ECGR 5105 Homework 7: CNNs and ResNet-Based CNNs

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GitHub Link

Click here to view the code

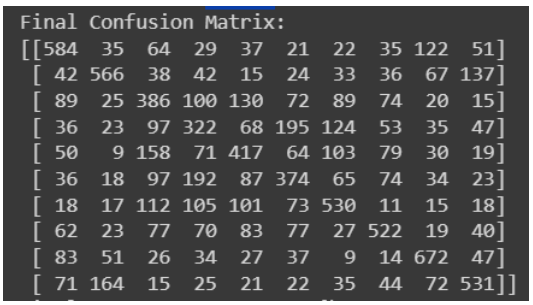
Problem 1a.

Training Time, Training Loss, and Evaluation Accuracy Results:

The values for the fully connected network from problem 2a of Homework 6 can be seen below:

The total training time was 8241 seconds or 2.289 hours.
The training loss was 0.5180834466234192 at epoch 291.
The final evaluation accuracy was 49.72%, but the best recorded accuracy was 50.49%
The F1 score was found to be 0.4902.
The confusion matrix can be seen below:

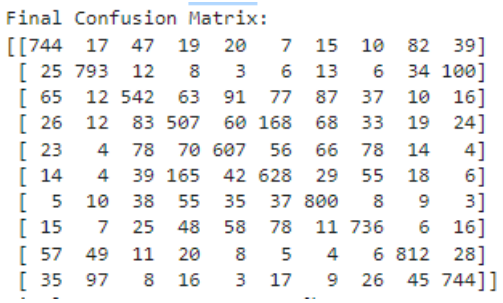
Figure 1: Fully Connected Network Confusion Matrix



The values for the CNN can be seen below:

The total training time was 4656.42 seconds or 1.293 hours. (Note: the network was run on a GPU while the last assignment was run on a CPU).
The training loss was 0.020175681252966222 at epoch 291.
The final evaluation accuracy was 69.13%.
The F1 score was found to be 0.6899.
The confusion matrix can be seen below:

Figure 2: CNN Confusion Matrix



```
Final Confusion Matrix:
[[744  17  47  19  20   7  15  10  82  39]
 [ 25 793  12   8   3   6  13   6  34 100]
 [ 65  12 542  63  91  77  87  37  10  16]
 [ 26  12  83 507  60 168  68  33  19  24]
 [ 23   4  78  70 607  56  66  78  14   4]
 [ 14   4  39 165  42 628  29  55  18   6]
 [  5  10  38  55  35  37 800   8   9   3]
 [ 15   7  25  48  58  78  11 736   6  16]
 [ 57  49  11  20   8   5   4   6 812  28]
 [ 35  97   8  16   3  17   9  26  45 744]]
```

These results show that a CNN provides a better training loss, accuracy, and F1 score than an equivalent fully connected network. The training time also proved to be better, though it needs to be taken into account that the CNN model was run on a GPU while the model from the last assignment was run on a CPU.

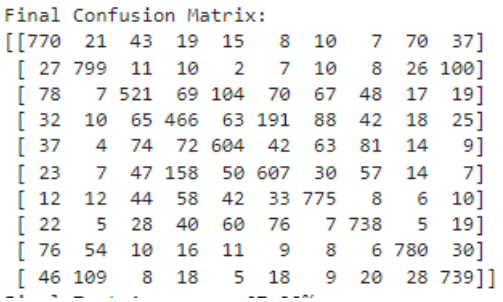
Problem 1b.

Training Time, Training Loss, and Evaluation Accuracy Results:

The values for a CNN with an extra layer can be seen below:

The total training time was 4147.21 seconds or 1.152 hours.
The training loss was 0.0076383733139385275 at epoch 291.
The final evaluation accuracy was 67.99%.
The F1 score was found to be 0.6779.
The confusion matrix can be seen below:

Figure 3: Fully Connected Network with an Extra Layer Confusion Matrix



```
Final Confusion Matrix:
[[770  21  43  19  15   8  10   7  70  37]
 [ 27 799  11  10   2   7  10   8  26 100]
 [ 78   7 521  69 104  70  67  48  17  19]
 [ 32  10  65 466  63 191  88  42  18  25]
 [ 37   4  74  72 604  42  63  81  14   9]
 [ 23   7  47 158  50 607  30  57  14   7]
 [ 12  12  44  58  42  33 775   8   6  10]
 [ 22   5  28  40  60  76   7 738   5  19]
 [ 76  54  10  16  11   9   8   6 780  30]
 [ 46 109   8  18   5  18   9  20  28 739]]
```

This shows that adding an extra layer with an activation and pooling function provided a faster training time and a better loss, accuracy, and F1 score.

Problem 2a.

Training Time, Training Loss, and Evaluation Accuracy Results:

The values for the RESNET-based CNN can be seen below:

The total training time was 13354.50 seconds or 3.710 hours.
The training loss was 0.0011161646848205653 at epoch 291.
The final evaluation accuracy was 74.06%.
The F1 score was found to be 0.7401.
The confusion matrix can be seen below:

Figure 4: RESNET-Based CNN Confusion Matrix

```
Final F1 Score: 0.7401
Final Precision: 0.7404
Final Recall: 0.7406
Final Confusion Matrix:
[[784  26  47  16  15  12   8  10  48  34]
 [ 19 881   7   4   4   3   4   4   9  65]
 [ 69   4 617  56  86  56  66  23  14   9]
 [ 24   9  62 563  56 163  68  23   8  24]
 [ 25   3  77  61 672  34  57  64   7   0]
 [ 15   5  43 168  43 658   9  43   6  10]
 [ 11   5  45  58  43  30 788  10   7   3]
 [ 16   3  26  36  70  73   8 749   4  15]
 [ 79  31   6  13  10   1   9   5 827  19]
 [ 23  59   4   4   7   6   5   5  20 867]]
```

These results show that the RESNET-based CNN takes three times longer to train, but provides a much better training loss, accuracy, and F1 score.

Problem 2b.

1. Weight Decay with Lambda of 0.001:
Training Time, Training Loss, and Evaluation Accuracy Results:

The values can be seen below:

The total training time was 12253.12 seconds or 3.404 hours.
The training loss was 0.00395170132809109 at epoch 291.
The final evaluation accuracy was 71.88%.
The F1 score was found to be 0.7192.
The confusion matrix can be seen below:

Figure 5: RESNET-Based CNN with Weight Decay Confusion Matrix

```
Final Confusion Matrix:
[[625  20 126  17  29   8  14  17 103  41]
 [ 11 849   9   6   6   8  15   3  18  75]
 [ 42   0 726  35  72  35  64  19   7   0]
 [  5   3 160 440  74 176  95  21  15  11]
 [  7   0 137  25 699  37  52  36   6   1]
 [  3   1 100 115  61 648  29  36   2   5]
 [  4   2  93  30  34  31 802   2   2   0]
 [  8   1  73  21 112  74   7 690   5   9]
 [ 37  20  21   9  13   5   9   2 864  20]
 [ 11  58  17   4   9  12  10  11  23 845]]
```

These results show that this model took less time to train than the model from Problem 2a, but it had a worse training loss, accuracy, and F1 score.

2. Dropout with p = 0.3:
Training Time, Training Loss, and Evaluation Accuracy Results:

The values can be seen below:

The total training time was 12440.79 seconds or 3.456 hours.
The training loss was 0.23845631339589654 at epoch 291.
The final evaluation accuracy was 83.11%.
The F1 score was found to be 0.8312.
The confusion matrix can be seen below:

Figure 6: RESNET-Based CNN with Dropout Confusion Matrix

```
Final Confusion Matrix:
[[729   3  78  12  38   0  24   3  91  22]
 [  4 881   3   2   9   3  21   0  30  47]
 [ 23   0 854  12  34   6  55  10   6   0]
 [  4   0  93 724  52  44  62  13   7   1]
 [  1   0  59  15 876   1  41   5   2   0]
 [  3   0  76 149  65 654  44   8   0   1]
 [  2   0  22   9   6   1 957   2   1   0]
 [  3   0  30  15 130  11  14 795   2   0]
 [  7   3   8   7   7   1  14   0 951   2]
 [ 13  23   9  13  12   0  14   2  24 890]]
```

These results show that this model took less time to train the model from Problem 2a, but had a worse training loss than the model from 2a. However, it had a better accuracy and F1 score.