```
Python 3.6.3 |Anaconda, Inc.| (default, Oct 13 2017, 12:02:49)
Type "copyright", "credits" or "license" for more information.

IPython 6.1.0 -- An enhanced Interactive Python.

In [1]: runfile('/home/hadoop1/Documents/prml/
assignment2/16210029_assignment2.py', wdir='/home/hadoop1/Documents/prml/
assignment2')
Data loaded!
Feature vectors were normalized!
================================================================================
#####   MNIST data with K-nearest neighbors  #####
```

Training confussion matrix

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 5554 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 6247 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 5595 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 5678 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 5397 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 5099 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 5469 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5858 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5473 | 0 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5630 |

Testing confussion matrix

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1339 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 0 |
| 1 | 17 | 1398 | 10 | 3 | 3 | 0 | 6 | 4 | 183 | 6 |
| 2 | 215 | 0 | 1110 | 21 | 1 | 0 | 6 | 1 | 41 | 0 |
| 3 | 290 | 1 | 34 | 889 | 0 | 17 | 0 | 5 | 224 | 3 |
| 4 | 380 | 3 | 2 | 1 | 776 | 0 | 14 | 11 | 160 | 80 |
| 5 | 304 | 0 | 4 | 23 | 0 | 571 | 28 | 0 | 277 | 7 |
| 6 | 141 | 1 | 3 | 1 | 0 | 1 | 1227 | 0 | 33 | 0 |
| 7 | 100 | 0 | 31 | 8 | 8 | 0 | 0 | 1092 | 125 | 71 |
| 8 | 116 | 3 | 2 | 4 | 0 | 3 | 0 | 0 | 1224 | 0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 9 | 177 | 1 | 0 | 3 | 6 | 1 | 0 | 31 | 223 | 886 |

| Parameter | Value |
|---|---|
| Accuracy | 0.7509 |
| Top 1 Accuracy | 0.7509 |
| Top 3 Accuracy | 0.8795 |

K-nearest neighbors Running time is 3127 Sec.

==========

##### MNIST data with Decision Tree #####

Training confussion matrix

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 5554 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 6247 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 5595 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 5678 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 0 | 0 | 5397 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 | 0 | 5099 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 5469 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5858 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5473 | 0 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5630 |

Testing confussion matrix

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1144 | 2 | 21 | 31 | 9 | 35 | 50 | 17 | 22 | 18 |
| 1 | 3 | 1490 | 25 | 10 | 6 | 14 | 31 | 13 | 26 | 12 |
| 2 | 28 | 40 | 1046 | 109 | 19 | 12 | 33 | 46 | 42 | 20 |
| 3 | 20 | 26 | 62 | 948 | 36 | 160 | 15 | 36 | 102 | 58 |
| 4 | 12 | 57 | 53 | 33 | 999 | 28 | 53 | 17 | 56 | 119 |
| 5 | 22 | 22 | 19 | 136 | 19 | 824 | 52 | 8 | 65 | 47 |
| 6 | 23 | 15 | 54 | 10 | 54 | 122 | 1082 | 6 | 37 | 4 |
| 7 | 7 | 26 | 69 | 62 | 15 | 8 | 1 | 1175 | 17 | 55 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 29 | 35 | 49 | 145 | 40 | 114 | 65 | 50 | 783 | 42 |
| 9 | 28 | 19 | 17 | 67 | 107 | 25 | 10 | 103 | 100 | 852 |

| Parameter | Value |
|---|---|
| Accuracy | 0.7388 |
| Top 1 Accuracy | 0.7388 |
| Top 3 Accuracy | 0.7536 |

Decision Tree Running time is 26 Sec.

==========

##### MNIST data with SVM #####

Training confussion matrix

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 5447 | 0 | 13 | 9 | 9 | 14 | 21 | 6 | 31 | 4 |
| 1 | 1 | 6109 | 34 | 13 | 5 | 20 | 8 | 10 | 40 | 7 |
| 2 | 31 | 39 | 5109 | 61 | 54 | 27 | 55 | 59 | 141 | 19 |
| 3 | 19 | 18 | 139 | 5112 | 10 | 147 | 17 | 50 | 109 | 57 |
| 4 | 8 | 20 | 29 | 11 | 5080 | 14 | 32 | 11 | 42 | 150 |
| 5 | 46 | 21 | 29 | 149 | 54 | 4532 | 77 | 17 | 119 | 55 |
| 6 | 19 | 12 | 33 | 3 | 23 | 71 | 5279 | 0 | 28 | 1 |
| 7 | 11 | 19 | 66 | 9 | 49 | 13 | 4 | 5523 | 17 | 147 |
| 8 | 38 | 115 | 59 | 120 | 36 | 156 | 47 | 26 | 4785 | 91 |
| 9 | 24 | 20 | 17 | 103 | 169 | 42 | 2 | 185 | 43 | 5025 |

Testing confussion matrix

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1303 | 0 | 4 | 2 | 0 | 1 | 9 | 0 | 27 | 3 |
| 1 | 0 | 1184 | 6 | 9 | 2 | 0 | 5 | 1 | 414 | 9 |
| 2 | 15 | 2 | 1130 | 32 | 12 | 0 | 18 | 7 | 172 | 7 |
| 3 | 10 | 0 | 24 | 1282 | 0 | 2 | 3 | 2 | 125 | 15 |
| 4 | 6 | 1 | 7 | 5 | 1100 | 0 | 11 | 1 | 181 | 115 |
| 5 | 14 | 1 | 8 | 108 | 10 | 402 | 45 | 2 | 579 | 45 |
| 6 | 18 | 0 | 9 | 1 | 3 | 5 | 1321 | 1 | 49 | 0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 7 | 19 | 1 | 10 | 18 | 8 | 1 | 1 | 1149 | 73 | 155 |
| 8 | 8 | 2 | 5 | 21 | 3 | 2 | 4 | 1 | 1299 | 7 |
| 9 | 9 | 2 | 6 | 14 | 11 | 3 | 1 | 4 | 96 | 1182 |

| Parameter | Value |
|---|---|
| Accuracy | 0.8109 |
| Top 1 Accuracy | 0.8109 |
| Top 3 Accuracy | 0.9668 |

SVM Running time is 97 Sec.

==========

##### MNIST data with Logistic Regression #####

Training confussion matrix

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 5443 | 0 | 13 | 9 | 8 | 17 | 24 | 4 | 32 | 4 |
| 1 | 2 | 6100 | 33 | 12 | 4 | 26 | 8 | 11 | 45 | 6 |
| 2 | 30 | 50 | 5098 | 67 | 63 | 20 | 54 | 57 | 138 | 18 |
| 3 | 20 | 28 | 126 | 5128 | 5 | 144 | 19 | 47 | 105 | 56 |
| 4 | 12 | 20 | 26 | 9 | 5078 | 6 | 34 | 10 | 41 | 161 |
| 5 | 48 | 24 | 28 | 148 | 52 | 4544 | 81 | 16 | 106 | 52 |
| 6 | 19 | 16 | 28 | 2 | 26 | 73 | 5272 | 4 | 27 | 2 |
| 7 | 14 | 25 | 58 | 12 | 48 | 11 | 4 | 5518 | 17 | 151 |
| 8 | 38 | 127 | 48 | 109 | 36 | 147 | 44 | 26 | 4820 | 78 |
| 9 | 28 | 31 | 15 | 100 | 161 | 37 | 3 | 168 | 43 | 5044 |

Testing confussion matrix

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1305 | 0 | 3 | 2 | 0 | 1 | 9 | 0 | 26 | 3 |
| 1 | 0 | 1263 | 4 | 12 | 2 | 0 | 4 | 1 | 339 | 5 |
| 2 | 9 | 3 | 1147 | 33 | 17 | 0 | 14 | 4 | 165 | 3 |
| 3 | 10 | 0 | 26 | 1285 | 0 | 1 | 4 | 2 | 126 | 9 |
| 4 | 6 | 1 | 6 | 5 | 1126 | 0 | 12 | 0 | 176 | 95 |
| 5 | 16 | 1 | 7 | 115 | 13 | 409 | 43 | 3 | 566 | 41 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 17 | 1 | 5 | 1 | 3 | 5 | 1329 | 1 | 45 | 0 |
| 7 | 15 | 0 | 9 | 25 | 6 | 1 | 1 | 1162 | 78 | 138 |
| 8 | 8 | 2 | 5 | 23 | 3 | 3 | 4 | 0 | 1299 | 5 |
| 9 | 10 | 2 | 4 | 17 | 11 | 3 | 1 | 2 | 107 | 1171 |

| Parameter | Value |
|---|---|
| Accuracy | 0.8211 |
| Top 1 Accuracy | 0.8211 |
| Top 3 Accuracy | 0.9683 |

Logistic regression Running time is 53 Sec.

