Decision Tree Algorithm

Prajjwal Vijaywargiya - 2017B3A70954H
Siddhi Mahesh Burse - 2017B3A70972H
Parth Krishna Sharma - 2017B3A70907H

```
In [1]: import numpy as np
        import pandas as pd
        import matplotlib.pyplot as plt
        import seaborn as sns
        %matplotlib inline
        from sklearn.tree import DecisionTreeClassifier
        from sklearn.metrics import accuracy_score,confusion_matrix,classification_report
```

```
In [2]: train_df = pd.read_csv('D:/BITS/DL/Assignments/Assignment1/mnist_train.csv')
        test_df = pd.read_csv('D:/BITS/DL/Assignments/Assignment1/mnist_test.csv')
```

```
In [3]: x_train,y_train = train_df.iloc[:,1:].values, train_df.iloc[:,0].values
        x_test,y_test = test_df.iloc[:,1:].values, test_df.iloc[:,0].values
```

```
In [4]: clf = DecisionTreeClassifier(criterion='entropy',min_samples_leaf=2,min_weight_fraction_leaf=0.0001,max
        _depth=15,min_samples_split=4)
```

```
In [5]: clf.fit(x_train,y_train)
```

```
Out[5]: DecisionTreeClassifier(ccp_alpha=0.0, class_weight=None, criterion='entropy',
                               max_depth=15, max_features=None, max_leaf_nodes=None,
                               min_impurity_decrease=0.0, min_impurity_split=None,
                               min_samples_leaf=2, min_samples_split=4,
                               min_weight_fraction_leaf=0.0001, presort='deprecated',
                               random_state=None, splitter='best')
```

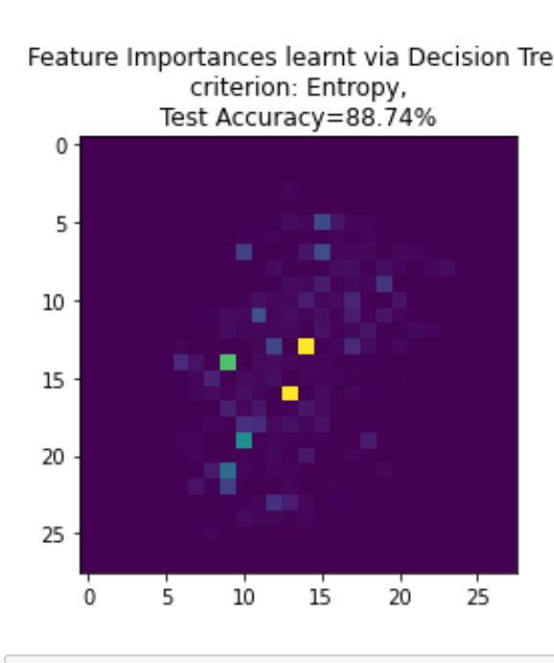
```
In [6]: prediction_test = clf.predict(x_test)
```

```
In [7]: acc = accuracy_score(y_test,prediction_test)
        acc
```

```
Out[7]: 0.8874
```

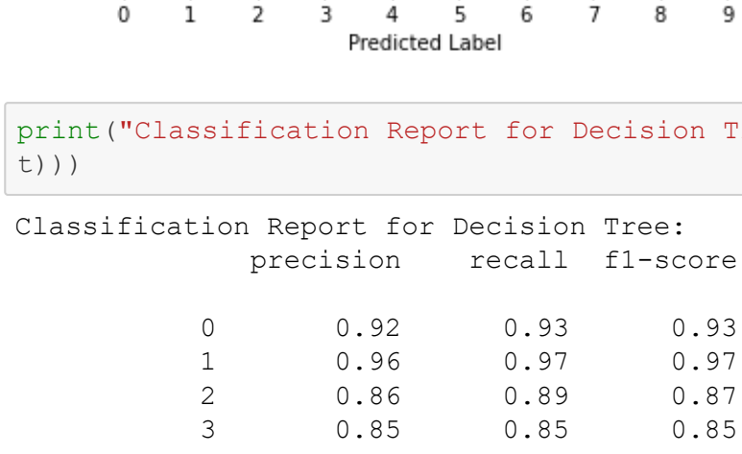
```
In [8]: importances = clf.feature_importances_
        ft = clf.feature_importances_
        ft = ft*25500
        plt.imshow(ft.reshape((28,28)))
        plt.title("Feature Importances learnt via Decision Tree\ncriterion: Entropy,\nTest Accuracy={}%".format
        (acc*100))
```

```
Out[8]: Text(0.5, 1.0, 'Feature Importances learnt via Decision Tree\ncriterion: Entropy,\nTest Accuracy=88.7
        4%')
```



```
In [9]: sns.heatmap(confusion_matrix(y_test,prediction_test),cmap='Blues_r',fmt='',annot=True,cbar=False)
        plt.ylabel("Correct Label")
        plt.xlabel("Predicted Label")
        plt.title("Confusion Matrix for Decision Tree\nModel Accuracy={}%".format(acc*100))
```

```
Out[9]: Text(0.5, 1.0, 'Confusion Matrix for Decision Tree\nModel Accuracy=88.74%')
```



	0	1	2	3	4	5	6	7	8	9
0	915	1	10	5	4	19	7	3	12	4
1	0	1104	6	4	1	6	5	5	4	0
2	10	8	914	20	8	13	21	14	20	4
3	8	8	26	861	4	52	4	16	11	20
4	7	1	18	6	873	6	13	7	15	36
5	15	4	4	43	8	757	14	1	27	19
6	16	4	18	4	23	20	850	4	18	1
7	3	9	31	11	14	5	3	930	7	15
8	10	3	27	44	24	20	11	11	802	22
9	12	4	7	17	40	17	4	20	20	868

```
In [10]: print("Classification Report for Decision Tree:\n{}".format(classification_report(y_test,prediction_tes
         t)))
```

```
Classification Report for Decision Tree:
              precision    recall  f1-score   support

           0       0.92      0.93      0.93       980
           1       0.96      0.97      0.97      1135
           2       0.86      0.89      0.87      1032
           3       0.85      0.85      0.85      1010
           4       0.87      0.89      0.88       982
           5       0.83      0.85      0.84       892
           6       0.91      0.89      0.90       958
           7       0.92      0.90      0.91      1028
           8       0.86      0.82      0.84       974
           9       0.88      0.86      0.87      1009

    accuracy                           0.89     10000
   macro avg       0.89      0.89      0.89     10000
weighted avg       0.89      0.89      0.89     10000
```

```
In [11]: indices = np.argsort(importances)[::-1]
```

In [12]:

```python
for f in range(x_train.shape[1]):
    print("{} Feature {} : {}".format(f+1,indices[f],importances[indices[f]]))
```

```
1 Feature 461 : 0.10005771861662746
2 Feature 378 : 0.09971260146917099
3 Feature 401 : 0.07211549889786366
4 Feature 542 : 0.05003210752126446
5 Feature 597 : 0.03529491950361849
6 Feature 319 : 0.025478094417570173
7 Feature 211 : 0.023631897414930436
8 Feature 155 : 0.023274291059641107
9 Feature 376 : 0.02168575872188201
10 Feature 206 : 0.019616754071280006
11 Feature 625 : 0.01917094705342835
12 Feature 271 : 0.015793498817472343
13 Feature 514 : 0.014356809203004245
14 Feature 656 : 0.013371683390381008
15 Feature 515 : 0.01312016344633828
16 Feature 398 : 0.012145224673141193
17 Feature 381 : 0.011876807649493087
18 Feature 297 : 0.010766254919249853
19 Feature 428 : 0.009630323356427883
20 Feature 485 : 0.008915999361770132
21 Feature 325 : 0.008147497537984692
22 Feature 657 : 0.008063163835953811
23 Feature 294 : 0.007703808669323691
24 Feature 550 : 0.0076749436659164
25 Feature 267 : 0.00766210653236479
26 Feature 596 : 0.007117437754605348
27 Feature 574 : 0.006749919070970159
28 Feature 490 : 0.006605251463005091
29 Feature 487 : 0.006543119399152042
30 Feature 354 : 0.006110500365445412
31 Feature 210 : 0.0057968391922388505
32 Feature 156 : 0.005520230489368123
33 Feature 327 : 0.0052582282912766
34 Feature 623 : 0.00504291355220124
35 Feature 399 : 0.004976388598694417
36 Feature 300 : 0.00482859086495225
37 Feature 517 : 0.004785795572889955
38 Feature 519 : 0.004755676553440852
39 Feature 351 : 0.0047384885849104915
40 Feature 243 : 0.0041388771370578815
41 Feature 291 : 0.004065234070176966
42 Feature 458 : 0.003947534091642139
43 Feature 241 : 0.003732678133747403
44 Feature 323 : 0.003555136787753262
45 Feature 432 : 0.0035457743117685565
46 Feature 247 : 0.0035295823767047857
47 Feature 345 : 0.0033102064333795267
48 Feature 321 : 0.0032118868887886366
49 Feature 240 : 0.003204207066080735
50 Feature 382 : 0.0031169243010497772
51 Feature 463 : 0.0031150524854956621
52 Feature 265 : 0.0030426252931207926
53 Feature 404 : 0.002969921591387746
54 Feature 153 : 0.0028516133320499416
55 Feature 317 : 0.0028488893359692345
56 Feature 296 : 0.0026793418572332007
57 Feature 236 : 0.0026148792422313032
58 Feature 682 : 0.002527094985969504
59 Feature 456 : 0.002505800450719805
60 Feature 491 : 0.0024958064216214913
61 Feature 430 : 0.0024942194238230706
62 Feature 403 : 0.0024389345425571405
63 Feature 516 : 0.002438529031472595
64 Feature 357 : 0.002289219379507956
65 Feature 465 : 0.002287926796462592
66 Feature 292 : 0.0022857945040019928
67 Feature 349 : 0.002272302196855429
68 Feature 295 : 0.0022541130530207916
69 Feature 405 : 0.002225321036259272
70 Feature 348 : 0.0022203797714281056
71 Feature 266 : 0.0021778938571696597
72 Feature 431 : 0.002169515706728828
73 Feature 318 : 0.0021659045022063236
74 Feature 347 : 0.002139434270876042
75 Feature 572 : 0.002136838748581306
76 Feature 384 : 0.0021259102917118716
77 Feature 214 : 0.0020908721787167447
78 Feature 269 : 0.002083637471919288
79 Feature 658 : 0.002068840133890967
80 Feature 293 : 0.0020468081772430885
81 Feature 213 : 0.0020467286732165925
82 Feature 607 : 0.002038444401427207
83 Feature 216 : 0.0020365645032990416
84 Feature 353 : 0.0020034400909949763
85 Feature 486 : 0.001984348388340491
86 Feature 212 : 0.0019735369164877704
87 Feature 157 : 0.001944453284968176
88 Feature 346 : 0.0019254156965755537
89 Feature 427 : 0.0019021879944647654
90 Feature 708 : 0.0018799337158836144
91 Feature 512 : 0.001871769035882171
92 Feature 686 : 0.0018439403126187008
93 Feature 328 : 0.0018239633279064221
94 Feature 455 : 0.001766009496247988
95 Feature 380 : 0.0017614885869552102
96 Feature 180 : 0.0017559165020850018
97 Feature 629 : 0.0017390228489418654
98 Feature 600 : 0.0017000632538050515
99 Feature 97 : 0.001665821024519031
100 Feature 577 : 0.0016475492119335203
101 Feature 154 : 0.0016446393245120215
102 Feature 375 : 0.0015487426229569446
103 Feature 684 : 0.0015486561831985143
104 Feature 598 : 0.0015419900068284536
105 Feature 270 : 0.0015320868368105178
106 Feature 436 : 0.0015077135424906086
107 Feature 322 : 0.001502177055040379
108 Feature 683 : 0.0014919325584577718
109 Feature 246 : 0.0014705328859620599
110 Feature 459 : 0.001448379035629891
111 Feature 518 : 0.0014400173049176448
112 Feature 370 : 0.001439740273997742
113 Feature 407 : 0.001438399557278681
114 Feature 244 : 0.0014342430221655422
115 Feature 655 : 0.0014313523751195202
116 Feature 435 : 0.0014239946005990519
117 Feature 217 : 0.0013695921854432662
118 Feature 539 : 0.0013472295978964597
119 Feature 186 : 0.0013401593277885032
120 Feature 358 : 0.0013366579684350299
121 Feature 601 : 0.0013185062713285895
122 Feature 544 : 0.0012548884048395655
123 Feature 158 : 0.001244695952940045
124 Feature 320 : 0.0012390796018748667
125 Feature 184 : 0.0012054695051821383
126 Feature 434 : 0.0012052680896797036
127 Feature 567 : 0.001191541160739032
128 Feature 538 : 0.0011732715046312593
129 Feature 218 : 0.0011710265270472881
130 Feature 238 : 0.0011708601235731716
131 Feature 178 : 0.0011556732011134643
132 Feature 326 : 0.0011504941146892914
133 Feature 570 : 0.0011188980819086404
134 Feature 547 : 0.001115851763484304
135 Feature 205 : 0.0011154128485561991
136 Feature 440 : 0.001111779965788228
137 Feature 679 : 0.0011070260471189712
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139 Feature 298 : 0.001054421612652612
140 Feature 185 : 0.0010518341184102085
141 Feature 546 : 0.0010409421697377106
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143 Feature 187 : 0.0010175409038678048
144 Feature 182 : 0.0009988439633125611
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147 Feature 457 : 0.0009428176898703322
148 Feature 521 : 0.00091813405589381
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151 Feature 316 : 0.0008903342147186314
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155 Feature 329 : 0.0008604712711258852
156 Feature 179 : 0.0008555715097191048
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174 Feature 356 : 0.0007111072657749514
175 Feature 602 : 0.0007033617437365871
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275 Feature 219 : 0.00022973396302684396
276 Feature 717 : 0.000225593344714498
277 Feature 305 : 0.00022096813725928975
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279 Feature 497 : 0.0002031424211230262
280 Feature 720 : 0.0002007396375588243
281 Feature 208 : 0.0001931914852479002
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283 Feature 549 : 0.00018647385026129745
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308 Feature 189 : 0.00013373599911553055
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310 Feature 500 : 0.00012912290930646502
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312 Feature 469 : 0.00012612534341893
313 Feature 606 : 0.000124005591333609
314 Feature 181 : 0.00012271157290684077
315 Feature 174 : 0.0001173773511457555
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324 Feature 652 : 9.326520268293438e-05
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326 Feature 98 : 9.104205292726319e-05
327 Feature 568 : 8.458271679160705e-05
328 Feature 231 : 8.143140864361099e-05
329 Feature 608 : 8.07006317634842e-05
330 Feature 228 : 7.897735123415233e-05
331 Feature 552 : 7.73751333488527e-05
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333 Feature 712 : 7.118773064131002e-05
334 Feature 678 : 6.859228973532344e-05
335 Feature 276 : 6.839251213625802e-05
336 Feature 414 : 6.345424175345378e-05
337 Feature 537 : 5.8530156874123416e-05
338 Feature 715 : 5.109521564746476e-05
339 Feature 303 : 5.085178011547995e-05
340 Feature 706 : 4.6987773421706355e-05
341 Feature 230 : 4.542514713740131e-05
342 Feature 651 : 4.255739111488194e-05
343 Feature 75 : 4.144134015800583e-05
344 Feature 425 : 3.720268689509823e-05
345 Feature 258 : 3.31077500579622e-05
346 Feature 565 : 3.148013561160946e-05
347 Feature 287 : 2.911109808848049e-05
348 Feature 662 : 2.9095516916091994e-05
349 Feature 609 : 2.37894331309255e-05
350 Feature 286 : 2.2307276011617e-05
351 Feature 383 : 1.9735792492749914e-05
352 Feature 525 : 1.8413437551832607e-05
353 Feature 387 : 1.6603238061194635e-05
354 Feature 628 : 1.3313349140808286e-05
355 Feature 650 : 1.210190925528151e-05
356 Feature 496 : 9.657272632223869e-06
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358 Feature 222 : 0.0
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360 Feature 221 : 0.0
361 Feature 200 : 0.0
362 Feature 201 : 0.0
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364 Feature 250 : 0.0
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373 Feature 199 : 0.0
374 Feature 49 : 0.0
375 Feature 56 : 0.0
376 Feature 55 : 0.0
377 Feature 54 : 0.0
378 Feature 53 : 0.0
379 Feature 52 : 0.0
380 Feature 51 : 0.0
381 Feature 50 : 0.0
382 Feature 48 : 0.0
383 Feature 58 : 0.0
384 Feature 47 : 0.0
385 Feature 46 : 0.0
386 Feature 45 : 0.0
387 Feature 44 : 0.0
388 Feature 43 : 0.0
389 Feature 42 : 0.0
390 Feature 41 : 0.0
391 Feature 57 : 0.0
392 Feature 59 : 0.0
393 Feature 39 : 0.0
394 Feature 69 : 0.0
395 Feature 77 : 0.0
396 Feature 76 : 0.0
397 Feature 74 : 0.0
398 Feature 73 : 0.0
399 Feature 72 : 0.0
400 Feature 71 : 0.0
401 Feature 70 : 0.0
402 Feature 68 : 0.0
403 Feature 60 : 0.0
404 Feature 67 : 0.0
405 Feature 66 : 0.0
406 Feature 65 : 0.0
407 Feature 64 : 0.0
408 Feature 63 : 0.0
409 Feature 62 : 0.0
410 Feature 61 : 0.0
411 Feature 40 : 0.0
412 Feature 38 : 0.0
413 Feature 198 : 0.0
414 Feature 9 : 0.0
415 Feature 16 : 0.0
416 Feature 15 : 0.0
417 Feature 14 : 0.0
418 Feature 13 : 0.0
419 Feature 12 : 0.0
420 Feature 11 : 0.0
421 Feature 10 : 0.0
422 Feature 8 : 0.0
423 Feature 18 : 0.0
424 Feature 7 : 0.0
425 Feature 6 : 0.0
426 Feature 5 : 0.0
427 Feature 4 : 0.0
428 Feature 3 : 0.0
429 Feature 2 : 0.0
430 Feature 1 : 0.0
431 Feature 17 : 0.0
432 Feature 19 : 0.0
433 Feature 37 : 0.0
434 Feature 29 : 0.0
435 Feature 36 : 0.0
436 Feature 35 : 0.0
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