Machine Learning Assignment Report
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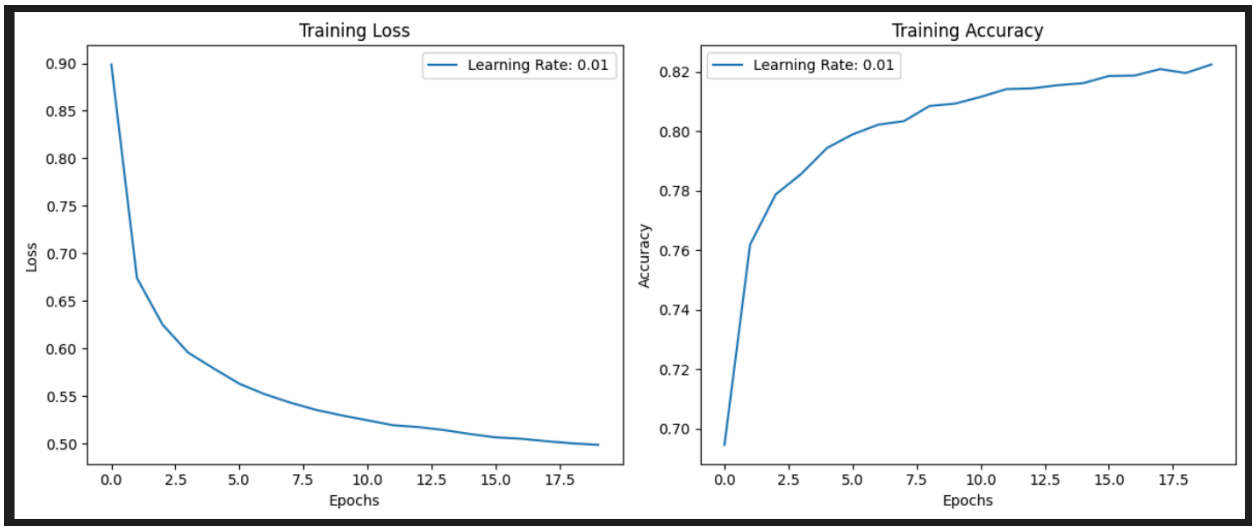
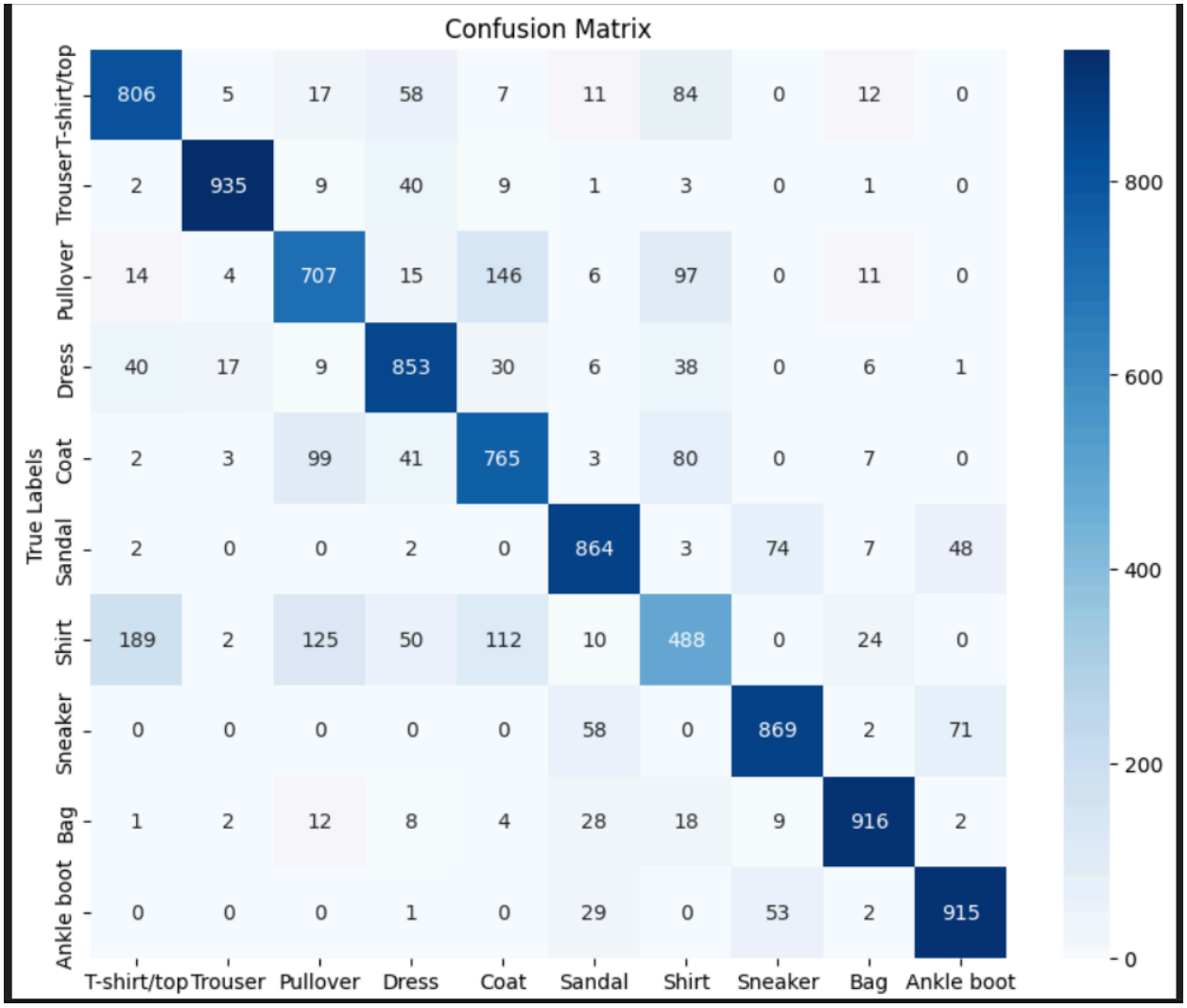
Model 1A :

```
architecture = [
{"type": "dense", "input_dim": 784, "output_dim": 128},
{"type": "batch_norm", "dim": 128},
{"type": "activation"},
{"type": "dropout"},
{"type": "dense", "input_dim": 128, "output_dim": 10}
]



model = NeuralNetwork(architecture, learning_rate=0.01, dropout_rate=0.1)
train_data, test_data = load_data()
epochs = 20
batch_size = 64
```

```
Train Loss: 0.4986
Train Accuracy: 0.8224
Validation Loss: 0.4829
Validation Accuracy: 0.8278
Validation Macro F1: 0.8276
Test Loss: 0.5432
Test Accuracy: 0.8157
```


Training Loss
Learning Rate: 0.01
Loss
Epochs
Training Accuracy
Learning Rate: 0.01
Accuracy
Epochs

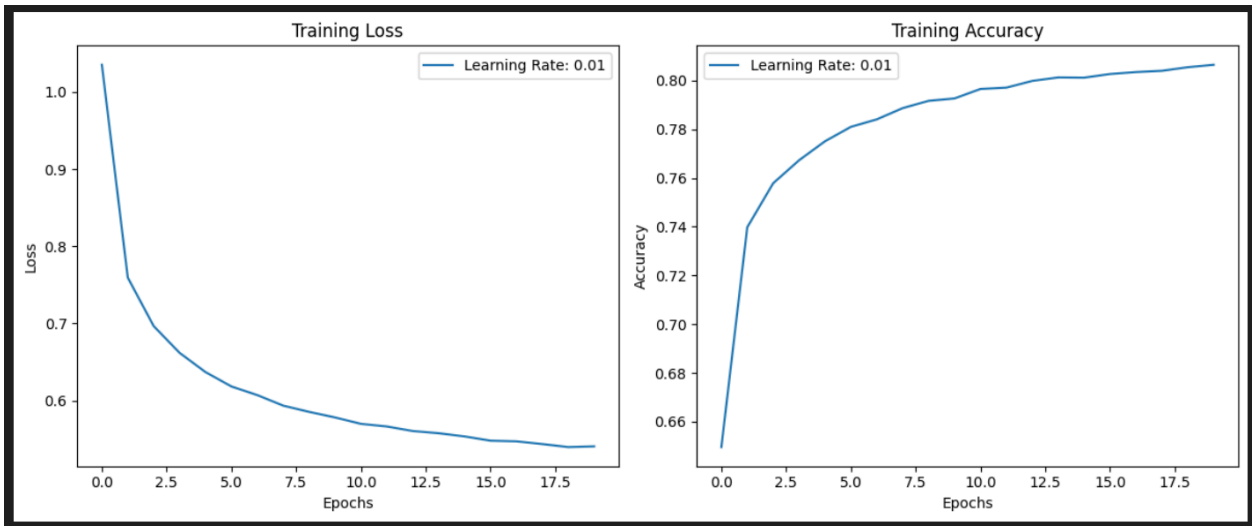

Training and Validation Loss
Train Loss
Validation Loss
Loss
Epochs
Training and Validation Accuracy
Train Accuracy
Validation Accuracy
Accuracy
Epochs
Validation Macro F1 Score
Validation Macro F1
Macro F1 Score
Epochs

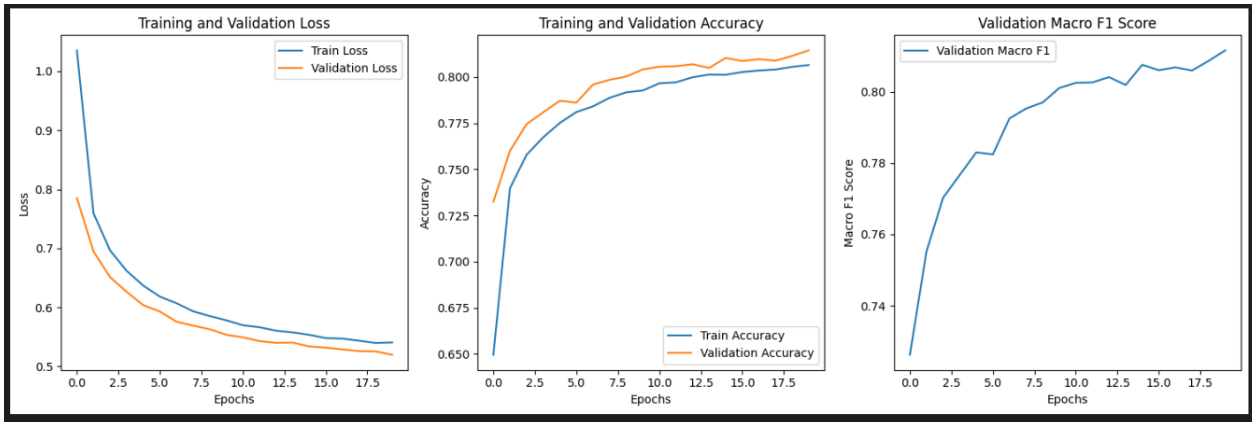

Confusion Matrix
True Labels
T-shirt/top
Trouser
Pullover
Dress
Coat
Sandal
Shirt
Sneaker
Bag
Ankle boot
806 5 17 58 7 11 84 0 12 0
2 935 9 40 9 1 3 0 1 0
14 4 707 15 146 6 97 0 11 0
40 17 9 853 30 6 38 0 6 1
2 3 99 41 765 3 80 0 7 0
2 0 0 2 0 864 3 74 7 48
189 2 125 50 112 10 488 0 24 0
0 0 0 0 0 58 0 869 2 71
1 2 12 8 4 28 18 9 916 2
0 0 0 1 0 29 0 53 2 915
800
600
400
200
0

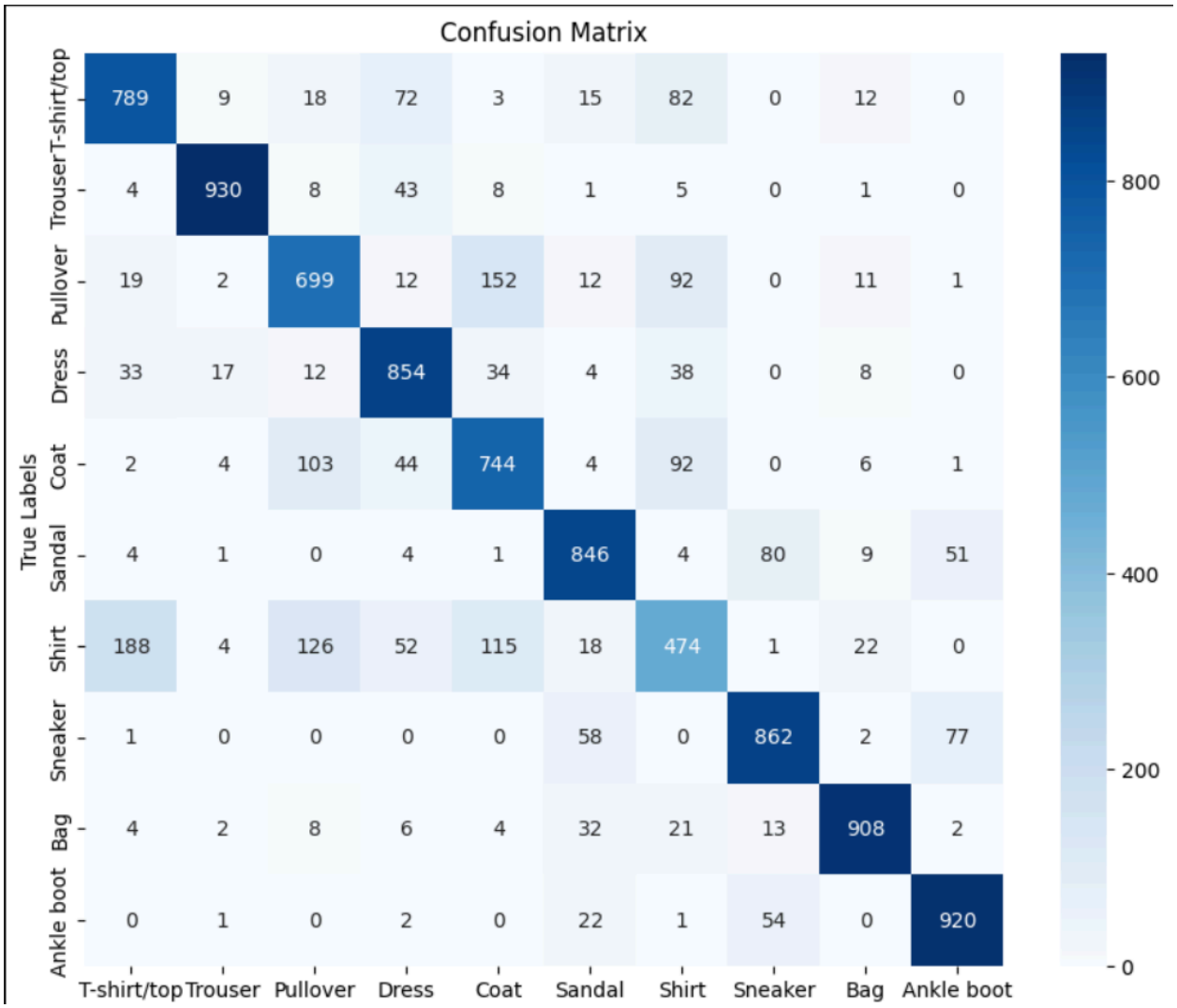
Model 1B:

```
architecture = [
{"type": "dense", "input_dim": 784, "output_dim": 128},
{"type": "batch_norm", "dim": 128},
{"type": "activation"},
{"type": "dropout"},
{"type": "dense", "input_dim": 128, "output_dim": 10}
]



model = NeuralNetwork(architecture, learning_rate=0.005, dropout_rate=0.1)
train_data, test_data = load_data()
epochs = 20
batch_size = 64
```

```
Train Loss: 0.5406
Train Accuracy: 0.8064
Validation Loss: 0.5197
Validation Accuracy: 0.8143
Validation Macro F1: 0.8116
Test Loss: 0.5537
Test Accuracy: 0.8071
```



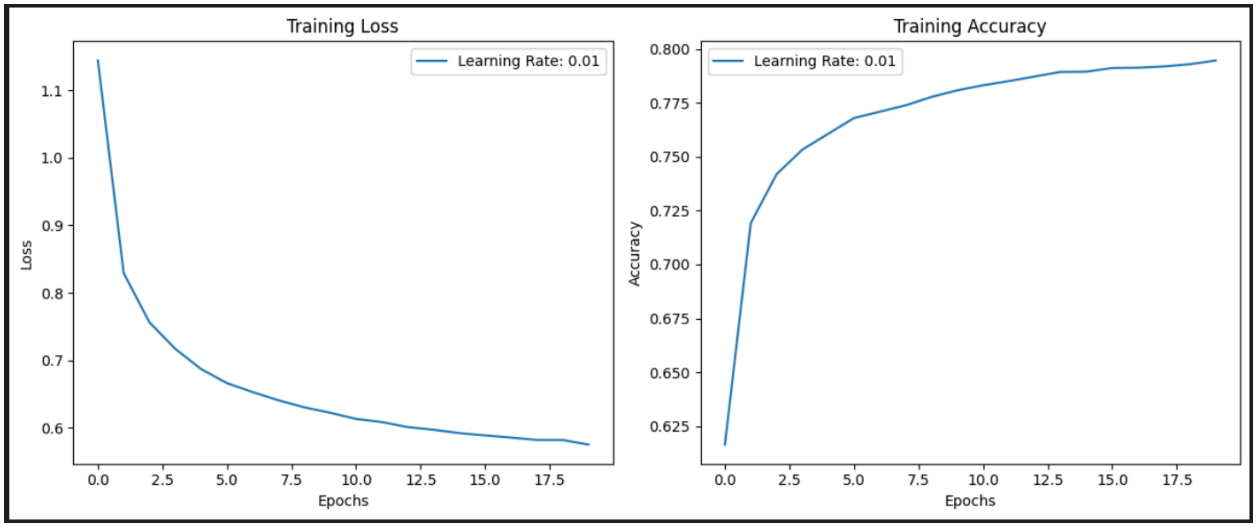

Training and Validation Loss
Train Loss
Validation Loss
Loss
Epochs
Training and Validation Accuracy
Train Accuracy
Validation Accuracy
Accuracy
Epochs
Validation Macro F1 Score
Validation Macro F1
Macro F1 Score
Epochs

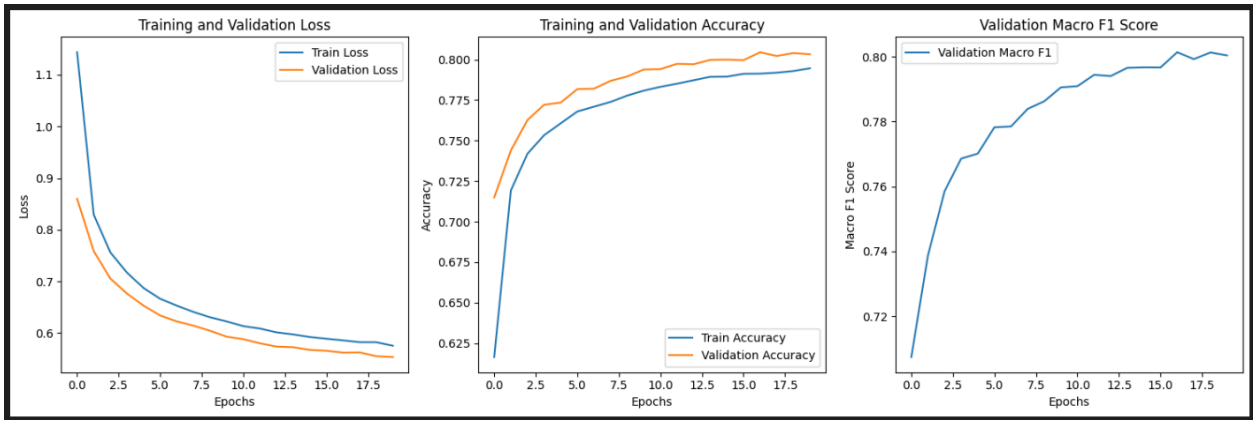

Confusion Matrix
True Labels
T-shirt/top
Trouser
Pullover
Dress
Coat
Sandal
Shirt
Sneaker
Bag
Ankle boot
789 9 18 72 3 15 82 0 12 0
4 930 8 43 8 1 5 0 1 0
19 2 699 12 152 12 92 0 11 1
33 17 12 854 34 4 38 0 8 0
2 4 103 44 744 4 92 0 6 1
4 1 0 4 1 846 4 80 9 51
188 4 126 52 115 18 474 1 22 0
1 0 0 0 0 58 0 862 2 77
4 2 8 6 4 32 21 13 908 2
0 1 0 2 0 22 1 54 0 920
800
600
400
200
0

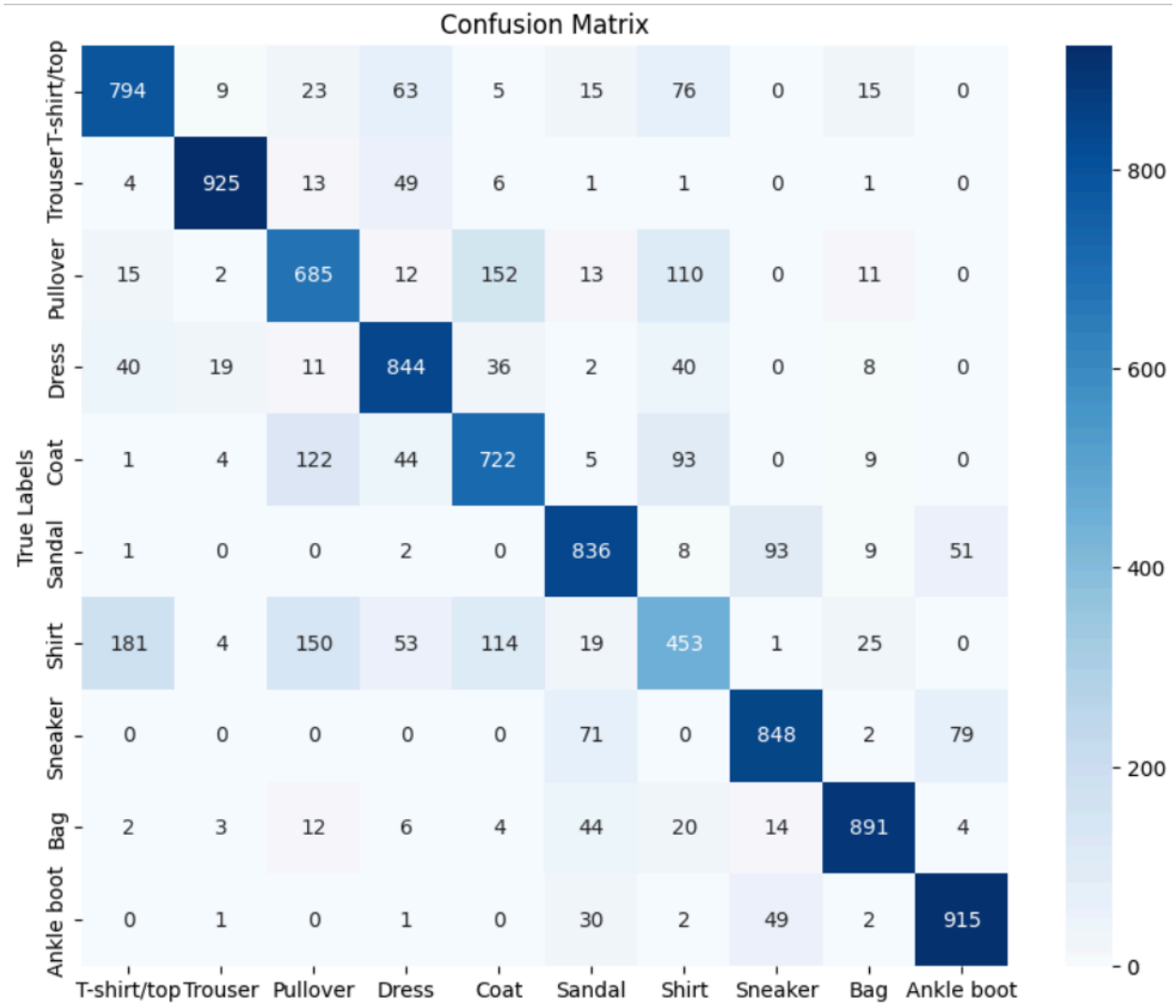
Model 1C:

```
architecture = [
{"type": "dense", "input_dim": 784, "output_dim": 128},
{"type": "batch_norm", "dim": 128},
{"type": "activation"},
{"type": "dropout"},
{"type": "dense", "input_dim": 128, "output_dim": 10}
]



model = NeuralNetwork(architecture, learning_rate=0.003, dropout_rate=0.1)
train_data, test_data = load_data()
epochs = 20
batch_size = 64
```

Train Loss: 0.5752
Train Accuracy: 0.7946
Validation Loss: 0.5533
Validation Accuracy: 0.8033
Validation Macro F1: 0.8004
Test Loss: 0.5864
Test Accuracy: 0.7955



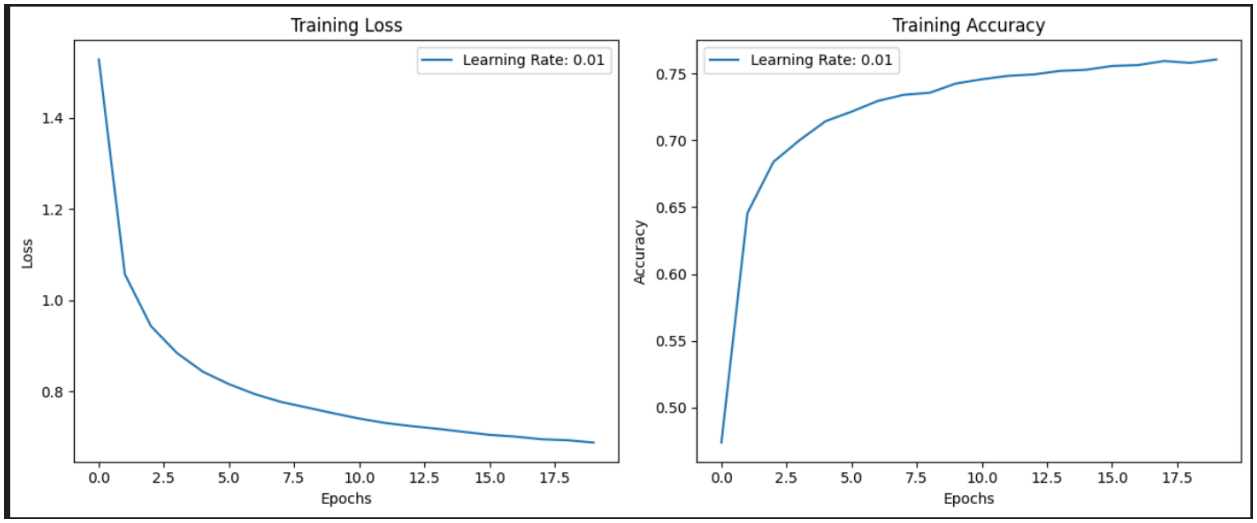

Training and Validation Loss
Train Loss
Validation Loss
Loss
Epochs
Training and Validation Accuracy
Train Accuracy
Validation Accuracy
Accuracy
Epochs
Validation Macro F1 Score
Validation Macro F1
Macro F1 Score
Epochs

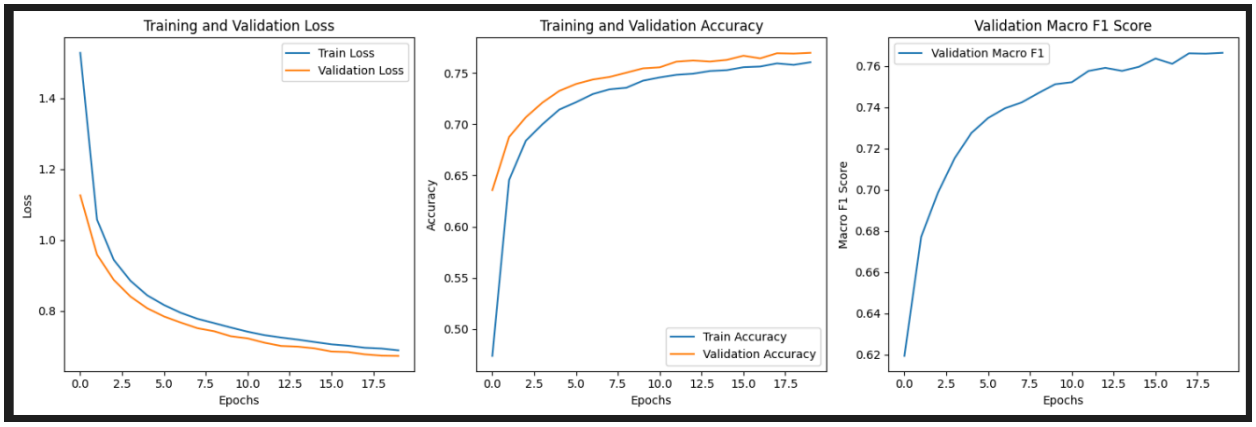

Confusion Matrix
True Labels
T-shirt/top
Trouser
Pullover
Dress
Coat
Sandal
Shirt
Sneaker
Bag
Ankle boot
794 9 23 63 5 15 76 0 15 0
4 925 13 49 6 1 1 0 1 0
15 2 685 12 152 13 110 0 11 0
40 19 11 844 36 2 40 0 8 0
1 4 122 44 722 5 93 0 9 0
1 0 0 2 0 836 8 93 9 51
181 4 150 53 114 19 453 1 25 0
0 0 0 0 0 71 0 848 2 79
2 3 12 6 4 44 20 14 891 4
0 1 0 1 0 30 2 49 2 915
800
600
400
200
0

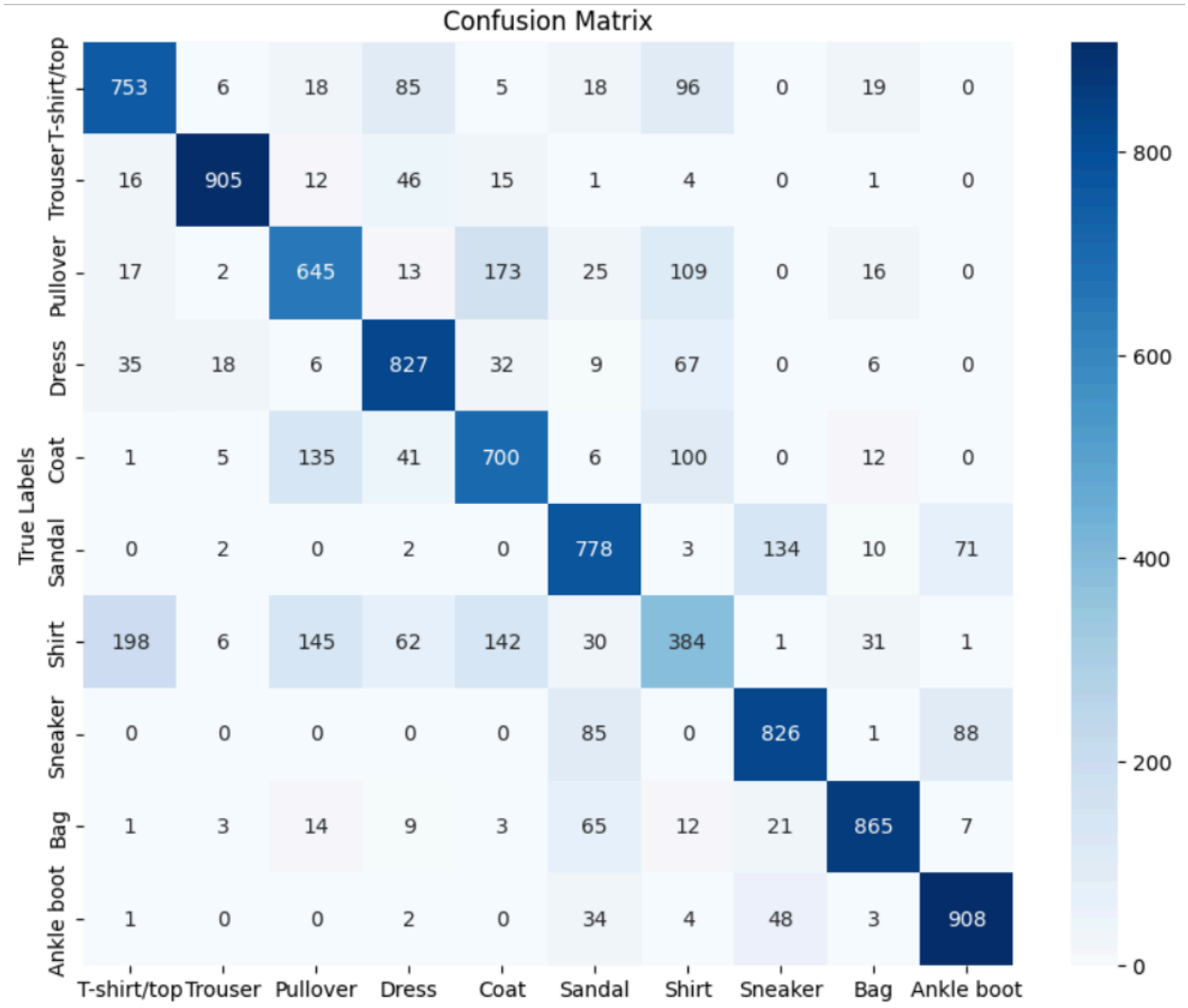
Model 1D:

```
architecture = [
{"type": "dense", "input_dim": 784, "output_dim": 128},
{"type": "batch_norm", "dim": 128},
{"type": "activation"},
{"type": "dropout"},
{"type": "dense", "input_dim": 128, "output_dim": 10}
]



model = NeuralNetwork(architecture, learning_rate=0.001, dropout_rate=0.1)
train_data, test_data = load_data()
epochs = 20
batch_size = 64
```

Train Loss: 0.6883
Train Accuracy: 0.7605
Validation Loss: 0.6726
Validation Accuracy: 0.7698
Validation Macro F1: 0.7665
Test Loss: 0.6930
Test Accuracy: 0.7627



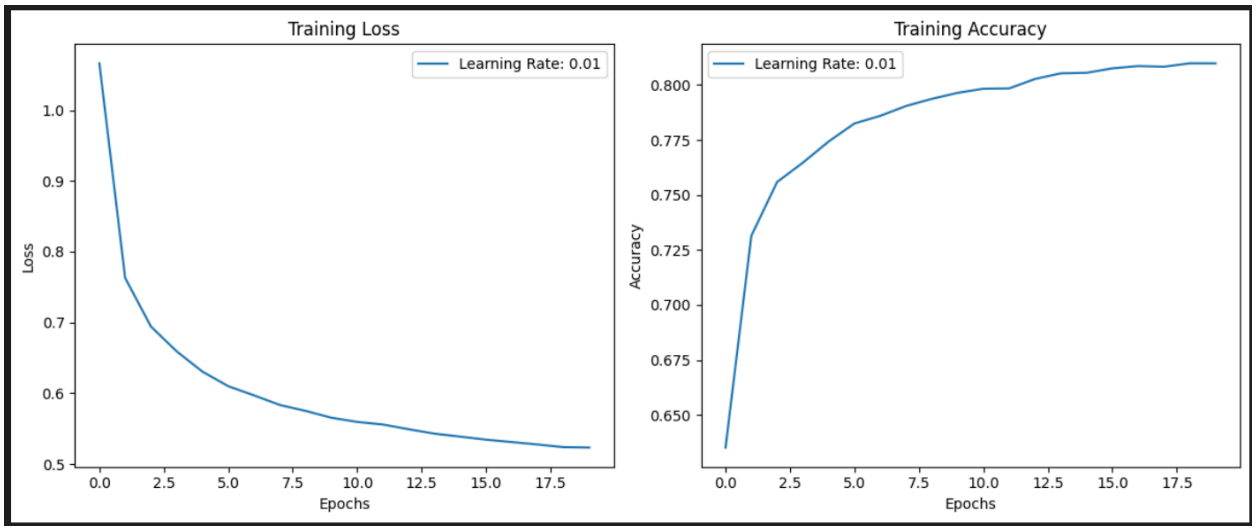

Training and Validation Loss
Train Loss
Validation Loss
Loss
Epochs
Training and Validation Accuracy
Train Accuracy
Validation Accuracy
Accuracy
Epochs
Validation Macro F1 Score
Validation Macro F1
Macro F1 Score
Epochs


Confusion Matrix
True Labels
T-shirt/top
Trouser
Pullover
Dress
Coat
Sandal
Shirt
Sneaker
Bag
Ankle boot
753 6 18 85 5 18 96 0 19 0
16 905 12 46 15 1 4 0 1 0
17 2 645 13 173 25 109 0 16 0
35 18 6 827 32 9 67 0 6 0
1 5 135 41 700 6 100 0 12 0
0 2 0 2 0 778 3 134 10 71
198 6 145 62 142 30 384 1 31 1
0 0 0 0 0 85 0 826 1 88
1 3 14 9 3 65 12 21 865 7
1 0 0 2 0 34 4 48 3 908
800
600
400
200
0

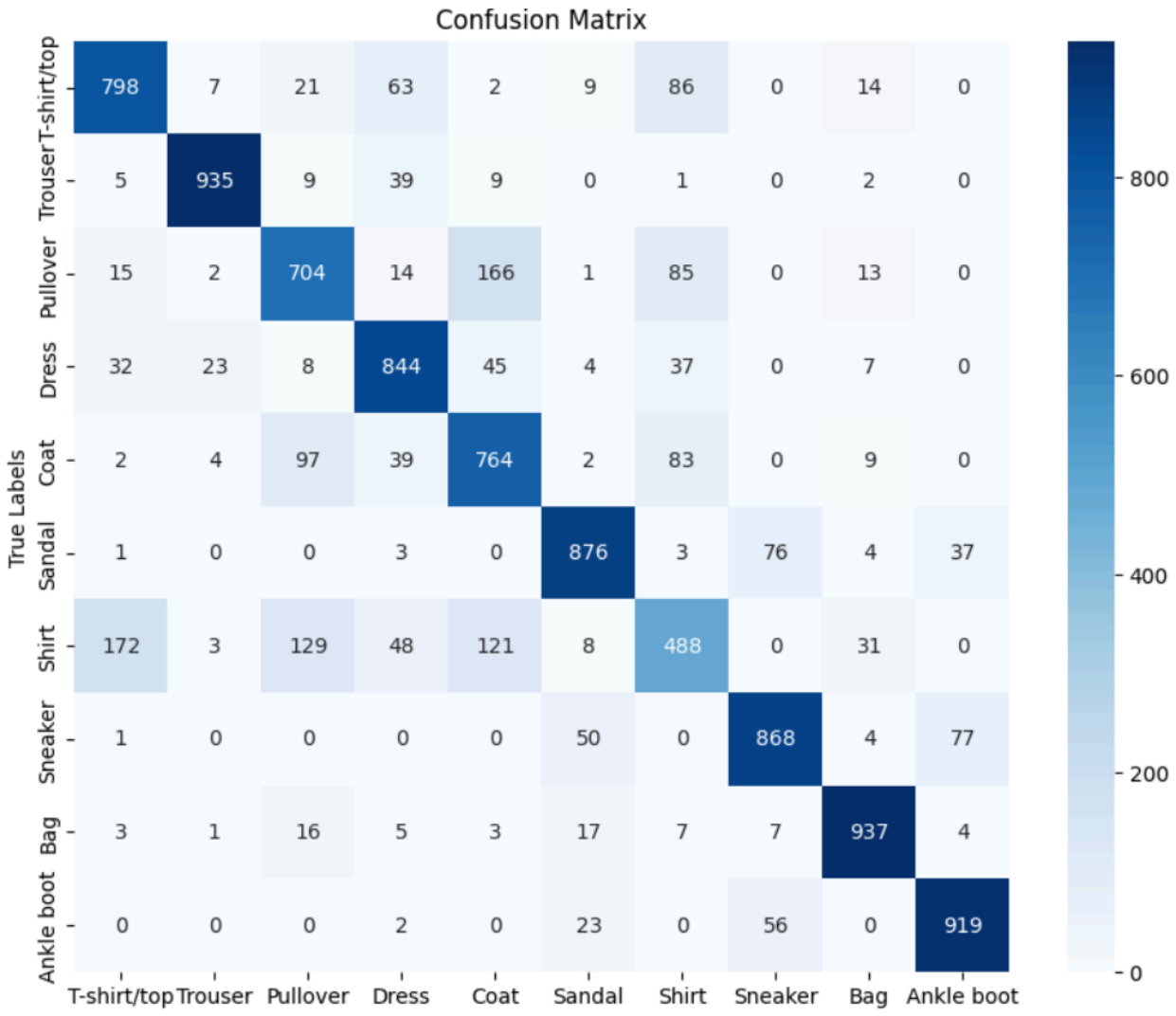
Model 2:

```
architecture = [
{"type": "dense", "input_dim": 784, "output_dim": 256},
{"type": "batch_norm", "dim": 256},
{"type": "activation"},
{"type": "dropout"},
{"type": "dense", "input_dim": 256, "output_dim": 128},
{"type": "batch_norm", "dim": 128},
{"type": "activation"},
{"type": "dropout"},
{"type": "dense", "input_dim": 128, "output_dim": 10}
]



model = NeuralNetwork(architecture, learning_rate=0.005, dropout_rate=0.1)
train_data, test_data = load_data()
epochs = 20
batch_size = 64
```

```
Train Loss: 0.5232
Train Accuracy: 0.8098
Validation Loss: 0.4839
Validation Accuracy: 0.8228
Validation Macro F1: 0.8210
Test Loss: 0.5221
Test Accuracy: 0.8175
```


Training Loss
Learning Rate: 0.01
Loss
Epochs
Training Accuracy
Learning Rate: 0.01
Accuracy
Epochs

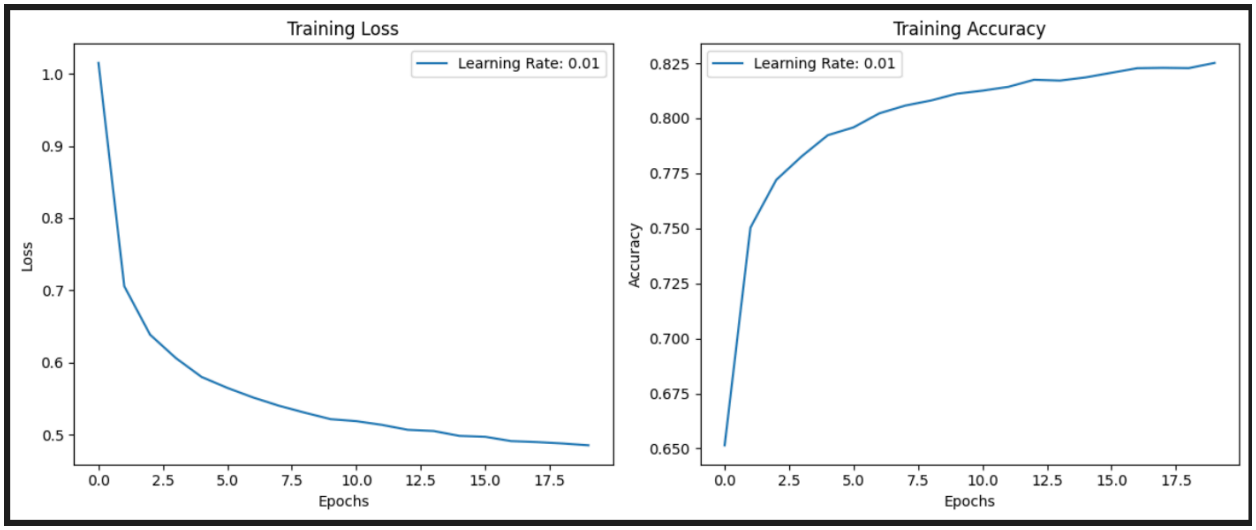

Training and Validation Loss
Train Loss
Validation Loss
Loss
Epochs
Training and Validation Accuracy
Train Accuracy
Validation Accuracy
Accuracy
Epochs
Validation Macro F1 Score
Validation Macro F1
Macro F1 Score
Epochs

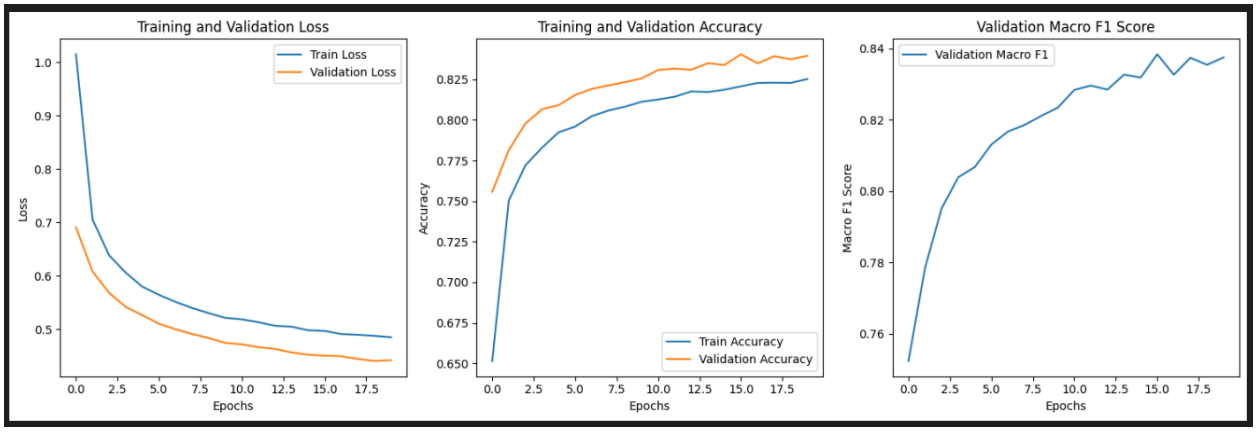

Confusion Matrix
True Labels
T-shirt/top
Trouser
Pullover
Dress
Coat
Sandal
Shirt
Sneaker
Bag
Ankle boot
798 7 21 63 2 9 86 0 14 0
5 935 9 39 9 0 1 0 2 0
15 2 704 14 166 1 85 0 13 0
32 23 8 844 45 4 37 0 7 0
2 4 97 39 764 2 83 0 9 0
1 0 0 3 0 876 3 76 4 37
172 3 129 48 121 8 488 0 31 0
1 0 0 0 0 50 0 868 4 77
3 1 16 5 3 17 7 7 937 4
0 0 0 2 0 23 0 56 0 919
800
600
400
200
0

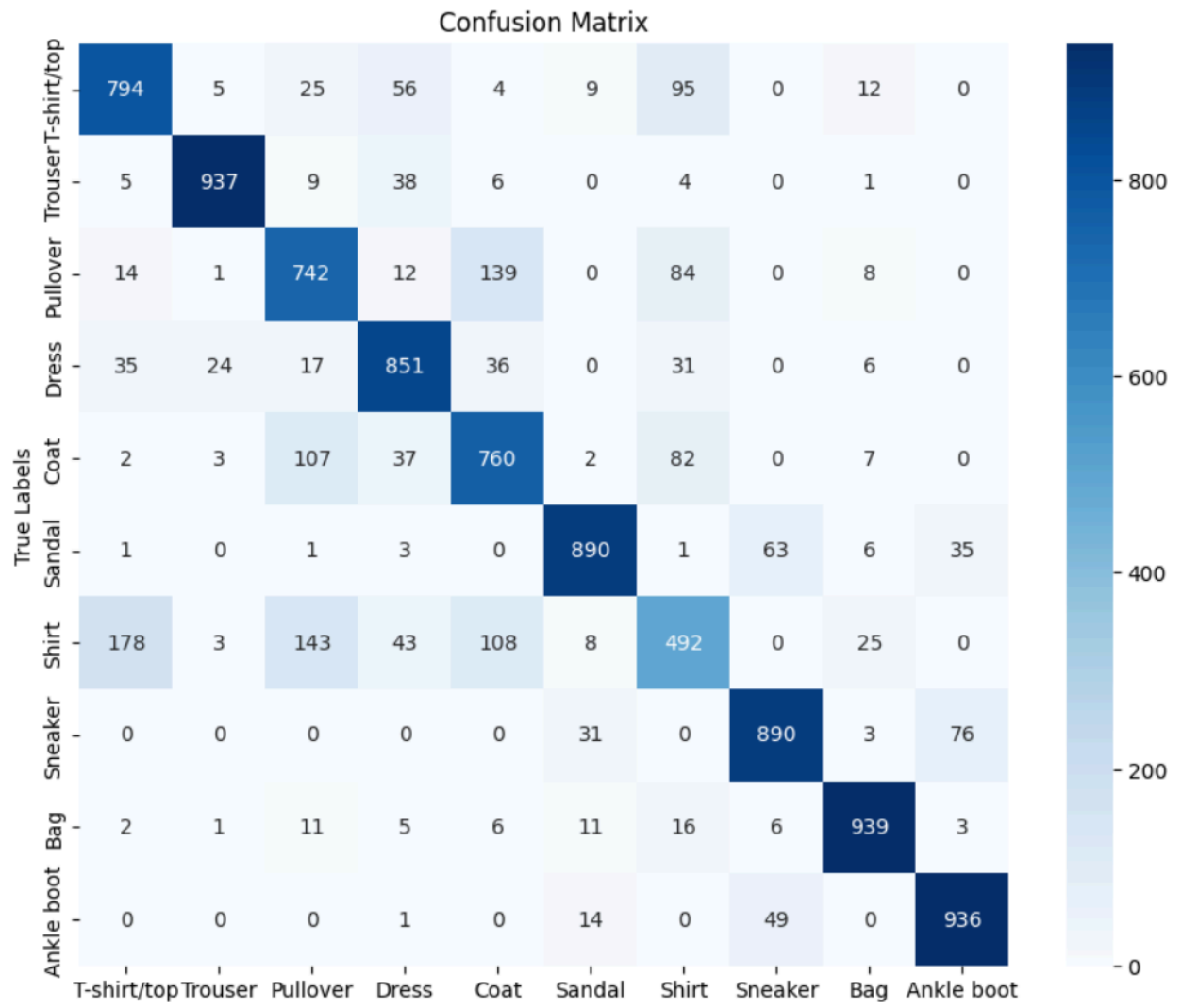
Model 3:

```
architecture = [
{"type": "dense", "input_dim": 784, "output_dim": 512},
{"type": "batch_norm", "dim": 512},
{"type": "activation"},
{"type": "dropout"},

{"type": "dense", "input_dim": 512, "output_dim": 512},
{"type": "batch_norm", "dim": 512},
{"type": "activation"},
{"type": "dropout"},

{"type": "dense", "input_dim": 512, "output_dim": 256},
{"type": "batch_norm", "dim": 256},
{"type": "activation"},
{"type": "dropout"},

{"type": "dense", "input_dim": 256, "output_dim": 10}



model = NeuralNetwork(architecture, learning_rate=0.005, dropout_rate=0.1)
train_data, test_data = load_data()
epochs = 20
batch_size = 64
```

```
Train Loss: 0.4853
Train Accuracy: 0.8252
Validation Loss: 0.4421
Validation Accuracy: 0.8395
Validation Macro F1: 0.8375
Test Loss: 0.4859
Test Accuracy: 0.8270
```


Training Loss
Learning Rate: 0.01
Loss
Epochs
Training Accuracy
Learning Rate: 0.01
Accuracy
Epochs


Training and Validation Loss
Train Loss
Validation Loss
Loss
Epochs
Training and Validation Accuracy
Train Accuracy
Validation Accuracy
Accuracy
Epochs
Validation Macro F1 Score
Validation Macro F1
Macro F1 Score
Epochs


Confusion Matrix
True Labels
T-shirt/top
Trouser
Pullover
Dress
Coat
Sandal
Shirt
Sneaker
Bag
Ankle boot
794 5 25 56 4 9 95 0 12 0
5 937 9 38 6 0 4 0 1 0
14 1 742 12 139 0 84 0 8 0
35 24 17 851 36 0 31 0 6 0
2 3 107 37 760 2 82 0 7 0
1 0 1 3 0 890 1 63 6 35
178 3 143 43 108 8 492 0 25 0
0 0 0 0 0 31 0 890 3 76
2 1 11 5 6 11 16 6 939 3
0 0 0 1 0 14 0 49 0 936
800
600
400
200
0