Random Forest Algorithm

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

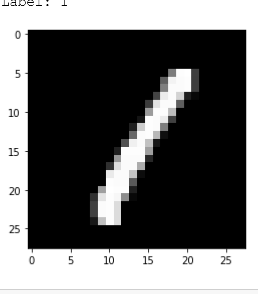
In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score,confusion_matrix,classification_report
```

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

In [3]:
```
X_train,y_train = train_file.iloc[:,1:].values, train_file.iloc[:,0].values
x_test,y_test = test_file.iloc[:,1:].values,test_file.iloc[:,0].values
```

In [4]:
```
index = 3
print("Label: " + str(y_train[index]))
plt.imshow(X_train[index].reshape((28,28)),cmap='gray')
plt.show()
```

```
Label: 1
```



In [5]:
```
clf = RandomForestClassifier(n_estimators=101,criterion='entropy',max_features = 'sqrt',verbose=2)
clf.fit(X_train,y_train)
```

```
building tree 1 of 101
```

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    1.0s remaining:    0.0s
```

```
building tree 2 of 101
building tree 3 of 101
building tree 4 of 101
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building tree 101 of 101
```

```
[Parallel(n_jobs=1)]: Done 101 out of 101 | elapsed:  1.8min finished
```

Out[5]:
```
RandomForestClassifier(bootstrap=True, ccp_alpha=0.0, class_weight=None,
                       criterion='entropy', max_depth=None, max_features='sqrt',
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=1, min_samples_split=2,
                       min_weight_fraction_leaf=0.0, n_estimators=101,
                       n_jobs=None, oob_score=False, random_state=None,
                       verbose=2, warm_start=False)
```

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

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 concurrent workers.
[Parallel(n_jobs=1)]: Done   1 out of   1 | elapsed:    0.0s remaining:    0.0s
[Parallel(n_jobs=1)]: Done 101 out of 101 | elapsed:    0.5s finished
```

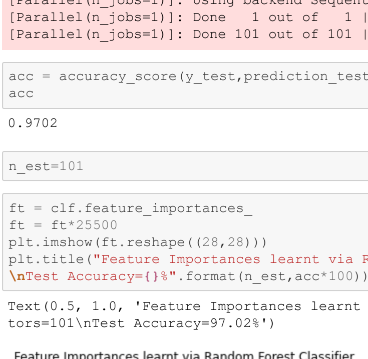
In [7]:
```
acc = accuracy_score(y_test,prediction_test)
acc
```

Out[7]:
```
0.9702
```

In [15]:
```
n_est=101
```

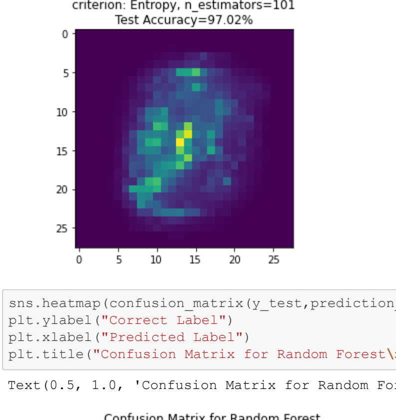
In [16]:
```
ft = clf.feature_importances_
ft = ft*25500
plt.imshow(ft.reshape((28,28)))
plt.title("Feature Importances learnt via Random Forest Classifier\ncriterion: Entropy, n_estimators={}\nTest Accuracy={}%".format(n_est,acc*100))
```

Out[16]:
```
Text(0.5, 1.0, 'Feature Importances learnt via Random Forest Classifier\ncriterion: Entropy, n_estimators=101\nTest Accuracy=97.02%')
```



In [17]:
```
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 Random Forest\nModel Accuracy={}%".format(acc*100))
```

Out[17]:
```
Text(0.5, 1.0, 'Confusion Matrix for Random Forest\nModel Accuracy=97.02%')
```



In [18]:
```
print("Classification Report for Random Forest:\n{}".format(classification_report(y_test,prediction_test)))
```

```
Classification Report for Random Forest:
              precision    recall  f1-score   support

           0       0.97      0.99      0.98       980
           1       0.99      0.99      0.99      1135
           2       0.96      0.97      0.96      1032
           3       0.97      0.97      0.97      1010
           4       0.97      0.97      0.97       982
           5       0.97      0.97      0.97       892
           6       0.98      0.98      0.98       958
           7       0.97      0.96      0.97      1028
           8       0.96      0.95      0.96       974
           9       0.96      0.95      0.96      1009

    accuracy                           0.97     10000
   macro avg       0.97      0.97      0.97     10000
weighted avg       0.97      0.97      0.97     10000
```

In [19]:
```
std = np.std([tree.feature_importances_ for tree in clf.estimators_],axis=0)
```

In [20]:
```
indices = np.argsort(ft)[::-1]
```

[illegible]