==========

---

Feature vectors were normalized!

==========

#####  Credit card data with K-nearest neighbors  #####

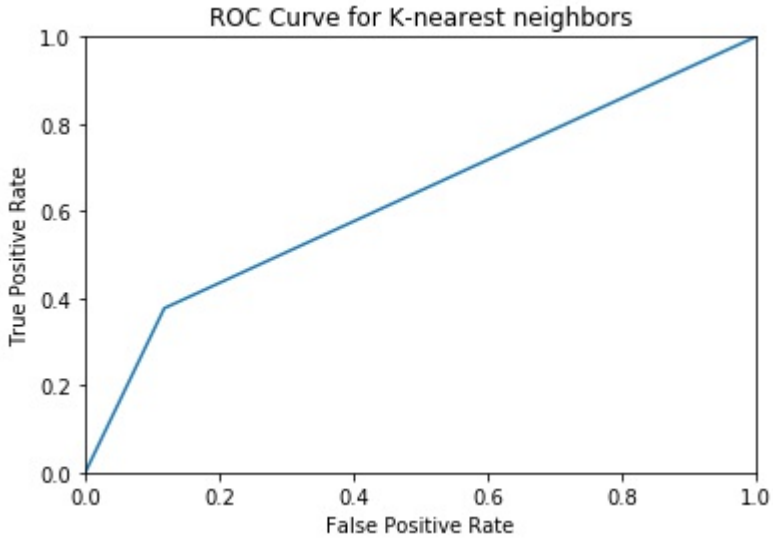
Training confussion matrix

| | 0 | 1 |
|---|---|---|
| 0 | 18688 | 0 |
| 1 | 14 | 5298 |

Testing confussion matrix

| | 0 | 1 |
|---|---|---|
| 0 | 4125 | 551 |
| 1 | 825 | 499 |

| Parameter | Value |
|---|---|
| Accuracy | 0.7707 |
| F1 Score | 0.4204 |
| Precision | 0.4752 |
| Recall Score | 0.3769 |




K-nearest neighbors Running time is 16 Sec.

==========

#####  Credit card data with Decision Tree  #####

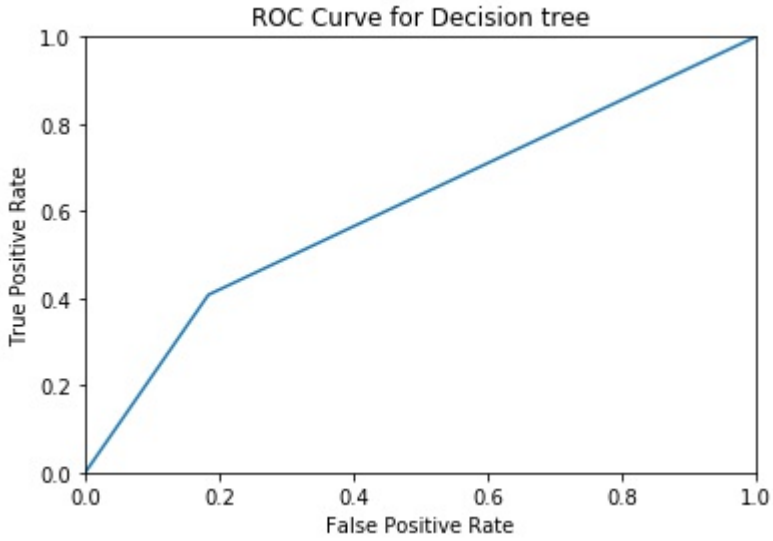
Training confussion matrix

| | 0 | 1 |
|---|---|---|
| 0 | 18688 | 0 |
| 1 | 14 | 5298 |

Testing confussion matrix

| | 0 | 1 |
|---|---|---|
| 0 | 3817 | 859 |
| 1 | 784 | 540 |

| Parameter | Value |
|---|---|
| Accuracy | 0.7262 |
| F1 Score | 0.3966 |
| Precision | 0.386 |
| Recall Score | 0.4079 |




Decision Tree Running time is 0 Sec.

==========

#####  Credit card data with SVM  #####

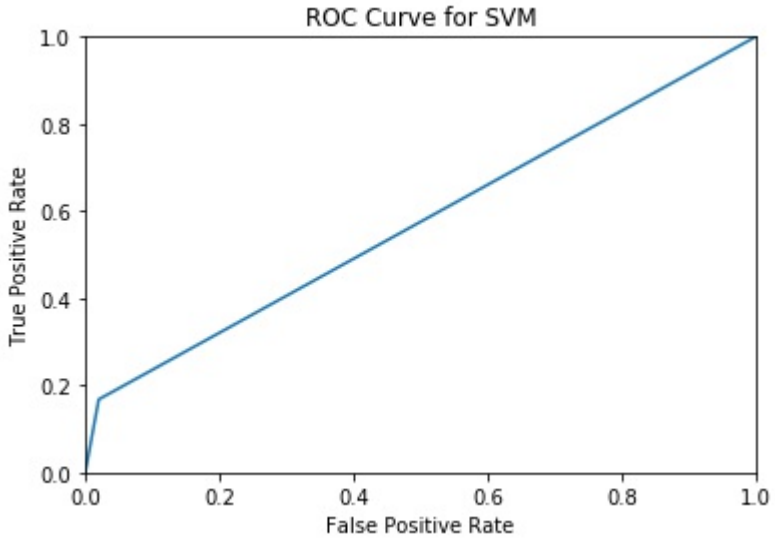
Training confussion matrix

| | 0 | 1 |
|---|---|---|
| 0 | 18368 | 320 |
| 1 | 4422 | 890 |

Testing confussion matrix

| | 0 | 1 |
|---|---|---|
| 0 | 4582 | 94 |
| 1 | 1102 | 222 |

| Parameter | Value |
|---|---|
| Accuracy | 0.8007 |
| F1 Score | 0.2707 |
| Precision | 0.7025 |
| Recall Score | 0.1677 |




SVM Running time is 6 Sec.

==========

#####  Credit card data with Logistic regression  #####

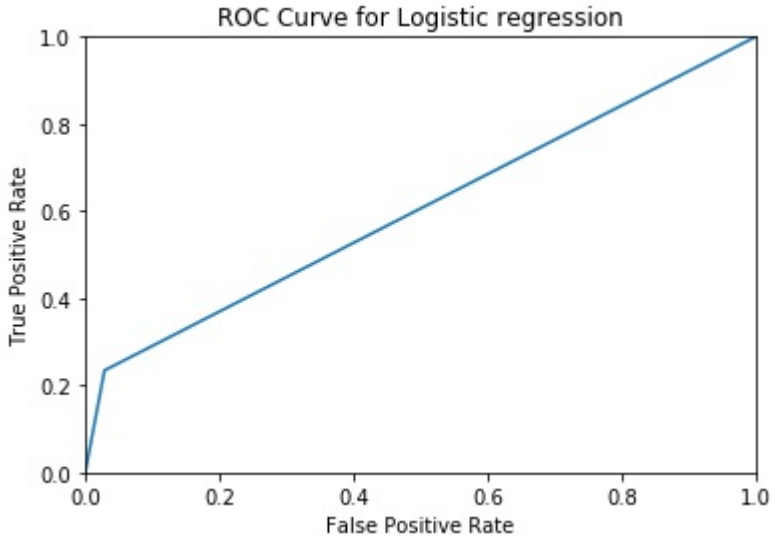
Training confussion matrix

| | 0 | 1 |
|---|---|---|
| 0 | 18186 | 502 |
| 1 | 4069 | 1243 |

Testing confussion matrix

| | 0 | 1 |
|---|---|---|
| 0 | 4542 | 134 |
| 1 | 1014 | 310 |

| Parameter | Value |
|---|---|
| Accuracy | 0.8087 |
| F1 Score | 0.3507 |
| Precision | 0.6982 |
| Recall Score | 0.2341 |




```
Logistic regression Running time is 0 Sec.
========================================================================
```

In [2]: