?

```
PS C:\Users\Michael\Documents\GitHub\PythonProjects\CSC 526\
2024-09-30 22:30:52.342853: I tensorflow/core/platform/cpu_f
To enable the following instructions: SSE SSE2 SSE3 SSE4.1 S
[0. 0. 0. 1. 0. 0. 0. 0. 0. 0.]
2024-09-30 22:30:56.635664: I tensorflow/compiler/mlir/mlir_
Training epoch 1
Accuracy: 0.9019
Training epoch 2
Accuracy: 0.9211
```

```
Accuracy: 0.9418
Training epoch 16
Accuracy: 0.9439
Training epoch 17
Accuracy: 0.9457
Training epoch 18
Accuracy: 0.9446
Training epoch 19
Accuracy: 0.9457
Training epoch 20
Accuracy: 0.9451
PS C:\Users\Michael\Documents\GitHub\PythonProjects\CSC 526\Week 2> █
```

From the start, our current model started at an accuracy of about 90.19%. After the 20 epochs of training, it improved to an accuracy score of 94.51%. This is a statistically significant growth, and the last few epochs did not improve that much so the model is near its max accuracy.

What Are Some of The Misclassified Images?

[32. 29. 30. 28. 23. 35. 43. 23. 28. 30.]

My code will print an array showing all the different numbers that have failed identification. The first element is the number 32. This represents the number of samples that were misclassified and were the number 0. Then the next one is for the number 1 and all the way

up to 9. You can see that our highest numbers of misclassifications are 5 and 6. This makes sense since handwritten 5 and 6 can look a lot like each other.

How Does Hidden Nodes Amount Affect Accuracy?

128 nodes

```
To enable the following instructions: s
[0. 0. 0. 1. 0. 0. 0. 0. 0.]
2024-09-30 22:32:33.345043: I tensorflow
Training epoch 1
Accuracy: 0.8676
Training epoch 2
Accuracy: 0.8979
Training epoch 3
Accuracy: 0.9105
Training epoch 4
Accuracy: 0.9105
```

```
Accuracy: 0.9405
Training epoch 17
Accuracy: 0.9476
Training epoch 18
Accuracy: 0.9499
Training epoch 19
Accuracy: 0.9482
Training epoch 20
Accuracy: 0.9517
PS C:\Users\Michael\Documents\GitHub\PythonProjects\CSC 526\Week 2> █
```

1024 nodes

```
2024-09-30 22:33:40.251058: I tensorflow/compiler
Training epoch 1
Accuracy: 0.9219
Training epoch 2
Accuracy: 0.9337
```

```

Training epoch 18
Accuracy: 0.9507
Training epoch 19
Accuracy: 0.9516
Training epoch 20
Accuracy: 0.9521
PS C:\Users\Michael\Documents\GitHub\PythonProjects\CSC 526\Week 2>

```

It seems like the first epoch of each model had a different amount of nodes had drastically different accuracies. 128 nodes in the hidden layer made the first epoch accuracy 86%. The hidden layer with 1024 had an epoch 1 accuracy of 92%. The final accuracies were not that different, this means that the level of complexity in the layer is not affecting the accuracy as much as other hyperparameters after the 20 epochs.

How Is Accuracy With Different Learning Rates?

0.05: 0.947

0.1: 0.9538

0.2: 0.9533

0.7: 0.9543

This experiment shows that very low learning rates can have a big negative impact on the accuracy rating. Tuning this will be a good tool for obtaining the most accurate model. The differences between accuracies will be larger once the model begins overfitting the curve or underfitting.

Does Accuracy Improve With Another Hidden Layer?

0.9566

0.9682

Another hidden layer increased the accuracy by a statistically significant amount. It increased the accuracy of the model by more than 1.1%. This means that as more layers are

created, the higher the accuracy will get. Once it is so complex that it takes a long time to train, then other hyperparameters must be tuned to make the model better.

How Does Batch Size Affect Accuracy?

20: 0.9566

40:0.9565

60:0.9554

Batch size affects accuracy because it is the amount of samples processed before pausing to edit the weights and biases of the neural network. The range I tested did not affect the accuracies that much, but if I tested even lower or higher, it would overfit and underfit the curve.

Best Accuracy?

Best: 0.9777

0.8 LR

4096 Nodes per layer

Batch size 30

2 Hidden Layers

The best accuracy I obtained in this experiment was 97.7%. This is much higher than the starting percentage. I tuned all these hyperparameters until they were the highest accuracies and found this. In conclusion, all of these hyperparameter tuning have increased the performance of the system by around 3% points. In a business situation, 3% accuracy could be very profitable, and getting that with simple hyperparameter tuning could very well be worth it.

References

Ganegedara, T. (2022). *TensorFlow in action*. Simon and Schuster.