```
274 Feature 710 : 24.38139907274976
275 Feature 681 : 23.783144575628157
276 Feature 633 : 23.74409453764527
277 Feature 524 : 23.73927618363386
278 Feature 661 : 23.259357327778037
279 Feature 260 : 23.152209567537895
280 Feature 580 : 22.914071720971553
281 Feature 622 : 22.5896218516591
282 Feature 98 : 22.54612847888759
283 Feature 315 : 22.438190773389884
284 Feature 246 : 22.334130568554663
285 Feature 274 : 22.269606571663633
286 Feature 219 : 22.234094631274207
287 Feature 101 : 22.104511853384302
288 Feature 370 : 22.061417779560912
289 Feature 510 : 21.95429894506219
290 Feature 651 : 21.85795536611927
291 Feature 686 : 21.851772375123627
292 Feature 302 : 21.47831136010106
293 Feature 176 : 21.340988246678187
294 Feature 232 : 21.323789252878843
295 Feature 386 : 21.296587687139482
296 Feature 259 : 20.714303142623827
297 Feature 149 : 20.47036018922644
298 Feature 247 : 19.494656243710782
299 Feature 634 : 19.475668573044928
300 Feature 682 : 17.522064805782463
301 Feature 190 : 17.220061952906768
302 Feature 189 : 17.18750486773457
303 Feature 442 : 17.016127302777047
304 Feature 553 : 16.983836801679292
305 Feature 608 : 16.97839546625897
306 Feature 497 : 16.70605508614741
307 Feature 525 : 16.697011998050126
308 Feature 470 : 16.48910271880792
309 Feature 687 : 16.193125122246915
310 Feature 581 : 16.143233075204652
311 Feature 102 : 15.872011560080589
312 Feature 160 : 15.84235007863705
313 Feature 342 : 15.557752947030023
314 Feature 248 : 15.232129218635546
315 Feature 414 : 14.941306656021174
316 Feature 415 : 14.849474253267891
317 Feature 711 : 14.63066119866354
318 Feature 130 : 14.123309741191855
319 Feature 635 : 14.049034400958881
320 Feature 509 : 13.830544740943711
321 Feature 709 : 13.786937059911912
322 Feature 122 : 13.764744208332608
323 Feature 359 : 13.702509981279464
324 Feature 275 : 13.158120401991455
325 Feature 680 : 12.958881717242004
326 Feature 161 : 12.8560419702469
327 Feature 231 : 12.830024059408146
328 Feature 314 : 12.429768977831642
329 Feature 663 : 12.33497646174014
330 Feature 203 : 12.204036049794507
331 Feature 103 : 12.03340027934618
332 Feature 123 : 11.98926154174759
333 Feature 712 : 11.749334478630795
334 Feature 662 : 11.583395387011349
335 Feature 537 : 11.54437080537374
336 Feature 713 : 10.997699316528124
337 Feature 554 : 10.95159180268817
338 Feature 526 : 10.689076623342077
339 Feature 131 : 10.516651351684043
340 Feature 498 : 10.475648964558395
341 Feature 688 : 10.437320950780364
342 Feature 331 : 10.214593086561075
343 Feature 565 : 10.128728921750884
344 Feature 387 : 9.85642765011167
345 Feature 425 : 9.77417036338013
346 Feature 593 : 9.668596816465236
347 Feature 303 : 9.57722499127748
348 Feature 191 : 9.37713151088152
349 Feature 96 : 9.362781094866554
350 Feature 220 : 9.093083091748769
351 Feature 286 : 8.802469627470032
352 Feature 708 : 8.769528685530897
353 Feature 481 : 8.733227985143753
354 Feature 453 : 8.721690362420803
355 Feature 689 : 8.606587274348879
356 Feature 162 : 8.567743230780819
357 Feature 499 : 8.470909829000005
358 Feature 148 : 8.367572064583547
359 Feature 715 : 8.297370848277273
360 Feature 175 : 8.032889151670792
361 Feature 609 : 7.838178723638879
362 Feature 443 : 7.815847757751725
363 Feature 636 : 7.799696376447213
364 Feature 97 : 7.780143800989219
365 Feature 471 : 7.672602340921024
366 Feature 679 : 7.5751072534078565
367 Feature 397 : 7.447359778179001
368 Feature 276 : 7.4096609406019684
369 Feature 714 : 7.296462791244879
370 Feature 95 : 7.08824191626017
371 Feature 258 : 6.798934246259596
372 Feature 582 : 6.798882414717943
373 Feature 707 : 6.524681541237154
374 Feature 527 : 6.280749151463298
375 Feature 230 : 6.125348472314605
376 Feature 341 : 6.089688869011478
377 Feature 369 : 5.778743368986197
378 Feature 132 : 5.67851233881599
379 Feature 555 : 5.547800958846753
380 Feature 650 : 5.405953683366743
381 Feature 690 : 5.181443751842769
382 Feature 192 : 5.064916182826172
383 Feature 637 : 5.009074207400062
384 Feature 741 : 4.876180405750132
385 Feature 717 : 4.753638987979537
386 Feature 163 : 4.640720380446894
387 Feature 121 : 4.616789223607384
388 Feature 202 : 4.595805133010952
389 Feature 716 : 4.593206063292466
390 Feature 610 : 4.452649817114495
391 Feature 740 : 4.14835398821371
392 Feature 313 : 4.103469572490827
393 Feature 718 : 3.7442575473010065
394 Feature 664 : 3.6771314626869755
395 Feature 68 : 3.485810644288437
396 Feature 691 : 3.4837588679544558
397 Feature 94 : 3.3094584521272257
398 Feature 285 : 3.2805802727562314
399 Feature 583 : 3.255629952927866
400 Feature 133 : 3.2304644726265668
401 Feature 536 : 3.209693865307634
402 Feature 104 : 3.15749850297717
403 Feature 174 : 3.149989865206639
404 Feature 678 : 3.12211150756157
405 Feature 621 : 3.0280402588774873
406 Feature 564 : 2.9283882901746923
407 Feature 360 : 2.8527319732154965
408 Feature 257 : 2.752207984980192
409 Feature 304 : 2.6675674945909296
410 Feature 444 : 2.657267709631623
411 Feature 472 : 2.651112699888357
412 Feature 70 : 2.5332228131184293
413 Feature 147 : 2.5258726461821412
414 Feature 229 : 2.423711994930216
415 Feature 416 : 2.4159791733447045
416 Feature 719 : 2.4059365869663463
417 Feature 638 : 2.3566023940998218
418 Feature 692 : 2.351787422625405
419 Feature 592 : 2.340290486329287
420 Feature 528 : 2.2914782922057464
421 Feature 388 : 2.26569643264673
422 Feature 221 : 2.254844386715667
423 Feature 201 : 2.229044975803586
424 Feature 742 : 2.2167886067405296
425 Feature 556 : 2.1743782665166753
426 Feature 508 : 2.122481402073858
427 Feature 500 : 2.0725968257717753
428 Feature 249 : 2.0538254947530086
429 Feature 120 : 2.027759175205654
430 Feature 739 : 1.9878341477610615
431 Feature 649 : 1.9326215340303203
432 Feature 69 : 1.8450863169011433
433 Feature 332 : 1.7896512543362146
434 Feature 480 : 1.771866291710724
435 Feature 665 : 1.6757449792765318
436 Feature 452 : 1.672856348181198
437 Feature 738 : 1.6182541681235663
438 Feature 611 : 1.5729786176062428
439 Feature 737 : 1.551555512731876
440 Feature 312 : 1.54314011494772
441 Feature 134 : 1.523051816779688
442 Feature 368 : 1.4830159334698978
443 Feature 71 : 1.4814445671686476
444 Feature 743 : 1.4703621094260817
445 Feature 105 : 1.4068067537379771
446 Feature 340 : 1.405726387832023
447 Feature 146 : 1.342366038837573
448 Feature 720 : 1.3169136783920194
449 Feature 584 : 1.3104878534121531
450 Feature 620 : 1.3096976760197585
451 Feature 164 : 1.283218081581397
452 Feature 135 : 1.2673526817828502
453 Feature 677 : 1.2564973312498742
454 Feature 424 : 1.2137352262562882
455 Feature 256 : 1.1734005692560494
456 Feature 706 : 1.1479015567429744
457 Feature 67 : 1.1076619282034523
458 Feature 284 : 1.0751152218908098
459 Feature 173 : 1.0579118103464016
460 Feature 666 : 1.0376852310324385
461 Feature 396 : 1.0196638756316594
462 Feature 693 : 0.9701994538398396
463 Feature 277 : 0.9636702429057201
464 Feature 93 : 0.916992924249729
465 Feature 228 : 0.9162582289407629
466 Feature 639 : 0.8810069103450999
467 Feature 744 : 0.835834275611157
468 Feature 305 : 0.7811794718603747
469 Feature 705 : 0.7496347390145787
470 Feature 72 : 0.7447989561060604
471 Feature 529 : 0.7331075454262738
472 Feature 75 : 0.7168929277706962
473 Feature 119 : 0.703574586929402
474 Feature 200 : 0.6968129647531696
475 Feature 501 : 0.6887659502603968
476 Feature 735 : 0.6856474178695147
477 Feature 745 : 0.6757035436964604
478 Feature 648 : 0.6622990117771368
479 Feature 746 : 0.6526869491160221
480 Feature 73 : 0.6433725329986707
481 Feature 193 : 0.5978379679394971
482 Feature 76 : 0.595480042668052
483 Feature 473 : 0.5940120057787587
484 Feature 92 : 0.5733268080340358
485 Feature 563 : 0.5663996108527527
486 Feature 145 : 0.563608197331265
487 Feature 667 : 0.5512728682160357
488 Feature 333 : 0.544914840071703
489 Feature 507 : 0.5324405140883111
490 Feature 721 : 0.5107127638360439
491 Feature 736 : 0.4941196675185036
492 Feature 106 : 0.4886224886610655
493 Feature 676 : 0.47455704287536254
494 Feature 535 : 0.47259994064788435
495 Feature 66 : 0.4218830015807696
496 Feature 694 : 0.42105244652973406
497 Feature 74 : 0.41346053619984735
498 Feature 172 : 0.4134375609636171
499 Feature 479 : 0.3952364744769532
500 Feature 591 : 0.38664092480276163
501 Feature 65 : 0.3864301475226421
502 Feature 612 : 0.37189867649356156
503 Feature 283 : 0.3588516635637023
504 Feature 445 : 0.3429762023329401
505 Feature 417 : 0.3412159533795181
506 Feature 136 : 0.32553727100426544
507 Feature 311 : 0.30382223493531413
508 Feature 451 : 0.3026195641796143
509 Feature 361 : 0.29075033238788345
510 Feature 423 : 0.2903967380647106
511 Feature 389 : 0.2743293742128972
512 Feature 557 : 0.26837199617546775
513 Feature 165 : 0.26704193534009635
514 Feature 255 : 0.26463828459081945
515 Feature 748 : 0.2616770850272779
516 Feature 306 : 0.25269855462070195
517 Feature 747 : 0.2391759221825095
518 Feature 118 : 0.23541008524766316
519 Feature 137 : 0.22968401343452757
520 Feature 502 : 0.2282306698539081
521 Feature 107 : 0.22434596080657113
522 Feature 91 : 0.22146433746704366
523 Feature 585 : 0.21940925103440986
524 Feature 144 : 0.21400057110203158
525 Feature 619 : 0.21329086373824885
526 Feature 339 : 0.2056539566114044
527 Feature 704 : 0.19128423793408258
528 Feature 647 : 0.1790532227598239
529 Feature 367 : 0.1769042389100249
530 Feature 278 : 0.16497479845099208
531 Feature 362 : 0.16457066757777472
532 Feature 640 : 0.16395669012012082
533 Feature 199 : 0.16111656703171007
534 Feature 77 : 0.1607544591870947
535 Feature 734 : 0.15842051011351035
536 Feature 108 : 0.15536284704087916
537 Feature 474 : 0.15116523974458987
538 Feature 722 : 0.14519116004147187
539 Feature 668 : 0.1422832844701804
540 Feature 446 : 0.13939991038086336
541 Feature 254 : 0.13525631712549002
542 Feature 418 : 0.13132281484963207
543 Feature 695 : 0.1270439100082986
544 Feature 64 : 0.12518203187675975
545 Feature 227 : 0.12427826413139695
546 Feature 641 : 0.12273956266407336
547 Feature 395 : 0.12009138606334331
548 Feature 250 : 0.11974564200636768
549 Feature 613 : 0.11444107214335172
550 Feature 675 : 0.11387873956653083
551 Feature 194 : 0.10355164938278291
552 Feature 222 : 0.10289867262038159
553 Feature 117 : 0.1003972018548436
554 Feature 390 : 0.09660790361909485
555 Feature 733 : 0.08968150433443012
556 Feature 749 : 0.08576897391813508
557 Feature 282 : 0.08230082380587597
558 Feature 171 : 0.08154183259670325
559 Feature 696 : 0.08128656203575
560 Feature 334 : 0.07890515795687227
561 Feature 732 : 0.07553552008253493
562 Feature 226 : 0.07513921773039943
563 Feature 422 : 0.07086823383724335
564 Feature 534 : 0.06649984986031526
565 Feature 223 : 0.06500685242613742
566 Feature 723 : 0.06384914249861273
567 Feature 310 : 0.06129777721395185
568 Feature 90 : 0.05511445429942777
569 Feature 307 : 0.05449999357274855
570 Feature 116 : 0.05409779880316746
571 Feature 562 : 0.053185282846713804
572 Feature 530 : 0.05116236429725183
573 Feature 166 : 0.050849599746340485
574 Feature 614 : 0.050438640982823926
575 Feature 63 : 0.0502840559337334
576 Feature 138 : 0.050009481572689356
577 Feature 478 : 0.04818932093566441
578 Feature 703 : 0.047088193606674
579 Feature 44 : 0.0447833783436801
580 Feature 338 : 0.042906403219637575
581 Feature 78 : 0.04194522176165393
582 Feature 506 : 0.04181735659558799
583 Feature 590 : 0.041027526937230545
584 Feature 669 : 0.03968995499487147
585 Feature 450 : 0.038718486495970976
586 Feature 772 : 0.03712765488118669
587 Feature 43 : 0.03696446108240757
588 Feature 771 : 0.036884704521891264
589 Feature 767 : 0.03616959695405223
590 Feature 773 : 0.033274483610059705
591 Feature 750 : 0.03221577304017595
592 Feature 769 : 0.031713643706027105
593 Feature 88 : 0.03012526243588098
594 Feature 89 : 0.02993148467020576
595 Feature 774 : 0.029157595137571 96
596 Feature 279 : 0.027631911065330875
597 Feature 674 : 0.02727012123058987
598 Feature 778 : 0.027188943299040147
599 Feature 447 : 0.0262061629162493
600 Feature 46 : 0.026014778350967525
601 Feature 642 : 0.025425837442319646
602 Feature 12 : 0.025302571515285012
603 Feature 79 : 0.02521021869684 0845
604 Feature 225 : 0.024877032862685826
605 Feature 503 : 0.02456667136713195
606 Feature 143 : 0.024418264258836937
607 Feature 170 : 0.02377123393995878
608 Feature 37 : 0.023525901309124162
609 Feature 39 : 0.023440387247132807
610 Feature 45 : 0.02280661516638991
611 Feature 309 : 0.021641903539340982
612 Feature 34 : 0.021168167130855734
613 Feature 558 : 0.02086798375287157
614 Feature 618 : 0.02038005425314837
615 Feature 195 : 0.019707557539850384
616 Feature 561 : 0.019519367535505466
617 Feature 139 : 0.019471950163982576
618 Feature 335 : 0.019173250964838216
619 Feature 770 : 0.018893401373561682
620 Feature 42 : 0.016964327684829653
621 Feature 475 : 0.016389872859275144
622 Feature 726 : 0.016094311251849673
623 Feature 586 : 0.014786314386280053
624 Feature 48 : 0.014080158136069358
625 Feature 41 : 0.012593561692854867
626 Feature 775 : 0.012423083049582274
627 Feature 768 : 0.011278253028119462
628 Feature 110 : 0.01029695964972434
629 Feature 477 : 0.009899938682869322
630 Feature 765 : 0.008718343101672476
631 Feature 251 : 0.008688619052127257
632 Feature 724 : 0.008503814966559626
633 Feature 363 : 0.008435363410080846
634 Feature 766 : 0.008249762347791153
635 Feature 505 : 0.007950405627038519
636 Feature 531 : 0.007438175642560825
637 Feature 87 : 0.007351806001011265
638 Feature 394 : 0.007268831049825445
639 Feature 764 : 0.007110601334030692
640 Feature 449 : 0.006955487684707445
641 Feature 198 : 0.0067181629762817306
642 Feature 50 : 0.005249974157674544
643 Feature 40 : 0.005249638521901854
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779 Feature 366 : 0.0
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781 Feature 364 : 0.0
782 Feature 337 : 0.0
783 Feature 336 : 0.0
784 Feature 0 : 0.0
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In [ ]: