# Output:

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Case I: Using AutoEncoder as hidden-layer and training the classifier layer

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Initializing the Feed-Forward Neural Network ...

Training Feed-Forward Neural Network ...

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Error on Training and Testing Set: Before Training

Error Fraction on training: 1.0

Error Fraction on testing: 0.902

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Epoch 1:

Error Fraction on training: 0.994

Error Fraction on testing: 0.295

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Epoch 2:

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Epoch 3:

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Epoch 4:

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Epoch 5:

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Epoch 6:

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Epoch 7:

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Epoch 8:

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Epoch 9:

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Epoch 10:

Error Fraction on training: 0.7665

Error Fraction on testing: 0.151

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Epoch 11:

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Epoch 12:

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Epoch 13:

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Epoch 14:

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Epoch 15:

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Epoch 16:

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Epoch 17:

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Epoch 18:

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Epoch 19:

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Epoch 20:

Error Fraction on training: 0.715

Error Fraction on testing: 0.155

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Epoch 21:

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Epoch 22:

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Epoch 23:

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Epoch 24:

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Epoch 25:

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Epoch 26:

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Epoch 27:

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Epoch 28:

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Epoch 29:

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Epoch 30:

Error Fraction on training: 0.6755

Error Fraction on testing: 0.158

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Epoch 31:

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Epoch 32:

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Epoch 33:

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Epoch 34:

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Epoch 35:

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Epoch 36:

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Epoch 37:

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Epoch 38:

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Epoch 39:

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Epoch 40:

Error Fraction on training: 0.653

Error Fraction on testing: 0.15

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Epoch 41:

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Epoch 42:

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Epoch 43:

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Epoch 44:

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Epoch 45:

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Epoch 46:

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Epoch 47:

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Epoch 48:

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Epoch 49:

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Epoch 50:

Error Fraction on training: 0.6455

Error Fraction on testing: 0.163

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Epoch 51:

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Epoch 52:

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Epoch 53:

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Epoch 54:

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Epoch 55:

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Epoch 56:

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Epoch 57:

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Epoch 58:

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Epoch 59:

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Epoch 60:

Error Fraction on training: 0.6295

Error Fraction on testing: 0.153

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Epoch 61:

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Epoch 62:

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Epoch 63:

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Epoch 64:

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Epoch 65:

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Epoch 66:

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Epoch 67:

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Epoch 68:

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Epoch 69:

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Epoch 70:

Error Fraction on training: 0.6135

Error Fraction on testing: 0.155

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Epoch 71:

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Epoch 72:

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Epoch 73:

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Epoch 74:

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Epoch 75:

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Epoch 76:

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Epoch 77:

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Epoch 78:

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Epoch 79:

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Epoch 80:

Error Fraction on training: 0.6175

Error Fraction on testing: 0.154

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Epoch 81:

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Epoch 82:

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Epoch 83:

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Epoch 84:

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Epoch 85:

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Epoch 86:

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Epoch 87:

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Epoch 88:

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Epoch 89:

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Epoch 90:

Error Fraction on training: 0.6135

Error Fraction on testing: 0.173

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Epoch 91:

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Epoch 92:

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Epoch 93:

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Epoch 94:

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Epoch 95:

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Epoch 96:

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Epoch 97:

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Epoch 98:

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Epoch 99:

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Epoch 100:

Error Fraction on training: 0.6035

Error Fraction on testing: 0.16

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Plotting Error Fraction of the Network

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Average Error over the training set, after training: 0.60975

Average Error over the training set, after training: 0.598

Plotting average error on Training and Testing set, after Training

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Plotting average error on digits, over Training and Testing set (after Training)

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Predicting over training and testing set:

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Confusion Matrix on Training Set:

0 1 2 3 4 5 6 7 8 9

0 381 0 3 0 1 8 3 2 2 0

1 0 385 7 1 0 2 4 0 1 0

2 4 2 356 8 2 4 6 8 5 5

3 1 1 13 348 1 13 4 5 8 6

4 2 0 11 2 327 8 3 6 10 31

5 21 2 7 22 8 311 10 2 14 3

6 13 2 11 1 5 19 340 3 4 2

7 4 9 20 0 9 6 1 336 2 13

8 9 3 11 25 5 26 3 4 309 5

9 6 6 5 9 13 16 1 13 13 318

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Confusion Matrix on Testing Set:

0 1 2 3 4 5 6 7 8 9

0 97 0 0 1 0 1 0 0 1 0

1 0 94 1 2 0 3 0 0 0 0

2 2 1 84 4 2 1 1 4 1 0

3 1 0 3 83 1 6 0 2 1 3

4 3 1 2 1 76 3 2 1 0 11

5 1 0 2 3 3 80 3 0 7 1

6 3 0 5 0 0 4 88 0 0 0

7 0 2 7 2 1 1 1 84 0 2

8 1 2 3 5 2 3 3 2 75 4

9 3 1 3 1 6 3 0 2 2 79

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Case II: Using AutoEncoder as hidden-layer and training the entire network

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Initializing the Feed-Forward Neural Network ...

