Classification of Grey-scale Images

Paula Kimmerling

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1. The Dataset

2. Training Choices

3. Fits

The Dataset

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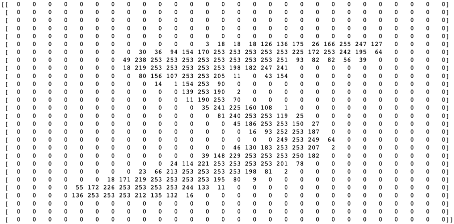
- There were 60,000 training samples and 10,000 testing samples already separated.
- Each sample was a pre-processed 28 x 28 matrix of integers 0 - 255, with 0 indicating no saturation vs 255 full saturation.



```
[[  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   3  18  18  18 126 136 175  26 166 255 247 127   0   0   0   0]
 [  0   0   0   0   0   0   0   0  30  36  94 154 170 253 253 253 253 253 225 172 253 242 195  64   0   0   0   0]
 [  0   0   0   0   0   0   0  49 238 253 253 253 253 253 253 253 253 251  93  82  82  56  39   0   0   0   0   0]
 [  0   0   0   0   0   0   0  18 219 253 253 253 253 253 198 182 247 241   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0  80 156 107 253 253 205  11   0  43 154   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0  14   1 154 253  90   0   0   0   0   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0 139 253 190   2   0   0   0   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0  11 190 253  70   0   0   0   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0  35 241 225 160 108   1   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0  81 240 253 253 119  25   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0  45 186 253 253 150  27   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  16  93 252 253 187   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 249 253 249  64   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0  46 130 183 253 253 207   2   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0  39 148 229 253 253 253 250 182   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0  24 114 221 253 253 253 253 201  78   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0  23  66 213 253 253 253 253 198  81   2   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0  18 171 219 253 253 253 253 195  80   9   0   0   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0  55 172 226 253 253 253 253 244 133  11   0   0   0   0   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0 136 253 253 253 212 135 132  16   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0]
 [  0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0]]
```

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5. Use bfgs as the non-linear solver.
6. Read back the binary numbers to integer to compare.

What Actually Happened

60,000 samples was too much for my local code. So I used the MLPCLassifier from sci-kit learn which runs faster because it has bits already compiled:

```
from sklearn.neural_network import MLPClassifier

clf = MLPClassifier(solver=‘lbfgs’,
    activation=‘logistic’,alpha=regParam,
hidden_layer_sizes=(k,), random_state=1)
start = time.time()
clf.fit(trainX,trainY)
end = time.time()
print("Time to train:", end-start)
```

`Time to train:` 581.859 $\approx$ 9.7 minutes

Fit to Train Data

It trained to fit the data perfectly in this case, because the ‘score’ attribute of the classifier gives an average percentage accuracy.

```
    pred = clf.predict(trainX)
    clf.score(trainX,trainY)
```

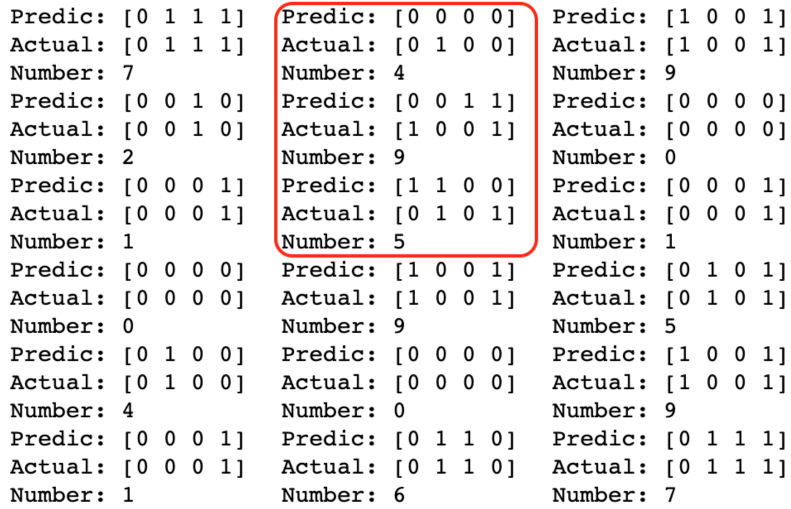
1.0 $= 100\%$

It also didn't do too badly on the testing data:

```
    pred = clf.predict(testX)
    clf.score(testX,testY)
```

0.8276 $= 82.76\%$

Examples of Test Data Outputs



```
Predic: [0 1 1 1]    Predic: [0 0 0 0]    Predic: [1 0 0 1]
Actual: [0 1 1 1]    Actual: [0 1 0 0]    Actual: [1 0 0 1]
Number: 7            Number: 4            Number: 9
Predic: [0 0 1 0]    Predic: [0 0 1 1]    Predic: [0 0 0 0]
Actual: [0 0 1 0]    Actual: [1 0 0 1]    Actual: [0 0 0 0]
Number: 2            Number: 9            Number: 0
Predic: [0 0 0 1]    Predic: [1 1 0 0]    Predic: [0 0 0 1]
Actual: [0 0 0 1]    Actual: [0 1 0 1]    Actual: [0 0 0 1]
Number: 1            Number: 5            Number: 1
Predic: [0 0 0 0]    Predic: [1 0 0 1]    Predic: [0 1 0 1]
Actual: [0 0 0 0]    Actual: [1 0 0 1]    Actual: [0 1 0 1]
Number: 0            Number: 9            Number: 5
Predic: [0 1 0 0]    Predic: [0 0 0 0]    Predic: [1 0 0 1]
Actual: [0 1 0 0]    Actual: [0 0 0 0]    Actual: [1 0 0 1]
Number: 4            Number: 0            Number: 9
Predic: [0 0 0 1]    Predic: [0 1 1 0]    Predic: [0 1 1 1]
Actual: [0 0 0 1]    Actual: [0 1 1 0]    Actual: [0 1 1 1]
Number: 1            Number: 6            Number: 7
```