Part 1

MLFNN

The MNIST dataset is a dataset of handwritten digits, comprising 60 000 training examples and 10 000 test examples.

1. loadMNISTImages is a function which returns a 28x28x[number of MNIST images] matrix containing the raw MNIST images.
2. It then reshape to Number of pixels x No of examples.
3. Then Convert to double and rescale to [0,1].

Format of Confusion Matrix

Confusion Matrix is 10X10 matrix where each row represents the true label of a test sample and the columns represents the predicted labels of NN classifiers.

RESULTS

Standard Deviation for Eta = 0.5 is 61.566
Standard Deviation for Eta = 0.6 72.978

For 1 iteration

```
octave:3> accuracy(Wkj ,Wji)
Accuracy is 92.210000
ConfusionMatrix =

   957      0      2      3      0      2      4      2     10      0
     0   1108      4      3      0      1      4      3     11      1
    11      0    932     17     14      3      8     15     31      1
     3      1     21    902      0     31      3     10     34      5
     2      0      5      1    945      0      6      4      6     13
    14      3      3     33      7    772     13      4     33     10
    17      3      6      1     19     16    851      0     45      0
     3      7     23      6      7      0      1    964      3     14
     4      1      4     11      7      6      6     12    920      3
     6      5      0     14     72      1      1     20     20    870
```

(for each iterations)

```
Recall for  1 is 0.976531
Recall for  2 is 0.976211
Recall for  3 is 0.903101
Recall for  4 is 0.893069
Recall for  5 is 0.962322
Recall for  6 is 0.865471
Recall for  7 is 0.888309
Recall for  8 is 0.937743
Recall for  9 is 0.944559
Recall for  10 is 0.862240
Specificity for  1 is 0.993348
Specificity for  2 is 0.997744
Specificity for  3 is 0.992417
Specificity for  4 is 0.990100
Specificity for  5 is 0.986028
Specificity for  6 is 0.993412
Specificity for  7 is 0.994913
Specificity for  8 is 0.992198
Specificity for  9 is 0.978617
Specificity for  10 is 0.994773
Precision for  1 is 0.941003
Precision for  2 is 0.982270
Precision for  3 is 0.932000
Precision for  4 is 0.910192
Precision for  5 is 0.882353
Precision for  6 is 0.927885
Precision for  7 is 0.948718
Precision for  8 is 0.932302
Precision for  9 is 0.826595
Precision for  10 is 0.948746
```

	0	1	2	3	4	5	6	7	8	9
Recall	0.976531	0.976211	0.903101	0.893069	0.962322	0.865471	0.888309	0.937743	0.944559	0.862240
Specificity	0.993348	0.997744	0.992417	0.990100	0.986028	0.993412	0.994913	0.992198	0.978617	0.994773
Precision	0.941003	0.982270	0.932000	0.910192	0.882353	0.927885	0.948718	0.932302	0.826595	0.948746

Performance metrics for First iteration

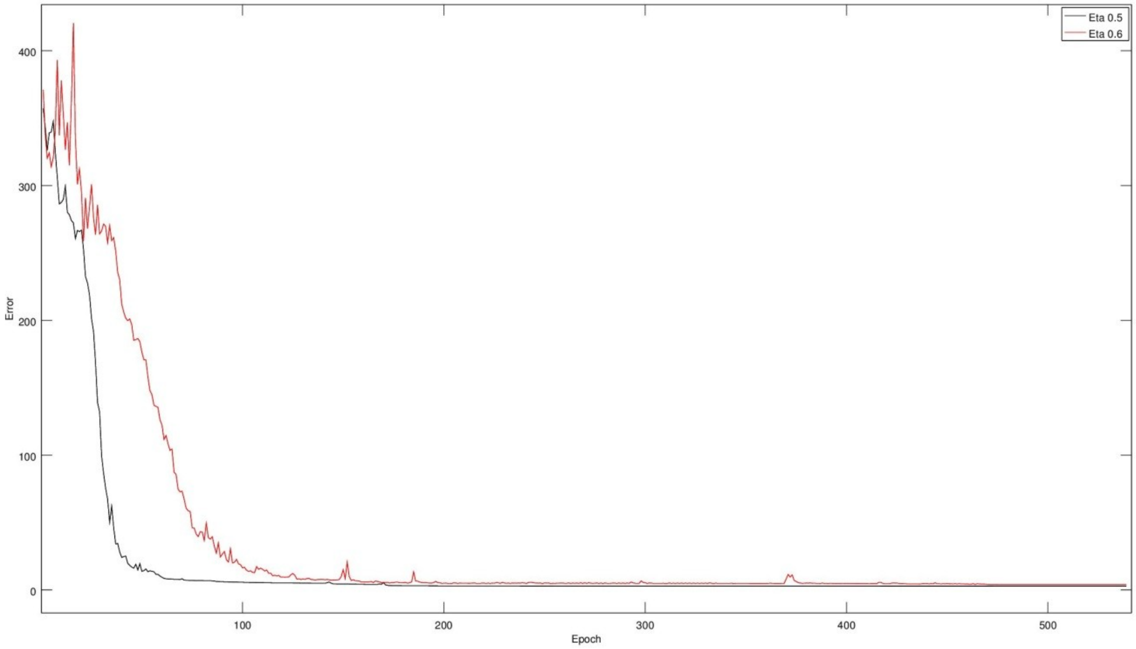

Fig. Error rate vs number of epochs

Part 2

Knn results(K=1)

Knn shows better results than MLFNN for K=1.
It has more accuracy compared to MLFNN.

```
octave:9> knnWrapper
Accuracy is 96.910000
ConfusionMatrix =

    973      1      1      0      0      1      3      1      0      0
      0   1129      3      0      1      1      1      0      0      0
      7      6    992      5      1      0      2     16      3      0
      0      1      2    970      1     19      0      7      7      3
      0      7      0      0    944      0      3      5      1     22
      1      1      0     12      2    860      5      1      6      4
      4      2      0      0      3      5    944      0      0      0
      0     14      6      2      4      0      0    992      0     10
      6      1      3     14      5     13      3      4    920      5
      2      5      1      6     10      5      1     11      1    967

Recall for  1 is 0.992857
Recall for  2 is 0.994714
Recall for  3 is 0.961240
Recall for  4 is 0.960396
Recall for  5 is 0.961303
Recall for  6 is 0.964126
Recall for  7 is 0.985386
Recall for  8 is 0.964981
Recall for  9 is 0.944559
Recall for  10 is 0.958375
Specificity for  1 is 0.997783
Specificity for  2 is 0.995713
Specificity for  3 is 0.998216
Specificity for  4 is 0.995662
Specificity for  5 is 0.997006
Specificity for  6 is 0.995169
Specificity for  7 is 0.998009
Specificity for  8 is 0.994984
Specificity for  9 is 0.998006
Specificity for  10 is 0.995106
Precision for  1 is 0.979859
Precision for  2 is 0.967438
Precision for  3 is 0.984127
Precision for  4 is 0.961348
Precision for  5 is 0. 961348
Precision for  6 is 0.951327
Precision for  7 is 0.981289
Precision for  8 is 0.956606
Precision for  9 is 0.980810
Precision for  10 is 0.956479
Accuracy is 96.910000
```

	0	1	2	3	4	5	6	7	8	9
Recall	0.992857	0.994714	0.961240	0.960396	0.961303	0.865471	0.964126	0.964981	0.944559	0.958375
Specificity	0.997783	0.995713	0.998216	0.995662	0.961303	0.995169	0.998009	0.994984	0.998006	0.995106
Precision	0.979859	0.967438	0.984127	0.961348	0.961348	0.951327	0.981289	0.956606	0.980810	0.956479

Performance metrics for KNN(K=1)

Part 3

Adding Noise

```
octave:3> accuracy
Accuracy is 96.290000
ConfusionMatrix =

    968      0      1      0      0      0      4      4      3      0
      0   1124      2      2      1      1      2      1      2      0
     10      3    984      5      6      1      6      9      8      0
      2      3     11    955      2     10      0     10     11      6
      1      0      1      0    943      0      8      2      2     25
      5      2      1     15      2    840     13      1      6      7
      8      3      1      1      4      2    933      0      6      0
      0      7      7      6      1      0      1    995      0     11
      3      5      3      6      6      2      6      6    931      6
      7      6      1      9     15      3      1      8      3    956

Recall for  1 is 0.987755
Recall for  2 is 0.990308
Recall for  3 is 0.953488
Recall for  4 is 0.945545
Recall for  5 is 0.960285
Recall for  6 is 0.941704
Recall for  7 is 0.973904
Recall for  8 is 0.967899
Recall for  9 is 0.955852
Recall for  10 is 0.947473
Specificity for  1 is 0.996009
Specificity for  2 is 0.996729
Specificity for  3 is 0.996878
Specificity for  4 is 0.995106
Specificity for  5 is 0.995897
Specificity for  6 is 0.997914
Specificity for  7 is 0.995466
Specificity for  8 is 0.995430
Specificity for  9 is 0.995458
Specificity for  10 is 0.993883
Precision for  1 is 0.964143
Precision for  2 is 0.974848
Precision for  3 is 0.972332
Precision for  4 is 0.955956
Precision for  5 is 0.962245
Precision for  6 is 0.977881
Precision for  7 is 0.957906
Precision for  8 is 0.960425
Precision for  9 is 0.957819
Precision for  10 is 0.945598
```

	0	1	2	3	4	5	6	7	8	9
Recall	0.987755	0.990308	0.953488	0.945545	0.960285	0.941704	0.973904	0.967899	0.955852	0.947473
Specificity	0.996009	0.996729	0.996878	0.995106	0.995897	0.997914	0.995466	0.995430	0.995458	0.993883
Precision	0.964143	0.974848	0.972332	0.955956	0.962245	0.977881	0.957906	0.960425	0.957819	0.945598

Performance metrics for Noise addition

Weight Decay

```
octave:23> accuracy
Accuracy is 49.730000
ConfusionMatrix =

    972      4      0      0      0      0      4      0      0      0
      1   1132      0      1      0      0      1      0      0      0
    271    664      0      1      7      0     84      5      0      0
    264    276      0    446      0     12      3      8      1      0
     40    147      0      0    720      0     73      1      1      0
    613    179      0      2      0     57     32      8      1      0
     70     41      0      0      2      0    845      0      0      0
     47    174      0      0      4      0      2    801      0      0
    273    659      0      0      2      0     34      6      0      0
    192    373      0      0    313      2      5    110     14      0

Recall for  1 is 0.991837
Recall for  2 is 0.997357
Recall for  3 is 0.000000
Recall for  4 is 0.441584
Recall for  5 is 0.733198
Recall for  6 is 0.063901
Recall for  7 is 0.882046
Recall for  8 is 0.779183
Recall for  9 is 0.000000
Recall for  10 is 0.000000
Specificity for  1 is 0.803659
Specificity for  2 is 0.716074
Specificity for  3 is 1.000000
Specificity for  4 is 0.999555
Specificity for  5 is 0.963628
Specificity for  6 is 0.998463
Specificity for  7 is 0.973678
Specificity for  8 is 0.984619
Specificity for  9 is 0.998117
Specificity for  10 is 1.000000
Precision for  1 is 0.354357
Precision for  2 is 0.310222
warning: division by zero
Precision for  3 is NaN
Precision for  4 is 0.991111
Precision for  5 is 0.687023
Precision for  6 is 0.802817
Precision for  7 is 0.780240
Precision for  8 is 0.853035
Precision for  9 is 0.000000
warning: division by zero
Precision for  10 is NaN
```

	0	1	2	3	4	5	6	7	8	9
Recall	0.991837	0.997357	0.000000	0.441584	0.733198	0.063901	0.882046	0.779183	0.000000	0.000000
Specificity	0.803659	0.716074	1.000000	0.999555	0.963628	0.998463	0.973678	0.984619	0.998117	1.000000
Precision	0.354357	0.310222	NaN	0.991111	0.687023	0.802817	0.780240	0.853035	0.000000	NaN

Performance metrics for weight decay

Analysis

1. Training the data by adding noise increases the accuracy
2. By weight decay accuracy is reduced as it is converging faster

References

1. Data - http://yann.lecun.com/exdb/mnist/
2. Image Extraction - http://ufldl.stanford.edu/wiki/index.php/Using_the_MNIST_Dataset