Training Feed-Forward Neural Network ...

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Error on Training and Testing Set: Before Training

Error Fraction on training: 1.0

Error Fraction on testing: 0.886

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Epoch 1:

Error Fraction on training: 0.988

Error Fraction on testing: 0.236

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Epoch 2:

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Epoch 3:

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Epoch 4:

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Epoch 5:

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Epoch 6:

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Epoch 7:

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Epoch 8:

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Epoch 9:

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Epoch 10:

Error Fraction on training: 0.408

Error Fraction on testing: 0.116

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Epoch 11:

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Epoch 12:

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Epoch 13:

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Epoch 14:

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Epoch 15:

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Epoch 16:

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Epoch 17:

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Epoch 18:

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Epoch 19:

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Epoch 20:

Error Fraction on training: 0.2585

Error Fraction on testing: 0.11

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Epoch 21:

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Epoch 22:

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Epoch 23:

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Epoch 24:

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Epoch 25:

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Epoch 26:

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Epoch 27:

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Epoch 28:

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Epoch 29:

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Epoch 30:

Error Fraction on training: 0.166

Error Fraction on testing: 0.112

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Epoch 31:

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Epoch 32:

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Epoch 33:

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Epoch 34:

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Epoch 35:

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Epoch 36:

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Epoch 37:

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Epoch 38:

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Epoch 39:

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Epoch 40:

Error Fraction on training: 0.0915

Error Fraction on testing: 0.113

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Epoch 41:

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Epoch 42:

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Epoch 43:

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Epoch 44:

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Epoch 45:

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Epoch 46:

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Epoch 47:

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Epoch 48:

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Epoch 49:

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Epoch 50:

Error Fraction on training: 0.049

Error Fraction on testing: 0.11

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Epoch 51:

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Epoch 52:

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Epoch 53:

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Epoch 54:

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Epoch 55:

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Epoch 56:

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Epoch 57:

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Epoch 58:

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Epoch 59:

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Epoch 60:

Error Fraction on training: 0.029

Error Fraction on testing: 0.113

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Epoch 61:

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Epoch 62:

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Epoch 63:

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Epoch 64:

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Epoch 65:

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Epoch 66:

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Epoch 67:

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Epoch 68:

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Epoch 69:

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Epoch 70:

Error Fraction on training: 0.021

Error Fraction on testing: 0.112

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Epoch 71:

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Epoch 72:

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Epoch 73:

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Epoch 74:

Error Fraction on training: 0.01

Error Fraction on testing: 0.111

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Plotting Error Fraction of the Network

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Average Error over the training set, after training: 0.183

Average Error over the testing set, after training: 0.341

Plotting average error on Training and Testing set, after Training

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Plotting average error on digits, over Training and Testing set (after Training)

====================================================================================================

Predicting over training and testing set:

====================================================================================================

Confusion Matrix on Training Set:

0 1 2 3 4 5 6 7 8 9

0 394 0 1 0 0 2 2 1 0 0

1 0 387 0 1 1 0 3 4 4 0

2 1 1 377 1 4 0 3 10 3 0

3 2 2 7 366 1 8 1 3 4 6

4 0 1 1 0 378 1 5 2 1 11

5 8 0 0 8 4 358 3 1 13 5

6 2 2 1 0 2 3 389 0 1 0

7 3 3 2 0 7 4 0 377 0 4

8 1 0 4 7 4 2 2 1 374 5

9 1 2 0 4 3 4 0 9 3 374

====================================================================================================

Confusion Matrix on Testing Set:

0 1 2 3 4 5 6 7 8 9

0 97 0 0 0 0 0 2 0 1 0

1 0 95 0 1 0 2 0 1 0 1

2 0 1 87 1 3 0 1 3 4 0

3 1 0 3 81 3 3 0 1 7 1

4 0 0 2 0 87 1 2 1 0 7

5 2 0 0 3 0 84 5 0 6 0

6 1 0 2 0 0 2 94 0 1 0

7 1 3 1 0 0 0 0 91 0 4

8 1 1 0 3 2 0 3 1 87 2

9 2 1 0 1 5 0 0 3 2 86