Experiential Learning Activity

ELC Project Report

Handwritten Text Recognition Using KNN

BE Second Year- COE

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TIET, Patiala **June 2024**

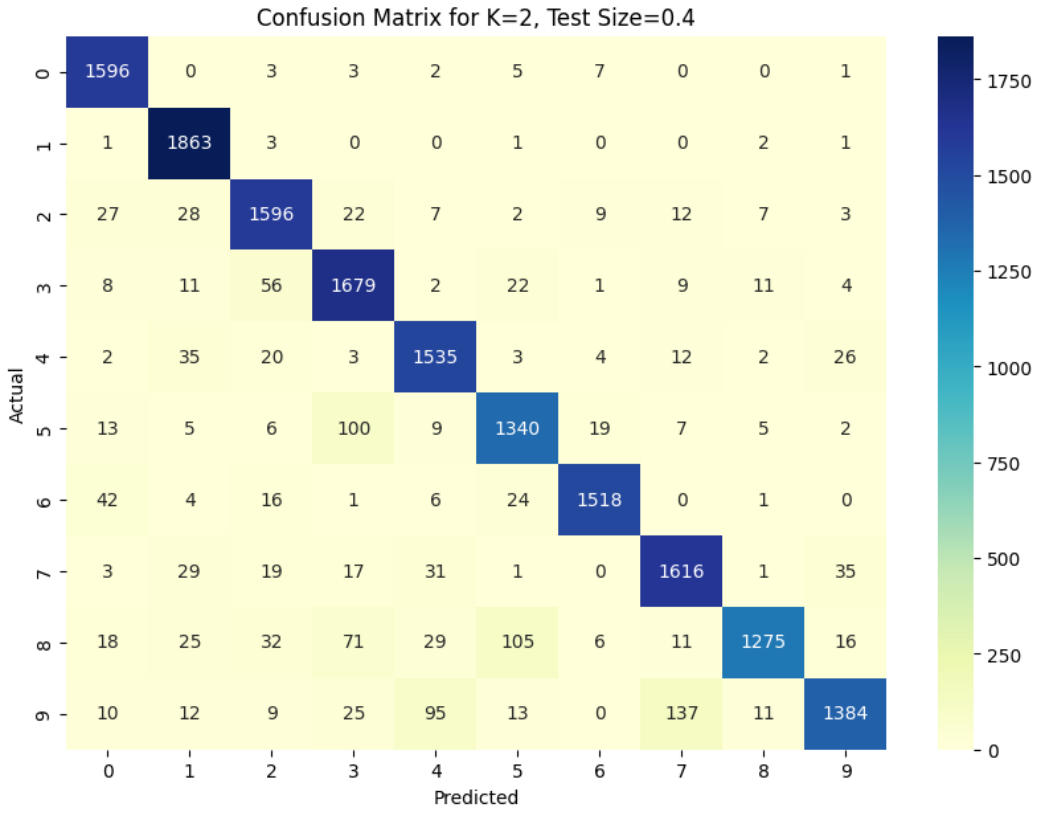
PROBLEM-STATEMENT

- Train your model using K-Nearest Neighbour Algorithm with having values of K as {2,4,5,6,7,10}, over data.csv file provided.
- The Train and Test split of the data should be in the ratio of 60:40, 70:30, 75:25, 80:20, 90:10, 95:5.
- Evaluate the performance of the model over test data for all these scenarios (36 cases), and submit and a single pdf file containing the results of all these scenarios (Accuracy, and Confusion Matrix), also your analysis regarding the dependency of the performance of model over training-testing split and k value.

CASE – 1 : (Train:Test) Split Ratio = 60:40

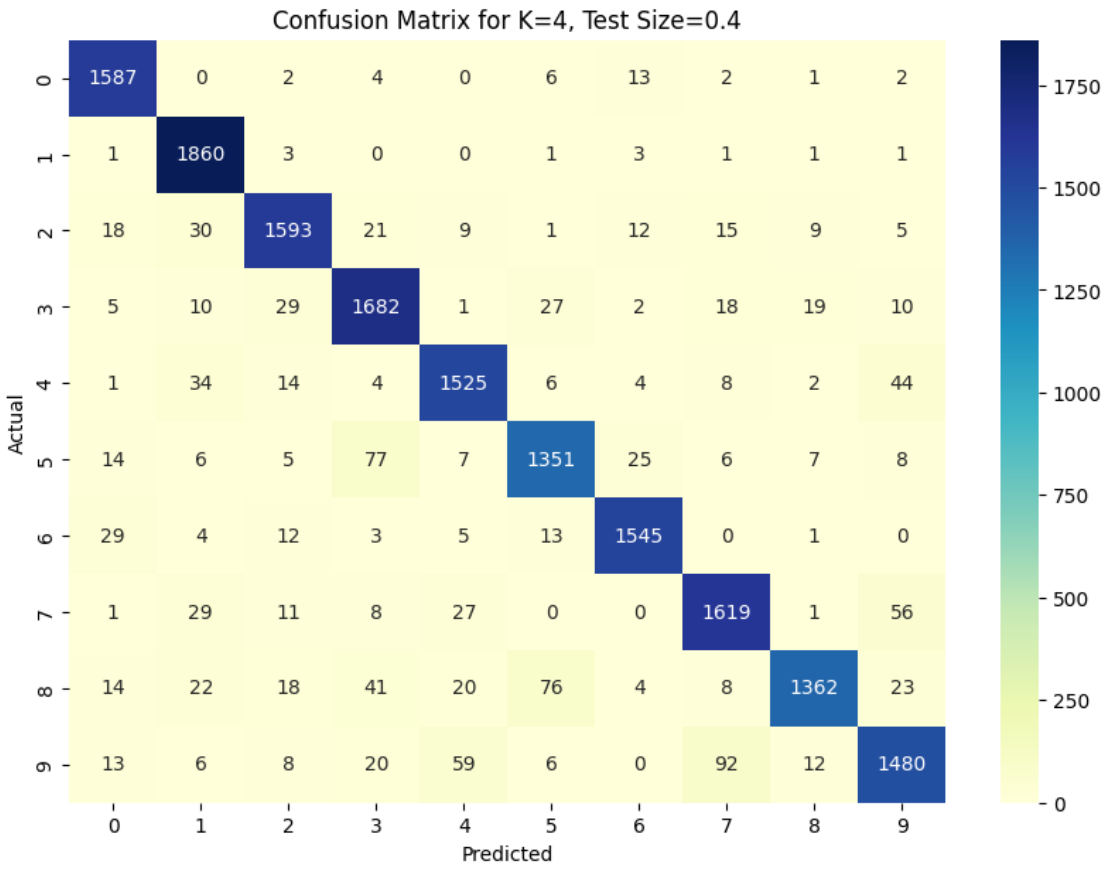
1.1 K=2

```
K=2, Test Size=0.4
Accuracy: 0.9167857142857143
Confusion Matrix:
 [[1596    0    3    3    2    5    7    0    0    1]
 [   1 1863    3    0    0    1    0    0    2    1]
 [  27   28 1596   22    7    2    9   12    7    3]
 [   8   11   56 1679    2   22    1    9   11    4]
 [   2   35   20    3 1535    3    4   12    2   26]
 [  13    5    6  100    9 1340   19    7    5    2]
 [  42    4   16    1    6   24 1518    0    1    0]
 [   3   29   19   17   31    1    0 1616    1   35]
 [  18   25   32   71   29  105    6   11 1275   16]
 [  10   12    9   25   95   13    0  137   11 1384]]
```



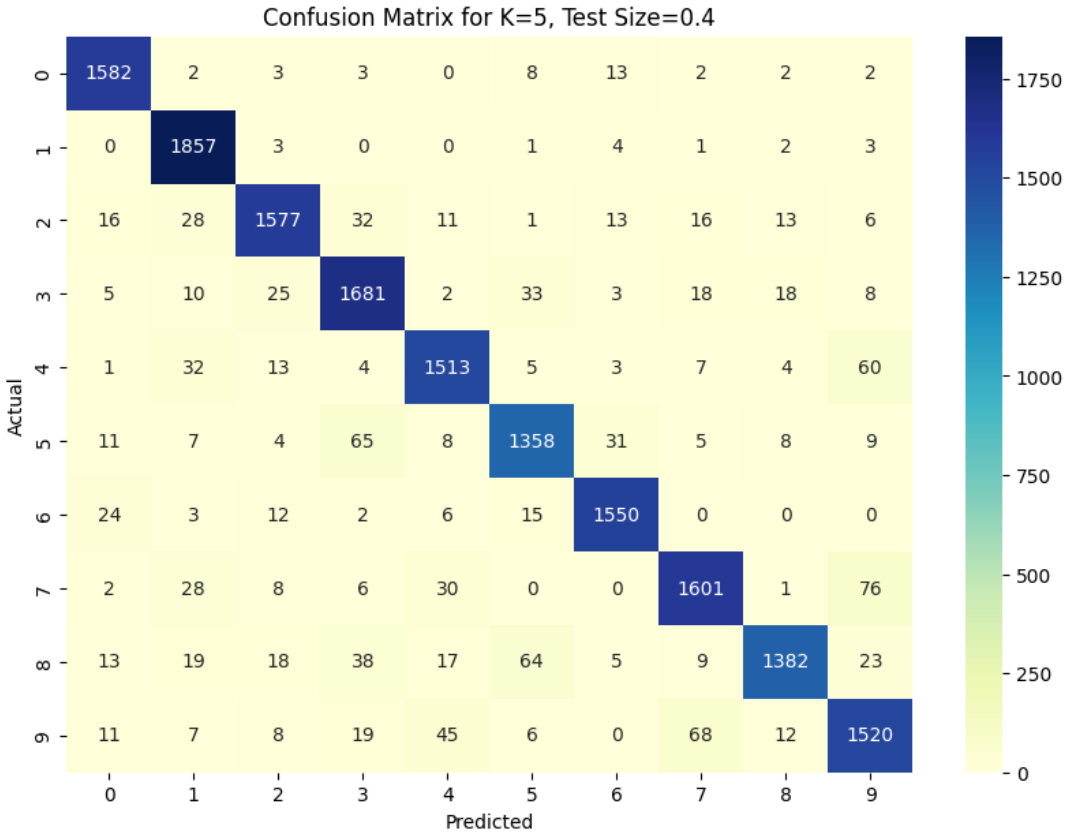
1.2 K=4

```
K=4, Test Size=0.4
Accuracy: 0.9288095238095239
Confusion Matrix:
 [[1587    0    2    4    0    6   13    2    1    2]
 [   1 1860    3    0    0    1    3    1    1    1]
 [  18   30 1593   21    9    1   12   15    9    5]
 [   5   10   29 1682    1   27    2   18   19   10]
 [   1   34   14    4 1525    6    4    8    2   44]
 [  14    6    5   77    7 1351   25    6    7    8]
 [  29    4   12    3    5   13 1545    0    1    0]
 [   1   29   11    8   27    0    0 1619    1   56]
 [  14   22   18   41   20   76    4    8 1362   23]
 [  13    6    8   20   59    6    0   92   12 1480]]
```



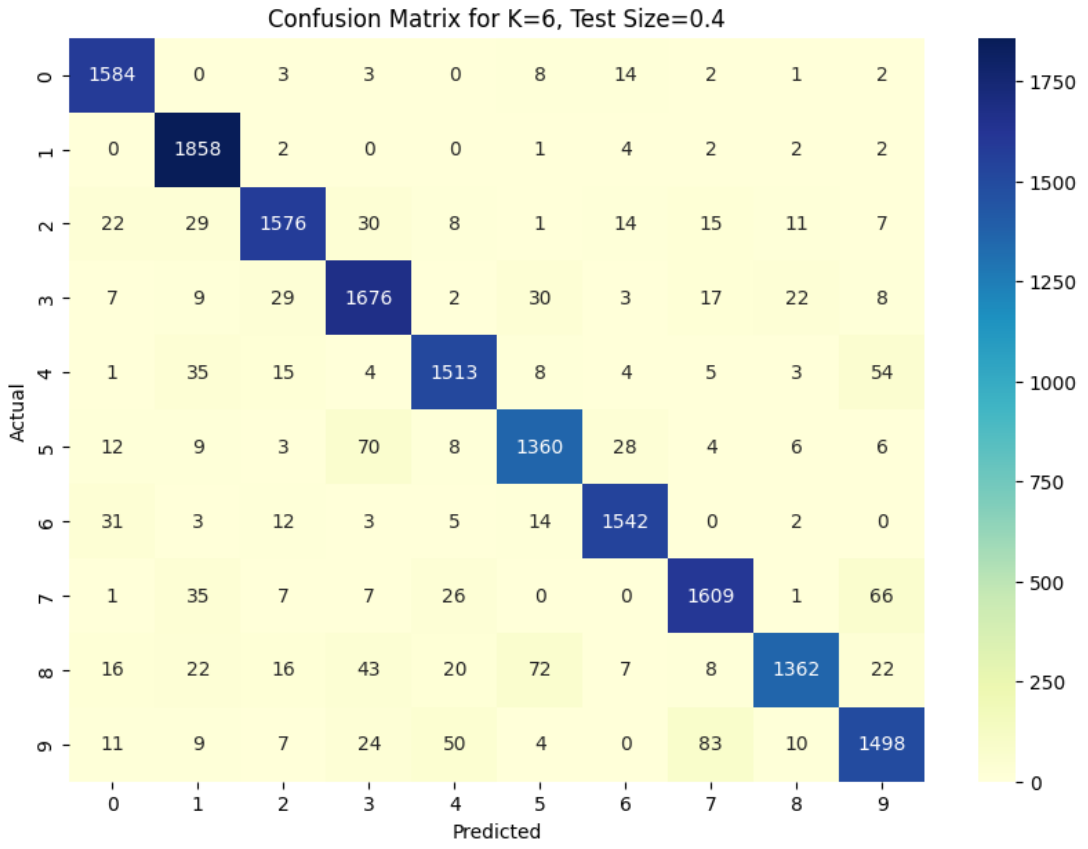
1.3 K=5

```
K=5, Test Size=0.4
Accuracy: 0.9298214285714286
Confusion Matrix:
 [[1582    2    3    3    0    8   13    2    2    2]
 [   0 1857    3    0    0    1    4    1    2    3]
 [  16   28 1577   32   11    1   13   16   13    6]
 [   5   10   25 1681    2   33    3   18   18    8]
 [   1   32   13    4 1513    5    3    7    4   60]
 [  11    7    4   65    8 1358   31    5    8    9]
 [  24    3   12    2    6   15 1550    0    0    0]
 [   2   28    8    6   30    0    0 1601    1   76]
 [  13   19   18   38   17   64    5    9 1382   23]
 [  11    7    8   19   45    6    0   68   12 1520]]
```



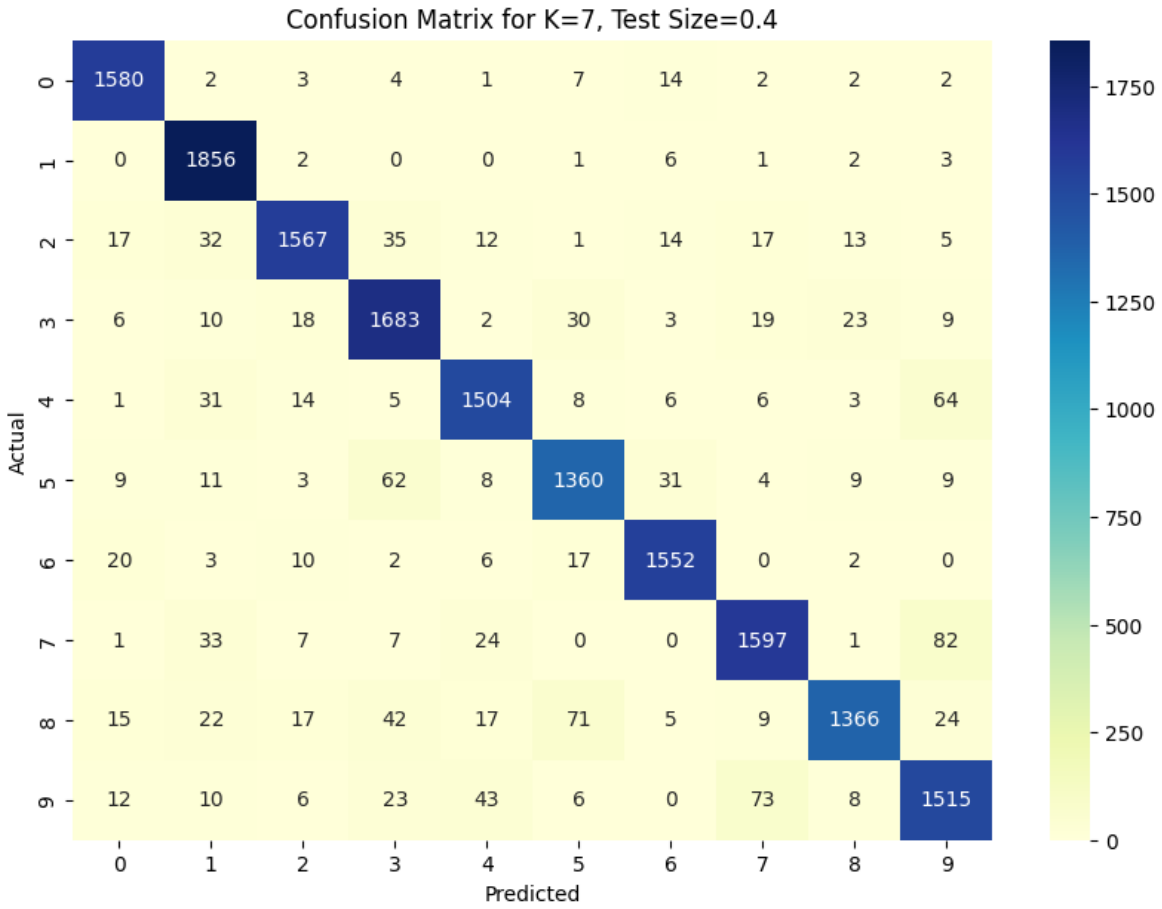
1.4 K=6

```
K=6, Test Size=0.4
Accuracy: 0.9272619047619047
Confusion Matrix:
 [[1584    0    3    3    0    8   14    2    1    2]
 [   0 1858    2    0    0    1    4    2    2    2]
 [  22   29 1576   30    8    1   14   15   11    7]
 [   7    9   29 1676    2   30    3   17   22    8]
 [   1   35   15    4 1513    8    4    5    3   54]
 [  12    9    3   70    8 1360   28    4    6    6]
 [  31    3   12    3    5   14 1542    0    2    0]
 [   1   35    7    7   26    0    0 1609    1   66]
 [  16   22   16   43   20   72    7    8 1362   22]
 [  11    9    7   24   50    4    0   83   10 1498]]
```



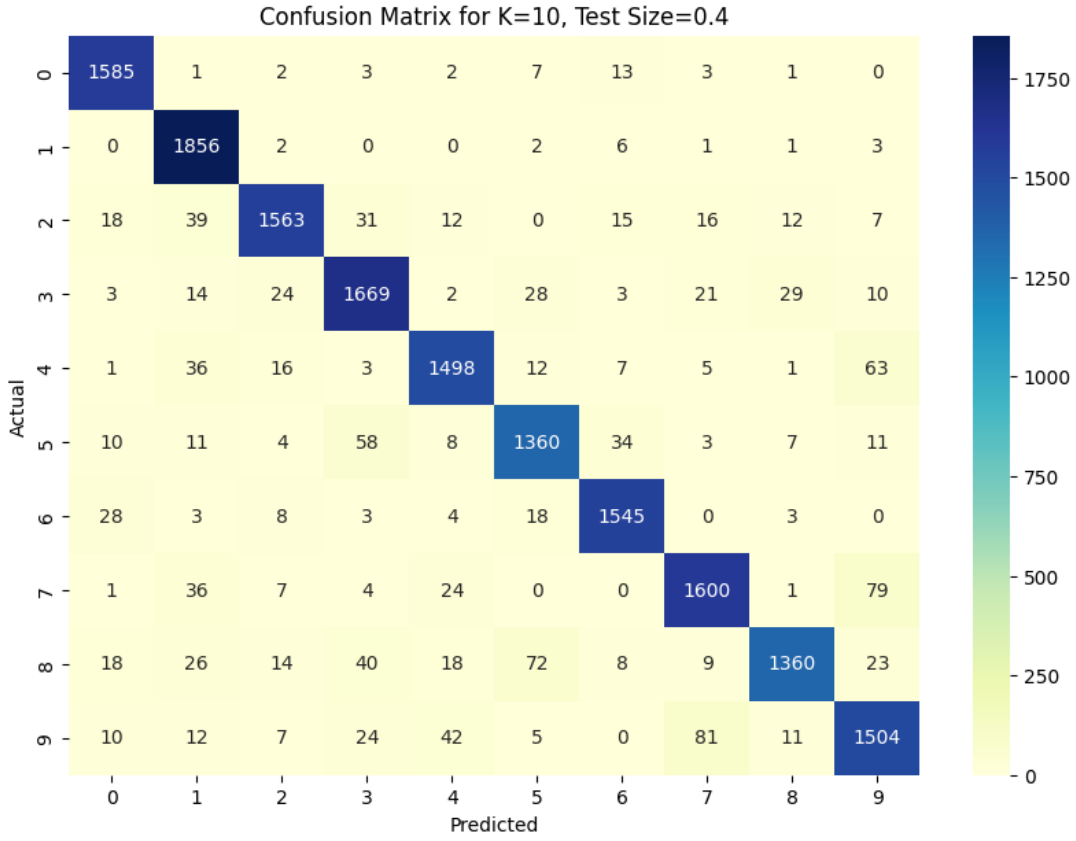
1.5 K=7

```
K=7, Test Size=0.4
Accuracy: 0.9273809523809524
Confusion Matrix:
 [[1580    2    3    4    1    7   14    2    2    2]
 [   0 1856    2    0    0    1    6    1    2    3]
 [  17   32 1567   35   12    1   14   17   13    5]
 [   6   10   18 1683    2   30    3   19   23    9]
 [   1   31   14    5 1504    8    6    6    3   64]
 [   9   11    3   62    8 1360   31    4    9    9]
 [  20    3   10    2    6   17 1552    0    2    0]
 [   1   33    7    7   24    0    0 1597    1   82]
 [  15   22   17   42   17   71    5    9 1366   24]
 [  12   10    6   23   43    6    0   73    8 1515]]
```



1.6 K=10

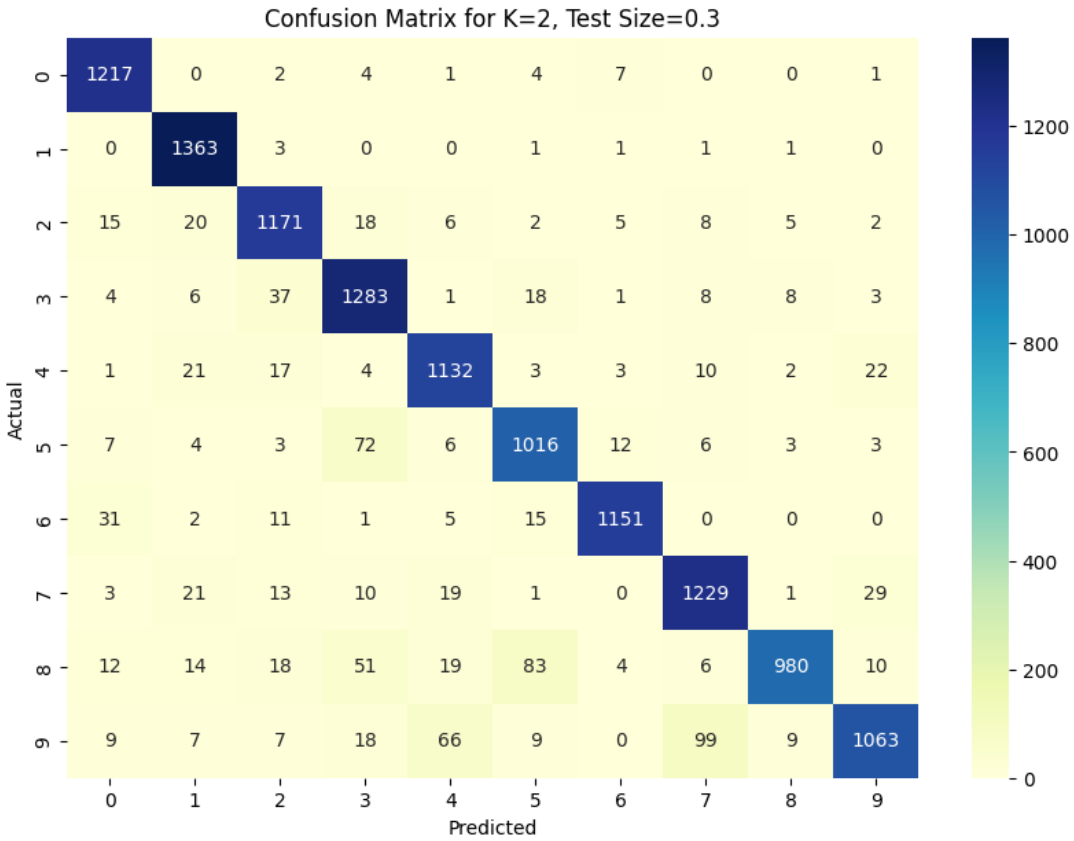
```
K=10, Test Size=0.4
Accuracy: 0.925
Confusion Matrix:
 [[1585    1    2    3    2    7   13    3    1    0]
 [   0 1856    2    0    0    2    6    1    1    3]
 [  18   39 1563   31   12    0   15   16   12    7]
 [   3   14   24 1669    2   28    3   21   29   10]
 [   1   36   16    3 1498   12    7    5    1   63]
 [  10   11    4   58    8 1360   34    3    7   11]
 [  28    3    8    3    4   18 1545    0    3    0]
 [   1   36    7    4   24    0    0 1600    1   79]
 [  18   26   14   40   18   72    8    9 1360   23]
 [  10   12    7   24   42    5    0   81   11 1504]]
```



CASE – 2 : (Train:Test) Split Ratio = 70:30

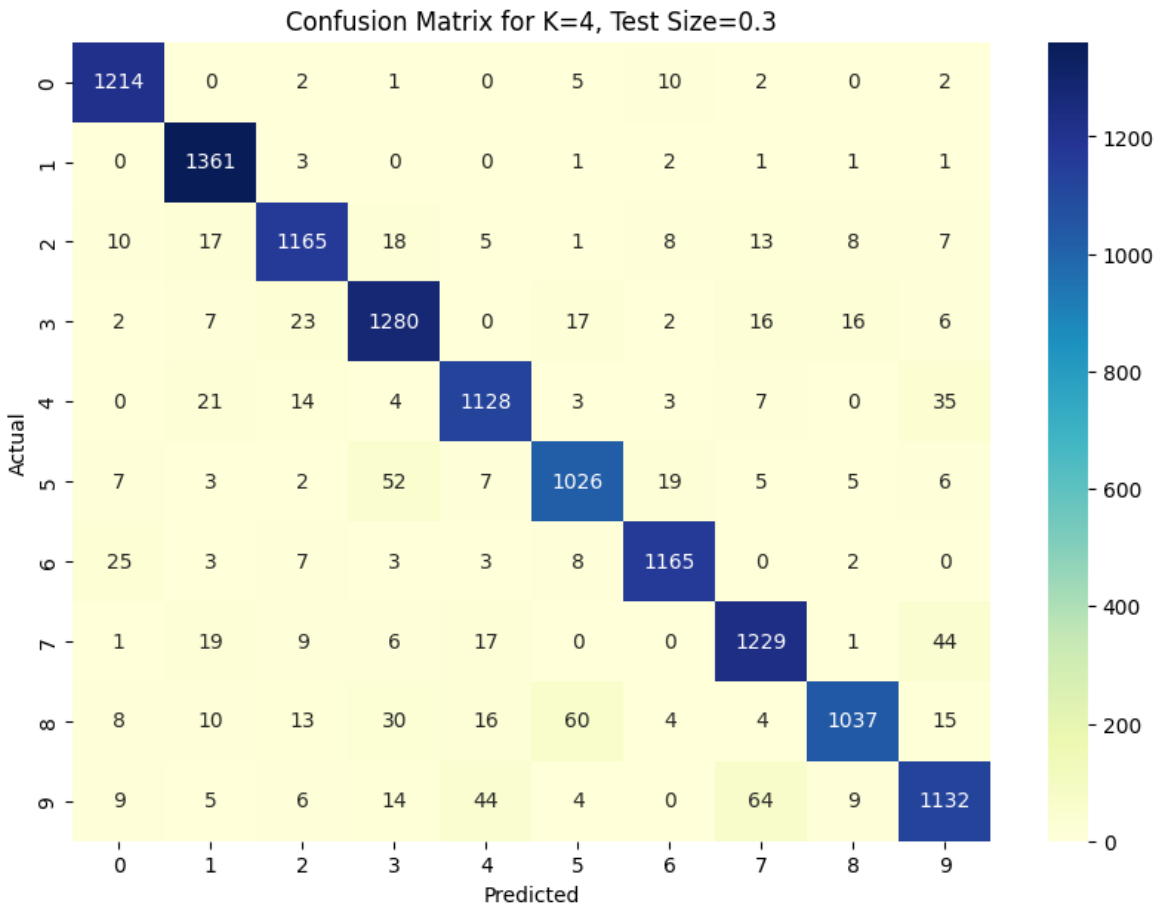
2.1 K=2

```
K=2, Test Size=0.3
Accuracy: 0.921031746031746
Confusion Matrix:
 [[1217    0    2    4    1    4    7    0    0    1]
 [   0 1363    3    0    0    1    1    1    1    0]
 [  15   20 1171   18    6    2    5    8    5    2]
 [   4    6   37 1283    1   18    1    8    8    3]
 [   1   21   17    4 1132    3    3   10    2   22]
 [   7    4    3   72    6 1016   12    6    3    3]
 [  31    2   11    1    5   15 1151    0    0    0]
 [   3   21   13   10   19    1    0 1229    1   29]
 [  12   14   18   51   19   83    4    6  980   10]
 [   9    7    7   18   66    9    0   99    9 1063]]
```



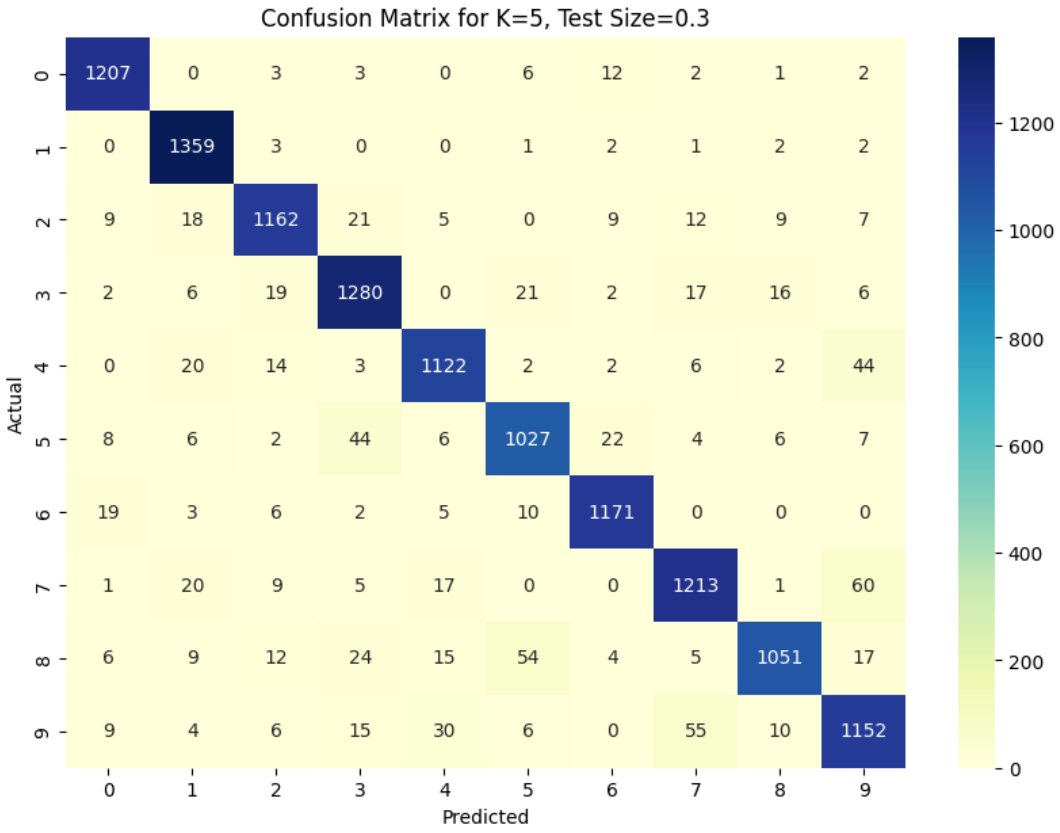
2.2 K=4

```
K=4, Test Size=0.3
Accuracy: 0.9315079365079365
Confusion Matrix:
 [[1214    0    2    1    0    5   10    2    0    2]
 [   0 1361    3    0    0    1    2    1    1    1]
 [  10   17 1165   18    5    1    8   13    8    7]
 [   2    7   23 1280    0   17    2   16   16    6]
 [   0   21   14    4 1128    3    3    7    0   35]
 [   7    3    2   52    7 1026   19    5    5    6]
 [  25    3    7    3    3    8 1165    0    2    0]
 [   1   19    9    6   17    0    0 1229    1   44]
 [   8   10   13   30   16   60    4    4 1037   15]
 [   9    5    6   14   44    4    0   64    9 1132]]
```



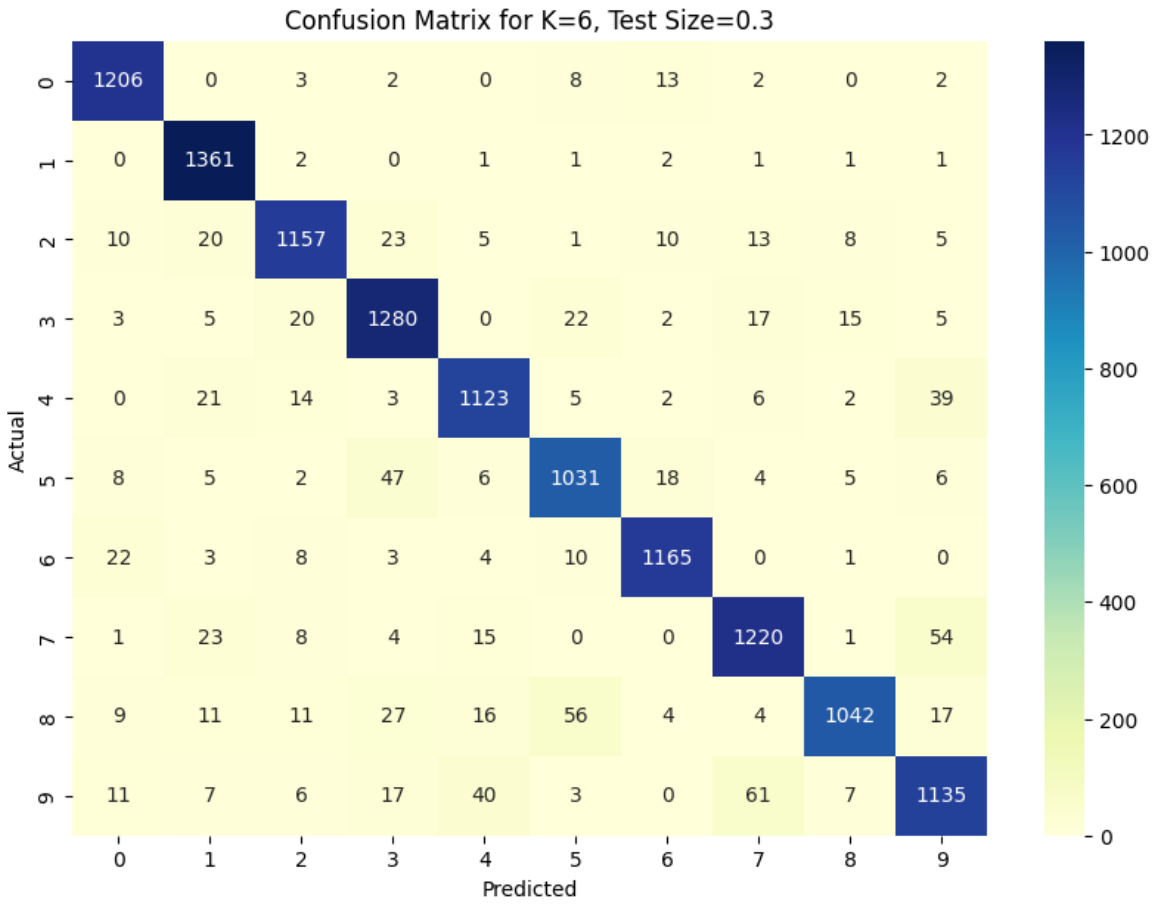
2.3 K=5

```
K=5, Test Size=0.3
Accuracy: 0.932063492063492
Confusion Matrix:
 [[1207    0    3    3    0    6   12    2    1    2]
 [   0 1359    3    0    0    1    2    1    2    2]
 [   9   18 1162   21    5    0    9   12    9    7]
 [   2    6   19 1280    0   21    2   17   16    6]
 [   0   20   14    3 1122    2    2    6    2   44]
 [   8    6    2   44    6 1027   22    4    6    7]
 [  19    3    6    2    5   10 1171    0    0    0]
 [   1   20    9    5   17    0    0 1213    1   60]
 [   6    9   12   24   15   54    4    5 1051   17]
 [   9    4    6   15   30    6    0   55   10 1152]]
```



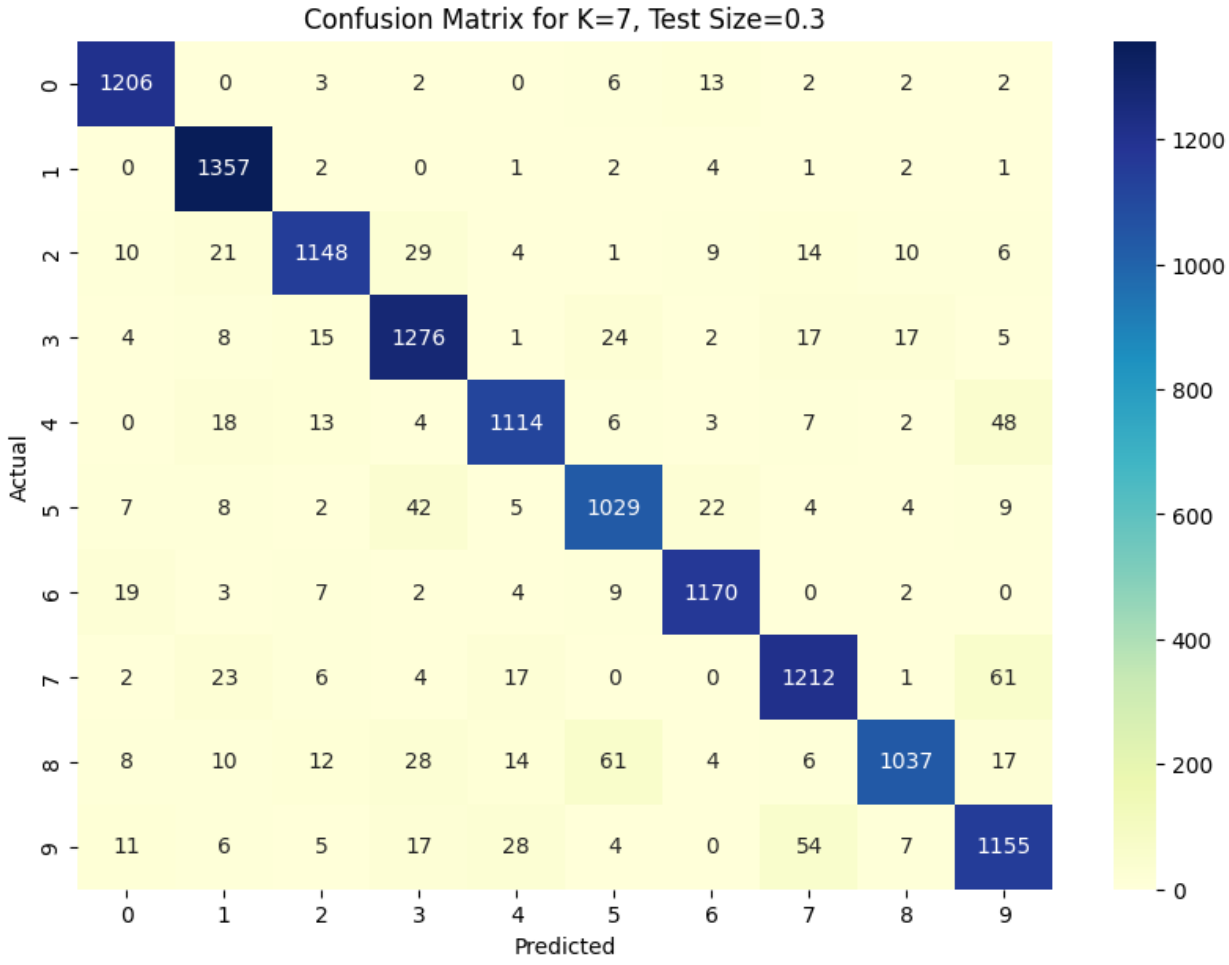
2.4 K=6

```
K=6, Test Size=0.3
Accuracy: 0.9301587301587302
Confusion Matrix:
 [[1206    0    3    2    0    8   13    2    0    2]
 [   0 1361    2    0    1    1    2    1    1    1]
 [  10   20 1157   23    5    1   10   13    8    5]
 [   3    5   20 1280    0   22    2   17   15    5]
 [   0   21   14    3 1123    5    2    6    2   39]
 [   8    5    2   47    6 1031   18    4    5    6]
 [  22    3    8    3    4   10 1165    0    1    0]
 [   1   23    8    4   15    0    0 1220    1   54]
 [   9   11   11   27   16   56    4    4 1042   17]
 [  11    7    6   17   40    3    0   61    7 1135]]
```



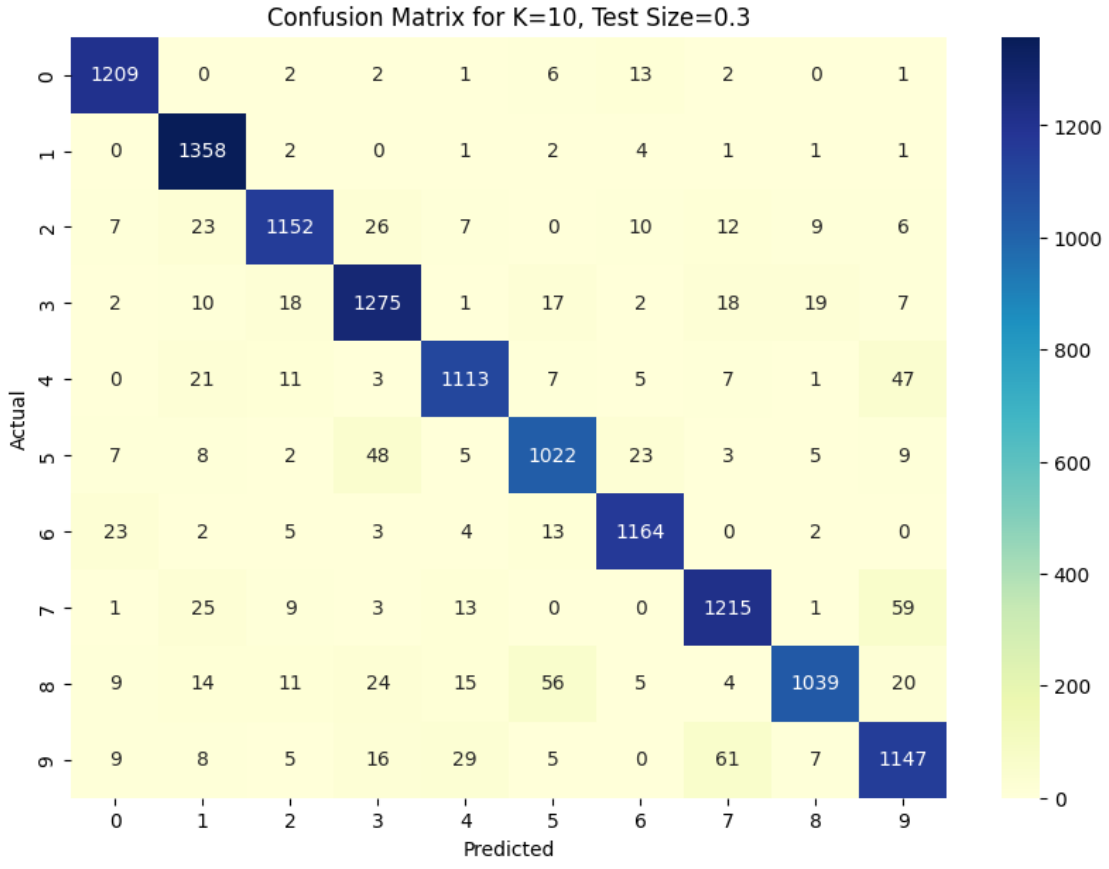
2.5 K=7

```
K=7, Test Size=0.3
Accuracy: 0.9288888888888889
Confusion Matrix:
 [[1206    0    3    2    0    6   13    2    2    2]
 [   0 1357    2    0    1    2    4    1    2    1]
 [  10   21 1148   29    4    1    9   14   10    6]
 [   4    8   15 1276    1   24    2   17   17    5]
 [   0   18   13    4 1114    6    3    7    2   48]
 [   7    8    2   42    5 1029   22    4    4    9]
 [  19    3    7    2    4    9 1170    0    2    0]
 [   2   23    6    4   17    0    0 1212    1   61]
 [   8   10   12   28   14   61    4    6 1037   17]
 [  11    6    5   17   28    4    0   54    7 1155]]
```



2.6 K=10

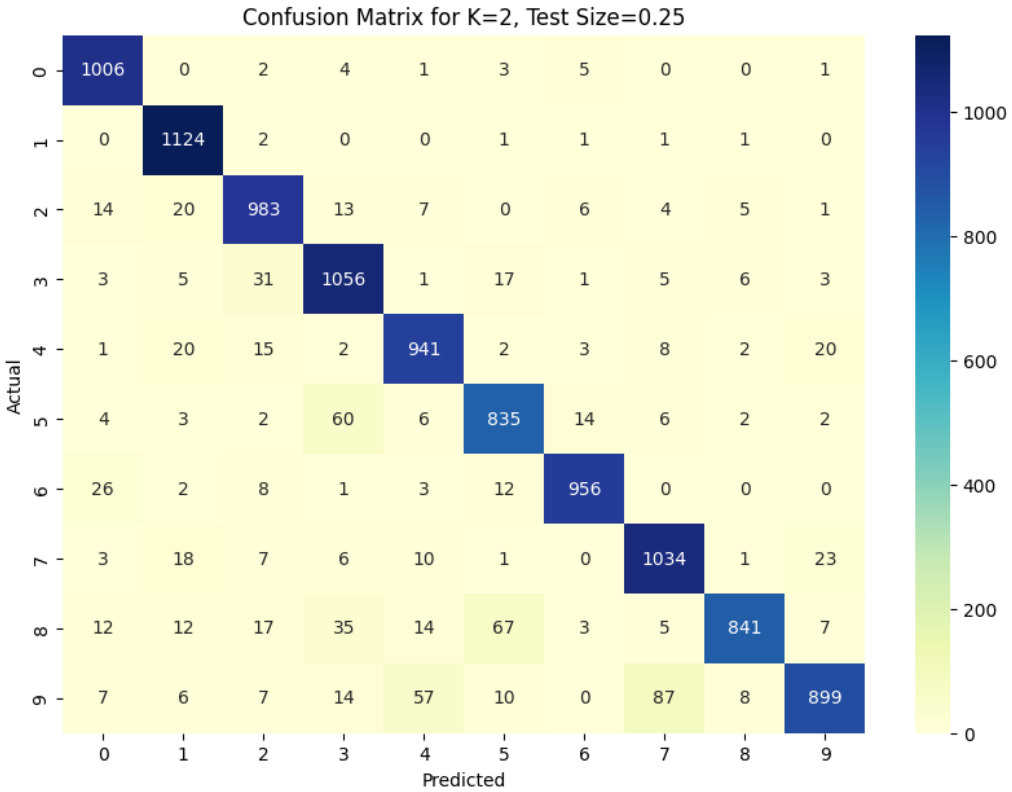
```
K=10, Test Size=0.3
Accuracy: 0.9280952380952381
Confusion Matrix:
 [[1209    0    2    2    1    6   13    2    0    1]
 [   0 1358    2    0    1    2    4    1    1    1]
 [   7   23 1152   26    7    0   10   12    9    6]
 [   2   10   18 1275    1   17    2   18   19    7]
 [   0   21   11    3 1113    7    5    7    1   47]
 [   7    8    2   48    5 1022   23    3    5    9]
 [  23    2    5    3    4   13 1164    0    2    0]
 [   1   25    9    3   13    0    0 1215    1   59]
 [   9   14   11   24   15   56    5    4 1039   20]
 [   9    8    5   16   29    5    0   61    7 1147]]
```



CASE – 3 : (Train:Test) Split Ratio = 75:25

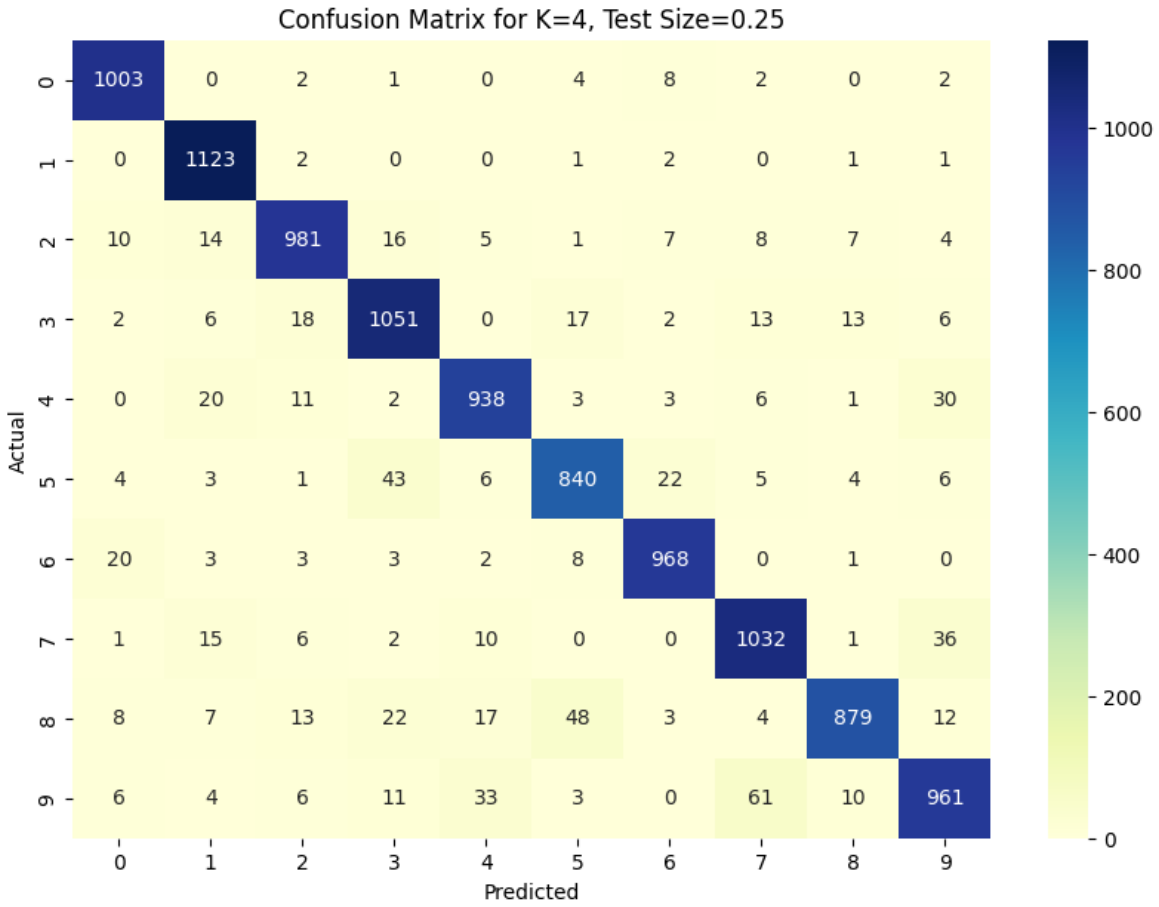
3.1 K=2

```
K=2, Test Size=0.25
Accuracy: 0.9214285714285714
Confusion Matrix:
 [[1006    0    2    4    1    3    5    0    0    1]
 [   0 1124    2    0    0    1    1    1    1    0]
 [  14   20  983   13    7    0    6    4    5    1]
 [   3    5   31 1056    1   17    1    5    6    3]
 [   1   20   15    2  941    2    3    8    2   20]
 [   4    3    2   60    6  835   14    6    2    2]
 [  26    2    8    1    3   12  956    0    0    0]
 [   3   18    7    6   10    1    0 1034    1   23]
 [  12   12   17   35   14   67    3    5  841    7]
 [   7    6    7   14   57   10    0   87    8  899]]
```



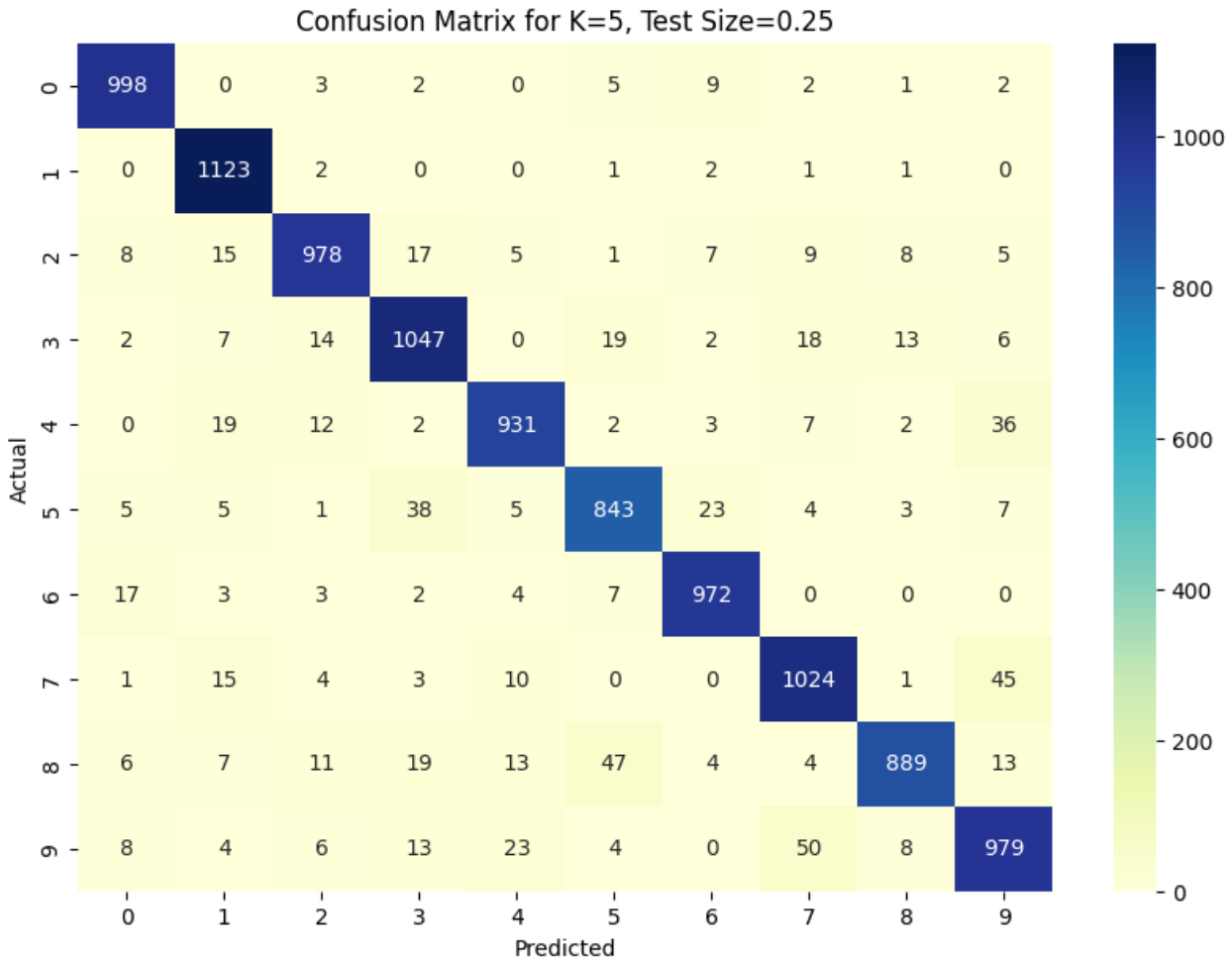
3.2 K=4

```
K=4, Test Size=0.25
Accuracy: 0.931047619047619
Confusion Matrix:
 [[1003    0    2    1    0    4    8    2    0    2]
 [   0 1123    2    0    0    1    2    0    1    1]
 [  10   14  981   16    5    1    7    8    7    4]
 [   2    6   18 1051    0   17    2   13   13    6]
 [   0   20   11    2  938    3    3    6    1   30]
 [   4    3    1   43    6  840   22    5    4    6]
 [  20    3    3    3    2    8  968    0    1    0]
 [   1   15    6    2   10    0    0 1032    1   36]
 [   8    7   13   22   17   48    3    4  879   12]
 [   6    4    6   11   33    3    0   61   10  961]]
```



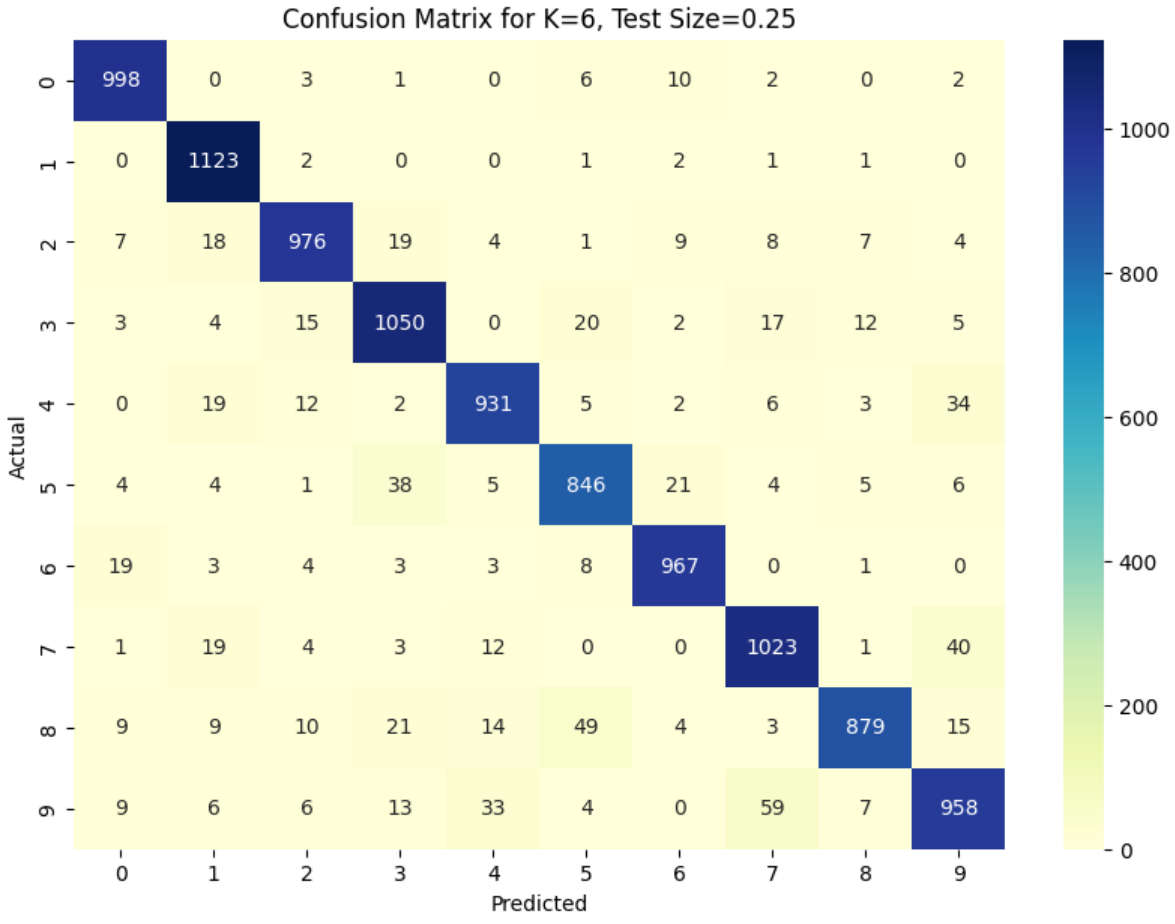
3.3 K=5

```
K=5, Test Size=0.25
Accuracy: 0.9318095238095238
Confusion Matrix:
 [[ 998    0    3    2    0    5    9    2    1    2]
 [   0 1123    2    0    0    1    2    1    1    0]
 [   8   15  978   17    5    1    7    9    8    5]
 [   2    7   14 1047    0   19    2   18   13    6]
 [   0   19   12    2  931    2    3    7    2   36]
 [   5    5    1   38    5  843   23    4    3    7]
 [  17    3    3    2    4    7  972    0    0    0]
 [   1   15    4    3   10    0    0 1024    1   45]
 [   6    7   11   19   13   47    4    4  889   13]
 [   8    4    6   13   23    4    0   50    8  979]]
```



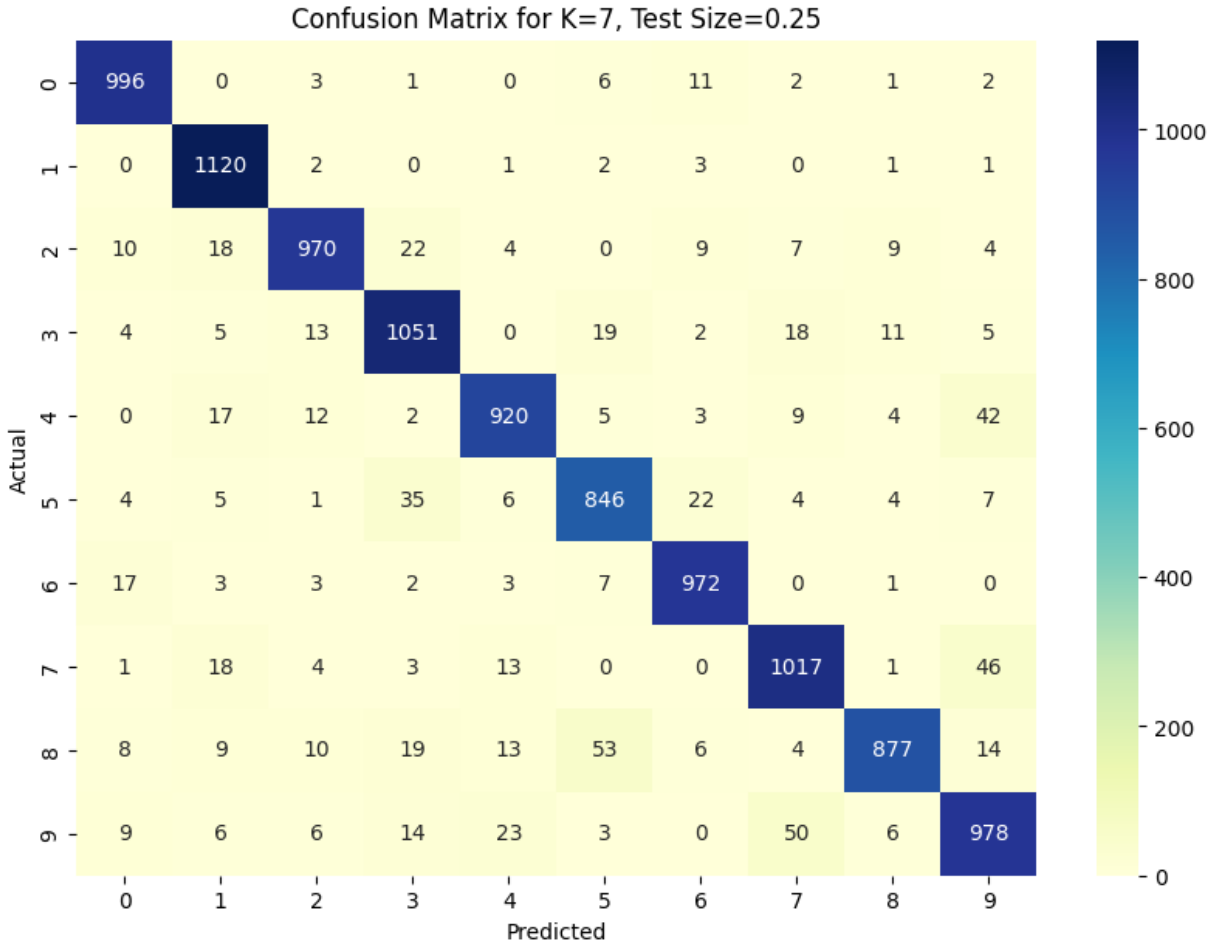
3.4 K=6

```
K=6, Test Size=0.25
Accuracy: 0.9286666666666666
Confusion Matrix:
 [[ 998    0    3    1    0    6   10    2    0    2]
 [   0 1123    2    0    0    1    2    1    1    0]
 [   7   18  976   19    4    1    9    8    7    4]
 [   3    4   15 1050    0   20    2   17   12    5]
 [   0   19   12    2  931    5    2    6    3   34]
 [   4    4    1   38    5  846   21    4    5    6]
 [  19    3    4    3    3    8  967    0    1    0]
 [   1   19    4    3   12    0    0 1023    1   40]
 [   9    9   10   21   14   49    4    3  879   15]
 [   9    6    6   13   33    4    0   59    7  958]]
```



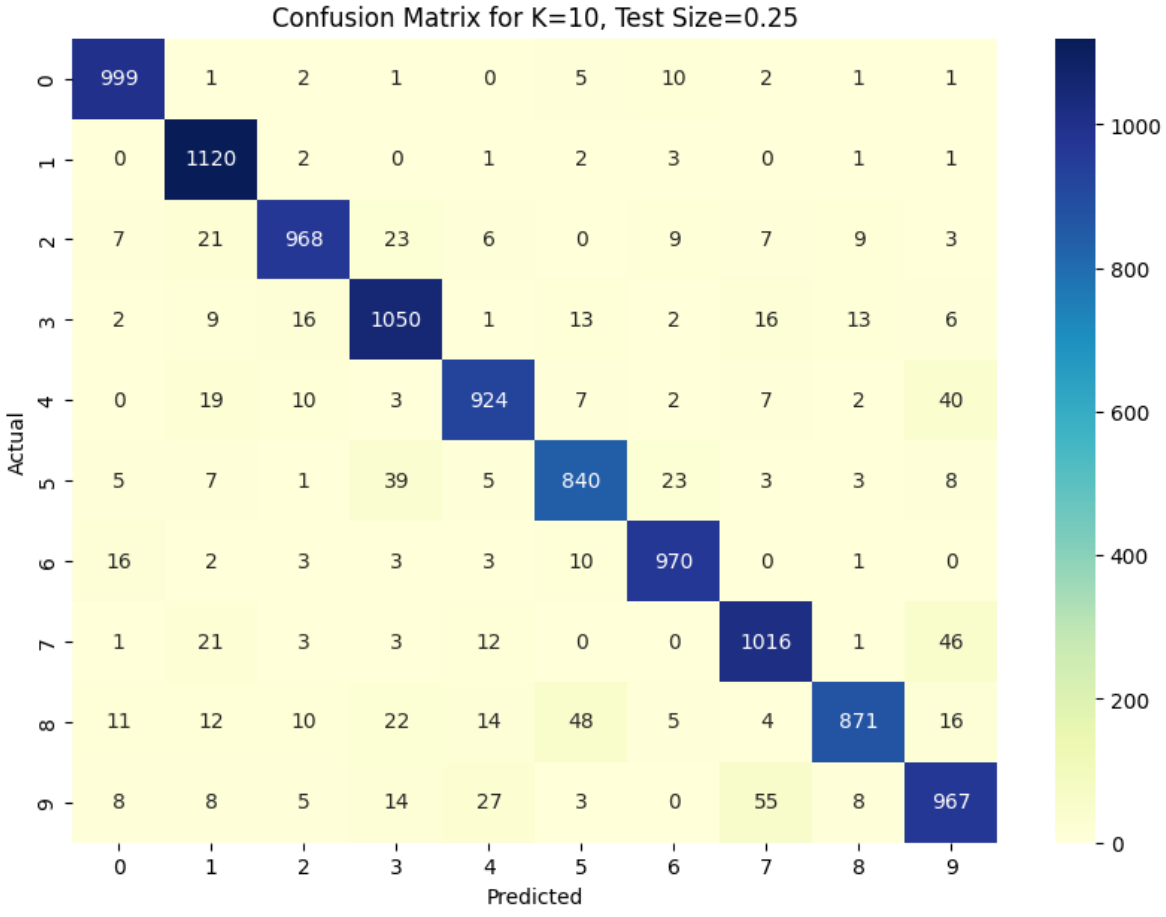
3.5 K=7

```
K=7, Test Size=0.25
Accuracy: 0.9282857142857143
Confusion Matrix:
 [[ 996    0    3    1    0    6   11    2    1    2]
 [   0 1120    2    0    1    2    3    0    1    1]
 [  10   18  970   22    4    0    9    7    9    4]
 [   4    5   13 1051    0   19    2   18   11    5]
 [   0   17   12    2  920    5    3    9    4   42]
 [   4    5    1   35    6  846   22    4    4    7]
 [  17    3    3    2    3    7  972    0    1    0]
 [   1   18    4    3   13    0    0 1017    1   46]
 [   8    9   10   19   13   53    6    4  877   14]
 [   9    6    6   14   23    3    0   50    6  978]]
```



3.6 K=10

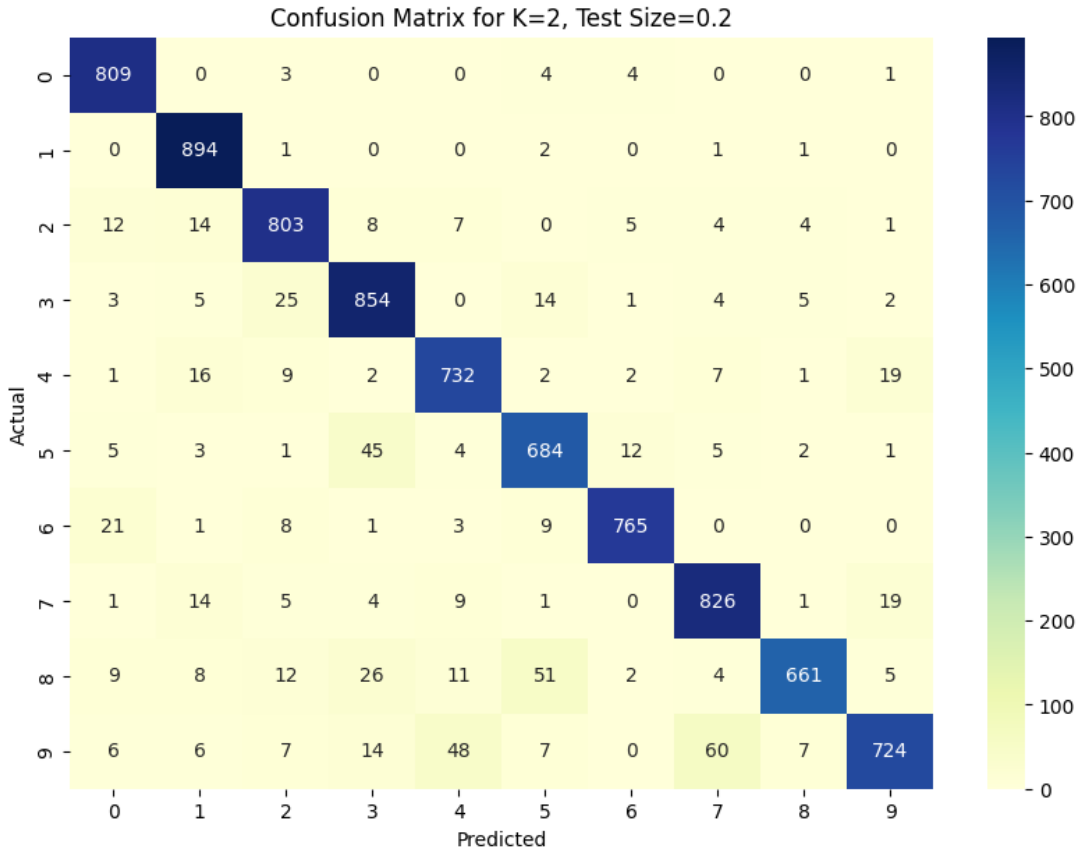
```
K=10, Test Size=0.25
Accuracy: 0.9261904761904762
Confusion Matrix:
 [[ 999    1    2    1    0    5   10    2    1    1]
 [   0 1120    2    0    1    2    3    0    1    1]
 [   7   21  968   23    6    0    9    7    9    3]
 [   2    9   16 1050    1   13    2   16   13    6]
 [   0   19   10    3  924    7    2    7    2   40]
 [   5    7    1   39    5  840   23    3    3    8]
 [  16    2    3    3    3   10  970    0    1    0]
 [   1   21    3    3   12    0    0 1016    1   46]
 [  11   12   10   22   14   48    5    4  871   16]
 [   8    8    5   14   27    3    0   55    8  967]]
```



CASE – 4 : (Train:Test) Split Ratio = 80:20

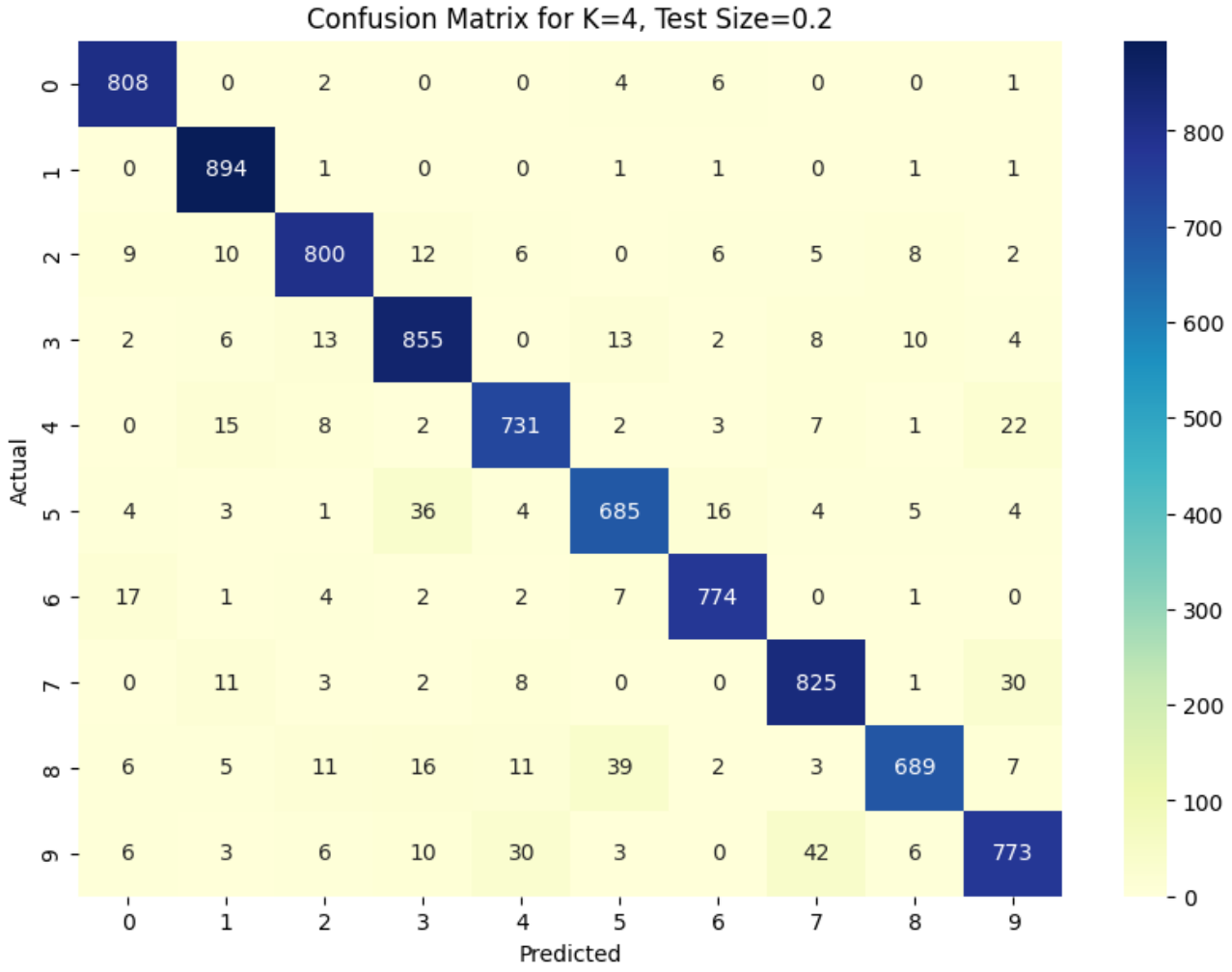
4.1 K=2

```
K=2, Test Size=0.2
Accuracy: 0.9228571428571428
Confusion Matrix:
 [[809   0   3   0   0   4   4   0   0   1]
 [  0 894   1   0   0   2   0   1   1   0]
 [ 12  14 803   8   7   0   5   4   4   1]
 [  3   5  25 854   0  14   1   4   5   2]
 [  1  16   9   2 732   2   2   7   1  19]
 [  5   3   1  45   4 684  12   5   2   1]
 [ 21   1   8   1   3   9 765   0   0   0]
 [  1  14   5   4   9   1   0 826   1  19]
 [  9   8  12  26  11  51   2   4 661   5]
 [  6   6   7  14  48   7   0  60   7 724]]
```



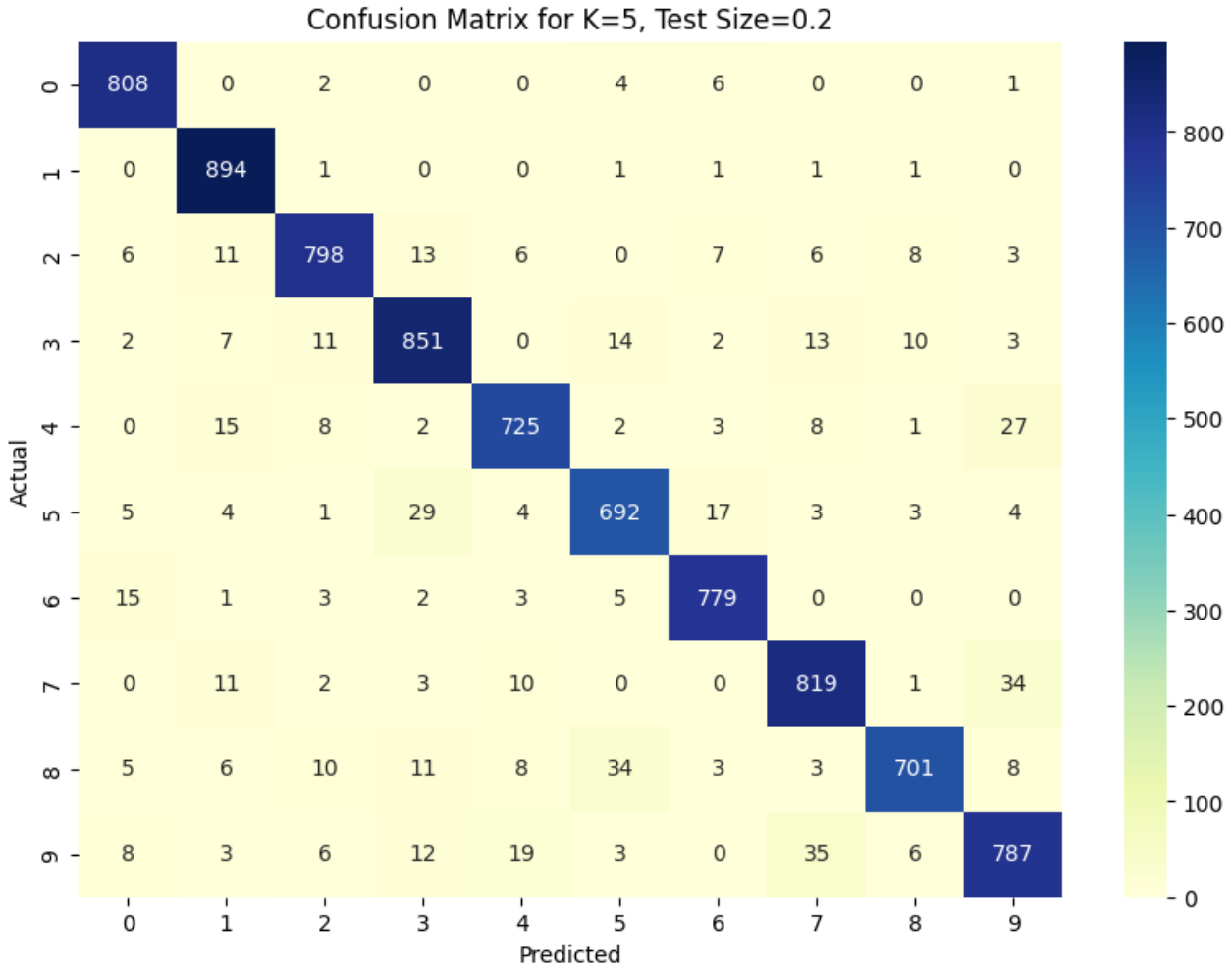
4.2 K=4

```
K=4, Test Size=0.2
Accuracy: 0.9326190476190476
Confusion Matrix:
 [[808   0   2   0   0   4   6   0   0   1]
 [  0 894   1   0   0   1   1   0   1   1]
 [  9  10 800  12   6   0   6   5   8   2]
 [  2   6  13 855   0  13   2   8  10   4]
 [  0  15   8   2 731   2   3   7   1  22]
 [  4   3   1  36   4 685  16   4   5   4]
 [ 17   1   4   2   2   7 774   0   1   0]
 [  0  11   3   2   8   0   0 825   1  30]
 [  6   5  11  16  11  39   2   3 689   7]
 [  6   3   6  10  30   3   0  42   6 773]]
```



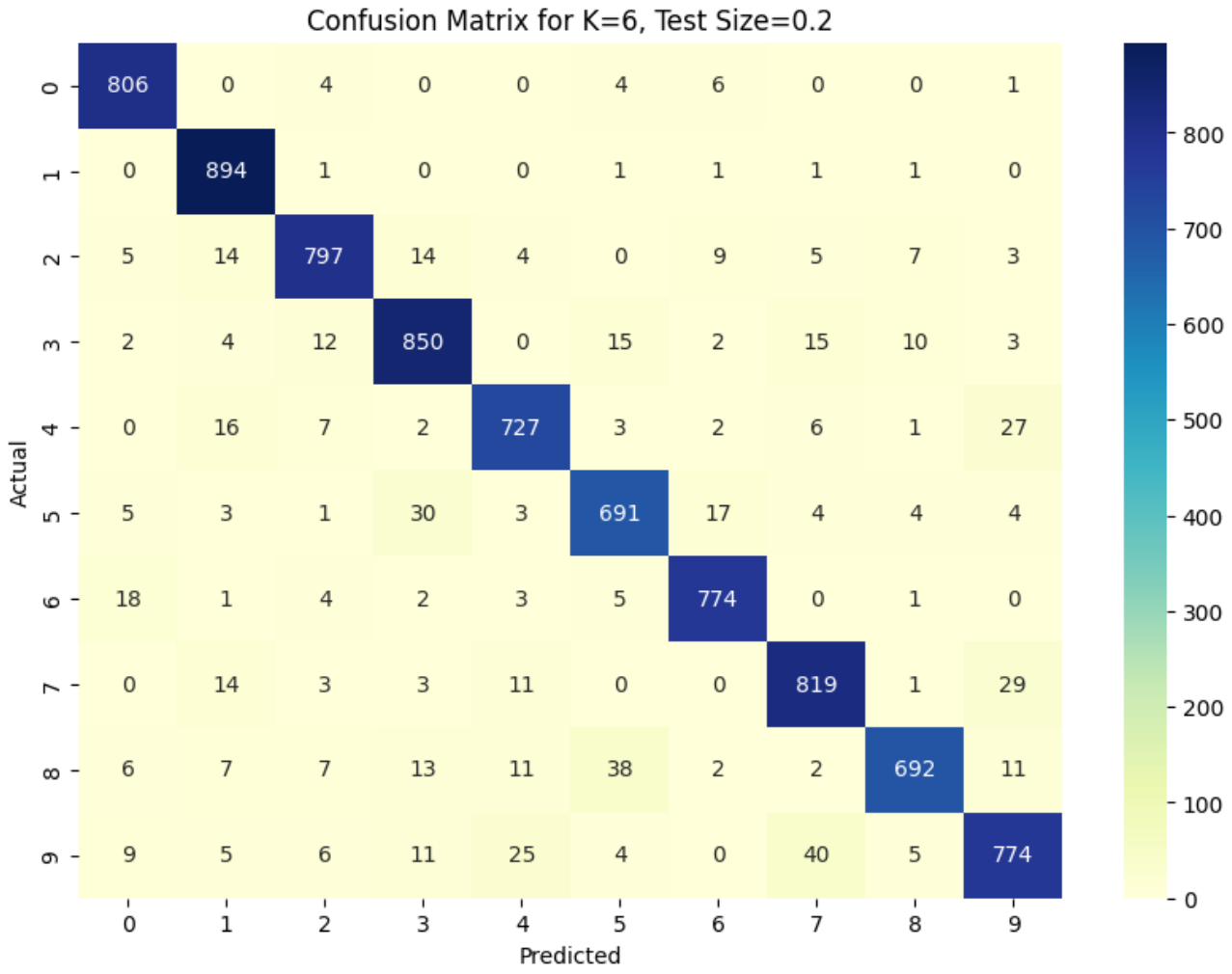
4.3 K=5

```
K=5, Test Size=0.2
Accuracy: 0.935
Confusion Matrix:
 [[808   0   2   0   0   4   6   0   0   1]
 [  0 894   1   0   0   1   1   1   1   0]
 [  6  11 798  13   6   0   7   6   8   3]
 [  2   7  11 851   0  14   2  13  10   3]
 [  0  15   8   2 725   2   3   8   1  27]
 [  5   4   1  29   4 692  17   3   3   4]
 [ 15   1   3   2   3   5 779   0   0   0]
 [  0  11   2   3  10   0   0 819   1  34]
 [  5   6  10  11   8  34   3   3 701   8]
 [  8   3   6  12  19   3   0  35   6 787]]
```



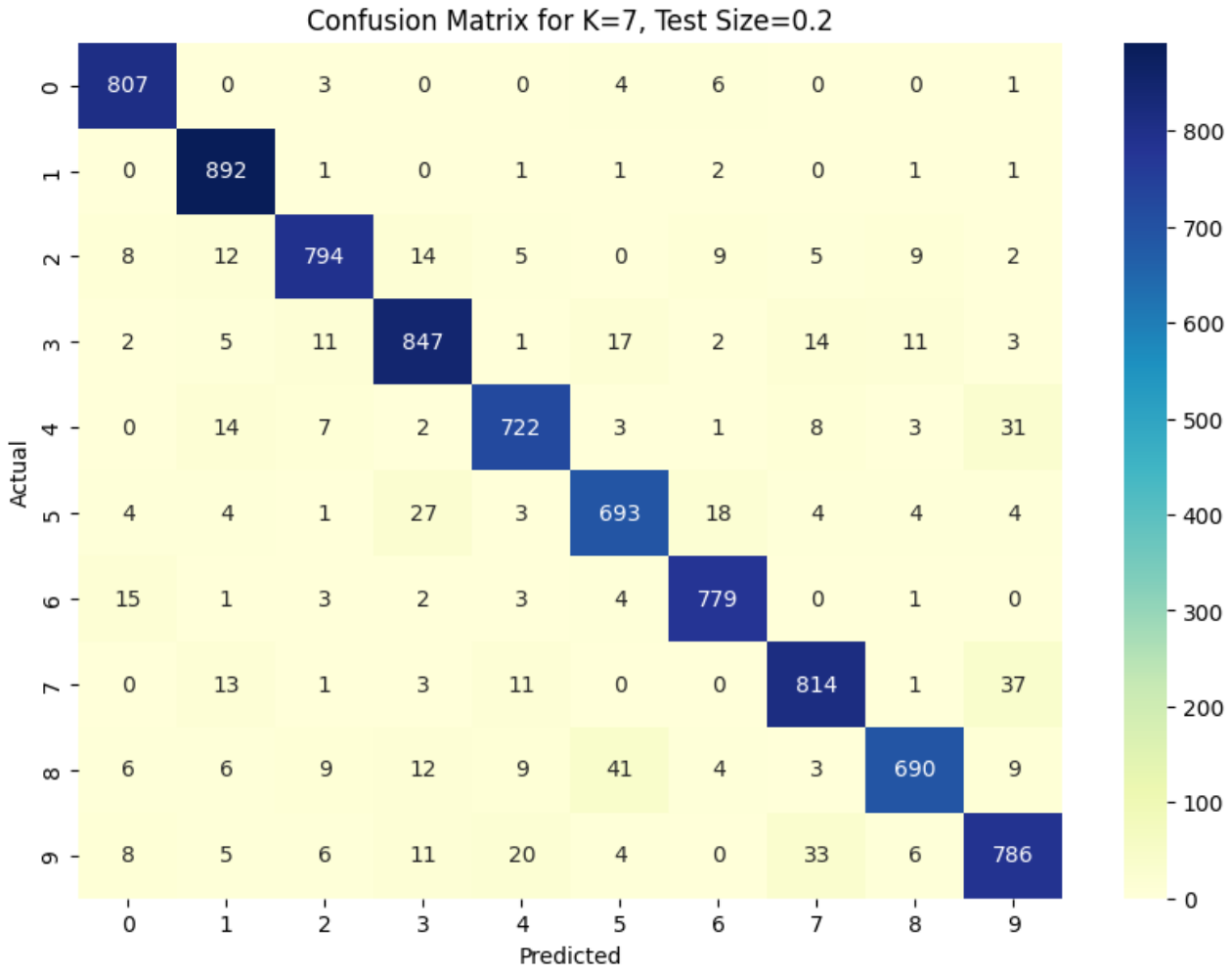
4.4 K=6

```
K=6, Test Size=0.2
Accuracy: 0.9314285714285714
Confusion Matrix:
 [[806   0   4   0   0   4   6   0   0   1]
 [  0 894   1   0   0   1   1   1   1   0]
 [  5  14 797  14   4   0   9   5   7   3]
 [  2   4  12 850   0  15   2  15  10   3]
 [  0  16   7   2 727   3   2   6   1  27]
 [  5   3   1  30   3 691  17   4   4   4]
 [ 18   1   4   2   3   5 774   0   1   0]
 [  0  14   3   3  11   0   0 819   1  29]
 [  6   7   7  13  11  38   2   2 692  11]
 [  9   5   6  11  25   4   0  40   5 774]]
```



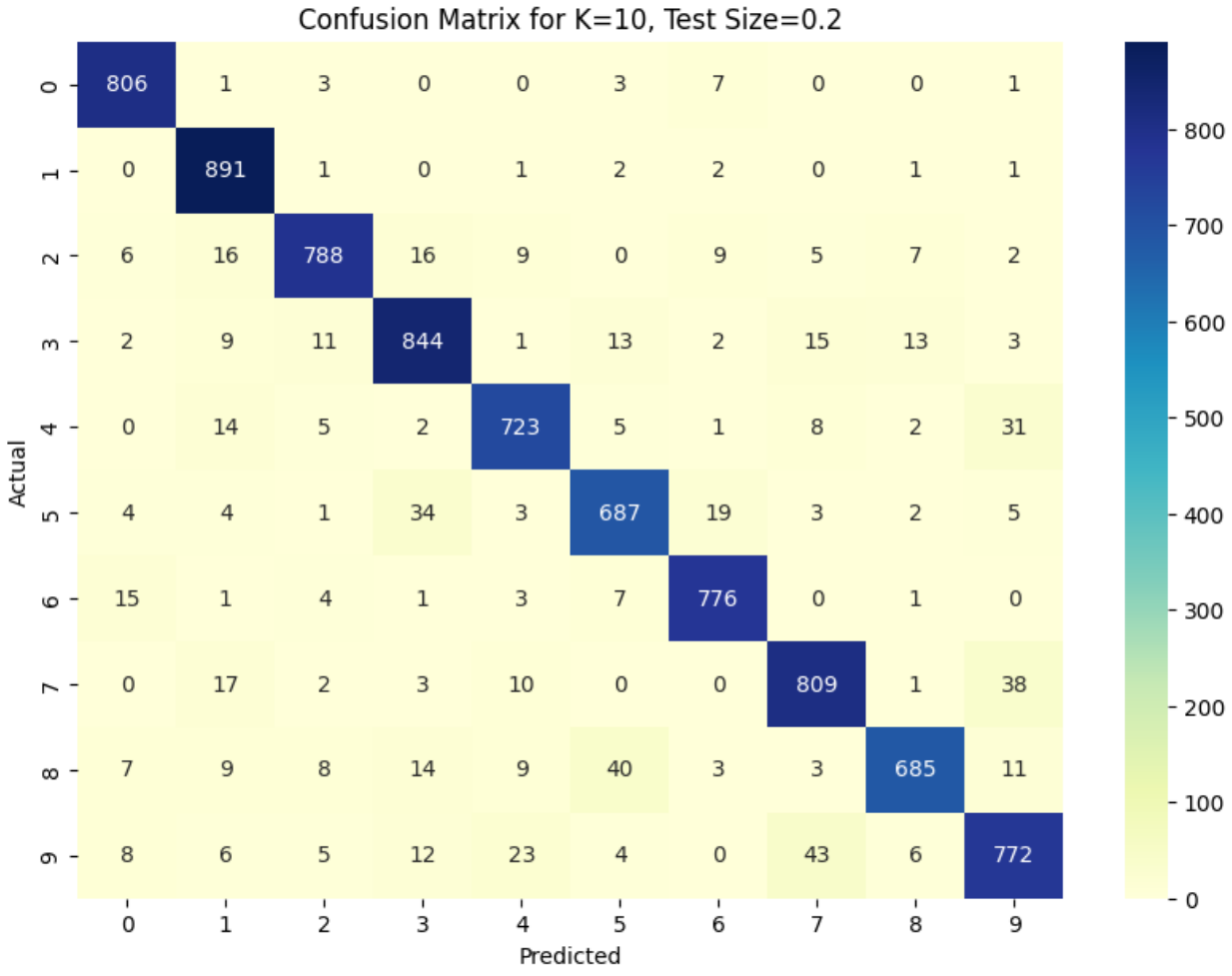
4.5 K=7

```
K=7, Test Size=0.2
Accuracy: 0.9314285714285714
Confusion Matrix:
 [[807   0   3   0   0   4   6   0   0   1]
 [  0 892   1   0   1   1   2   0   1   1]
 [  8  12 794  14   5   0   9   5   9   2]
 [  2   5  11 847   1  17   2  14  11   3]
 [  0  14   7   2 722   3   1   8   3  31]
 [  4   4   1  27   3 693  18   4   4   4]
 [ 15   1   3   2   3   4 779   0   1   0]
 [  0  13   1   3  11   0   0 814   1  37]
 [  6   6   9  12   9  41   4   3 690   9]
 [  8   5   6  11  20   4   0  33   6 786]]
```



4.6 K=10

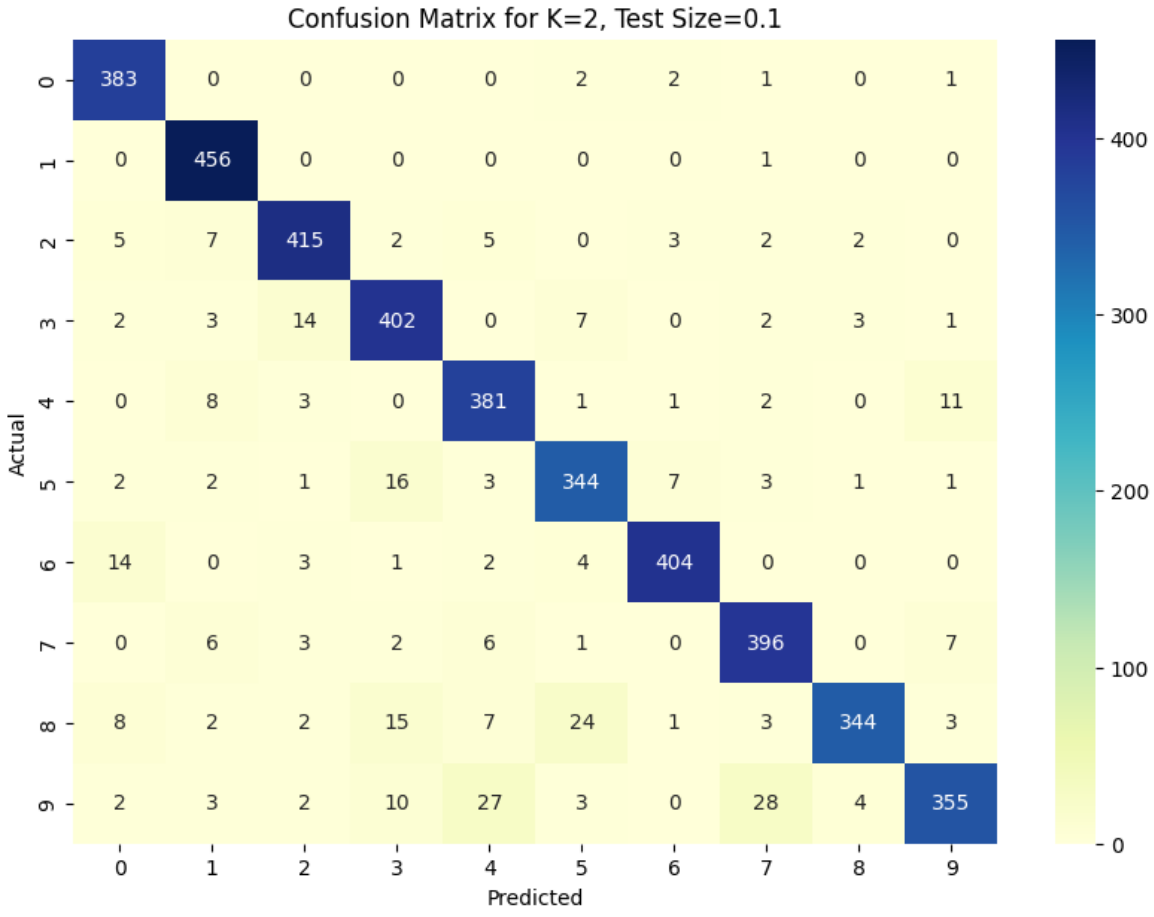
```
K=10, Test Size=0.2
Accuracy: 0.9263095238095238
Confusion Matrix:
 [[806   1   3   0   0   3   7   0   0   1]
 [  0 891   1   0   1   2   2   0   1   1]
 [  6  16 788  16   9   0   9   5   7   2]
 [  2   9  11 844   1  13   2  15  13   3]
 [  0  14   5   2 723   5   1   8   2  31]
 [  4   4   1  34   3 687  19   3   2   5]
 [ 15   1   4   1   3   7 776   0   1   0]
 [  0  17   2   3  10   0   0 809   1  38]
 [  7   9   8  14   9  40   3   3 685  11]
 [  8   6   5  12  23   4   0  43   6 772]]
```



CASE – 5 : (Train:Test) Split Ratio = 90:10

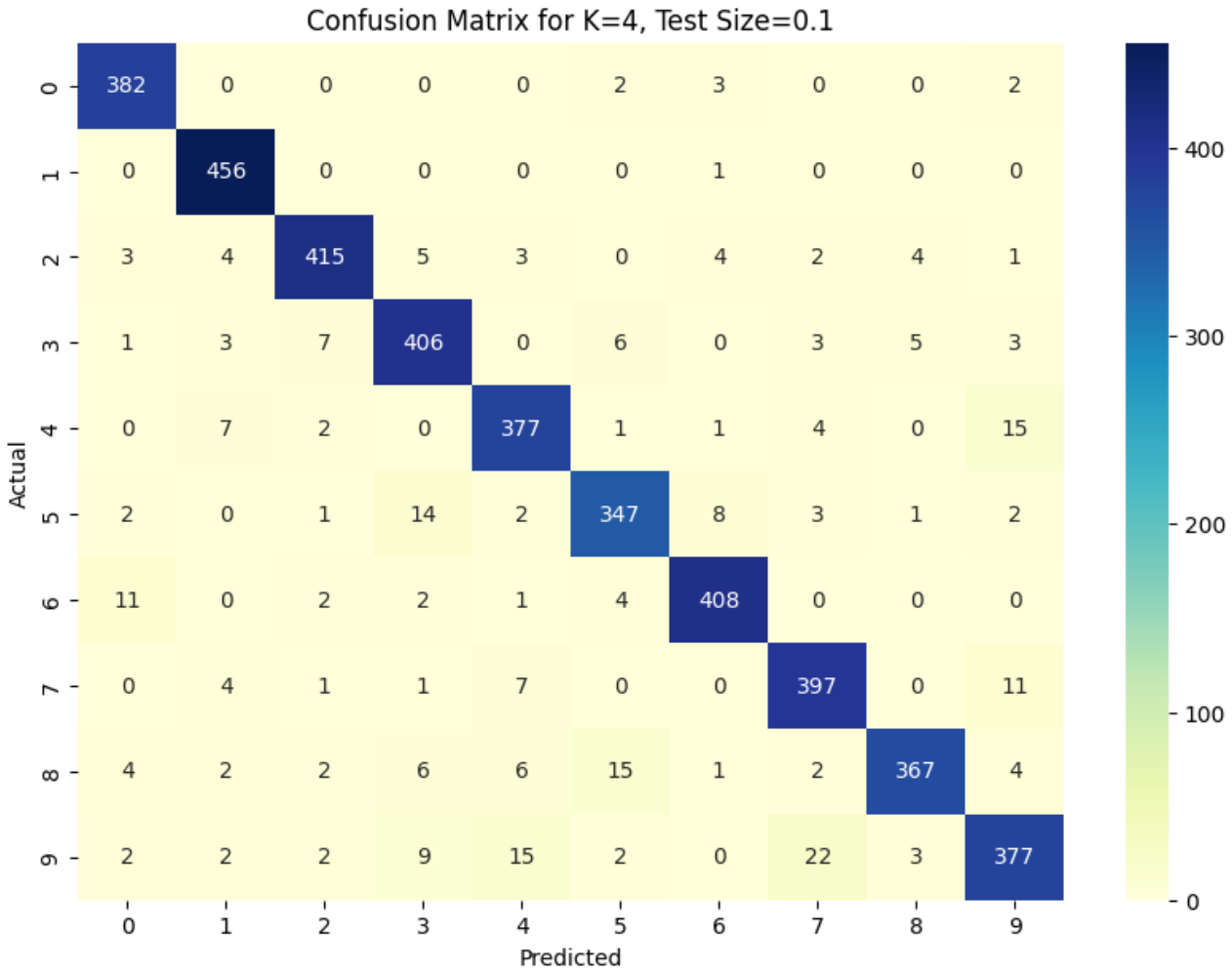
5.1 K=2

```
K=2, Test Size=0.1
Accuracy: 0.9238095238095239
Confusion Matrix:
 [[383   0   0   0   0   2   2   1   0   1]
 [  0 456   0   0   0   0   0   1   0   0]
 [  5   7 415   2   5   0   3   2   2   0]
 [  2   3  14 402   0   7   0   2   3   1]
 [  0   8   3   0 381   1   1   2   0  11]
 [  2   2   1  16   3 344   7   3   1   1]
 [ 14   0   3   1   2   4 404   0   0   0]
 [  0   6   3   2   6   1   0 396   0   7]
 [  8   2   2  15   7  24   1   3 344   3]
 [  2   3   2  10  27   3   0  28   4 355]]
```



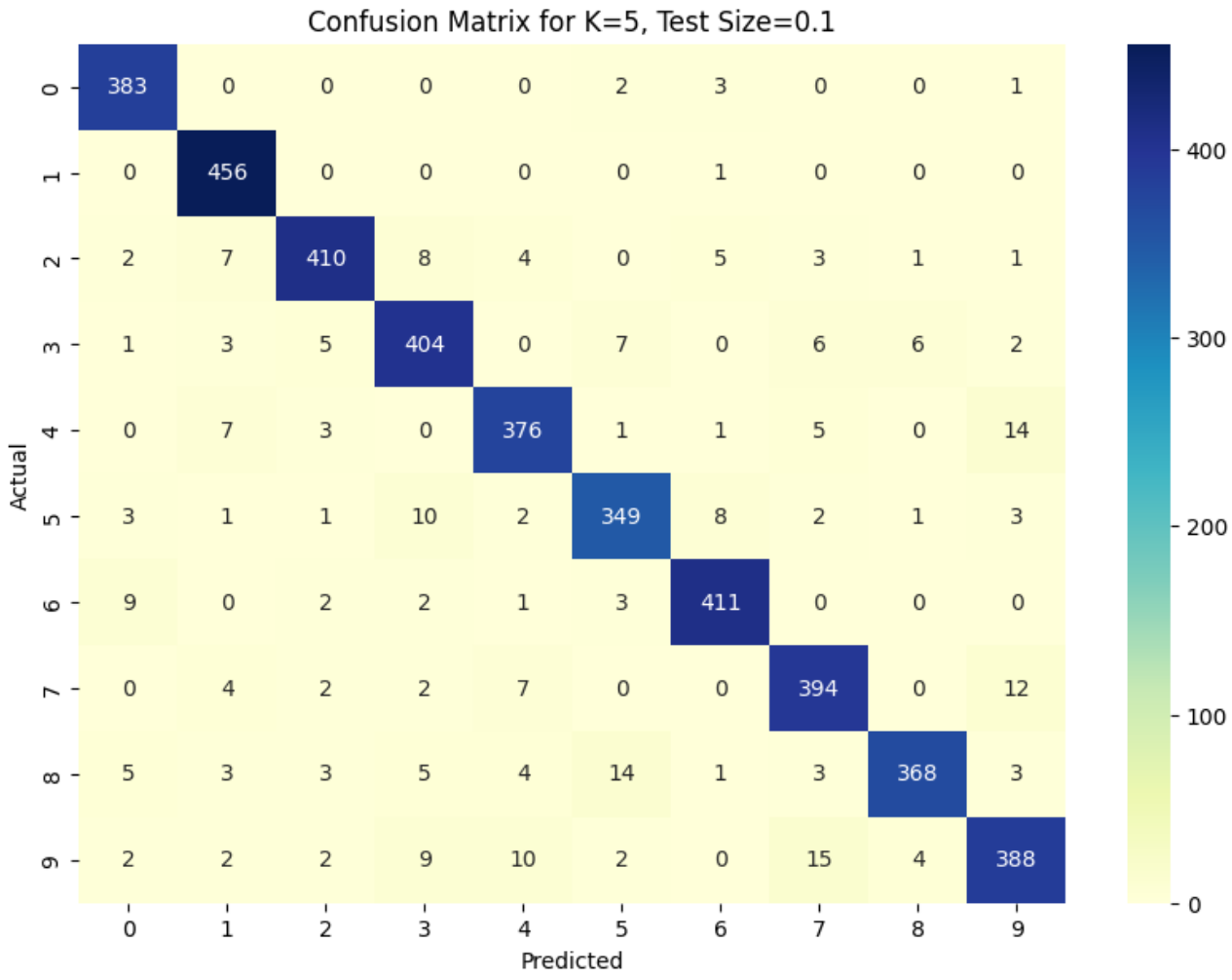
5.2 K=4

```
K=4, Test Size=0.1
Accuracy: 0.9361904761904762
Confusion Matrix:
 [[382   0   0   0   0   2   3   0   0   2]
 [  0 456   0   0   0   0   1   0   0   0]
 [  3   4 415   5   3   0   4   2   4   1]
 [  1   3   7 406   0   6   0   3   5   3]
 [  0   7   2   0 377   1   1   4   0  15]
 [  2   0   1  14   2 347   8   3   1   2]
 [ 11   0   2   2   1   4 408   0   0   0]
 [  0   4   1   1   7   0   0 397   0  11]
 [  4   2   2   6   6  15   1   2 367   4]
 [  2   2   2   9  15   2   0  22   3 377]]
```



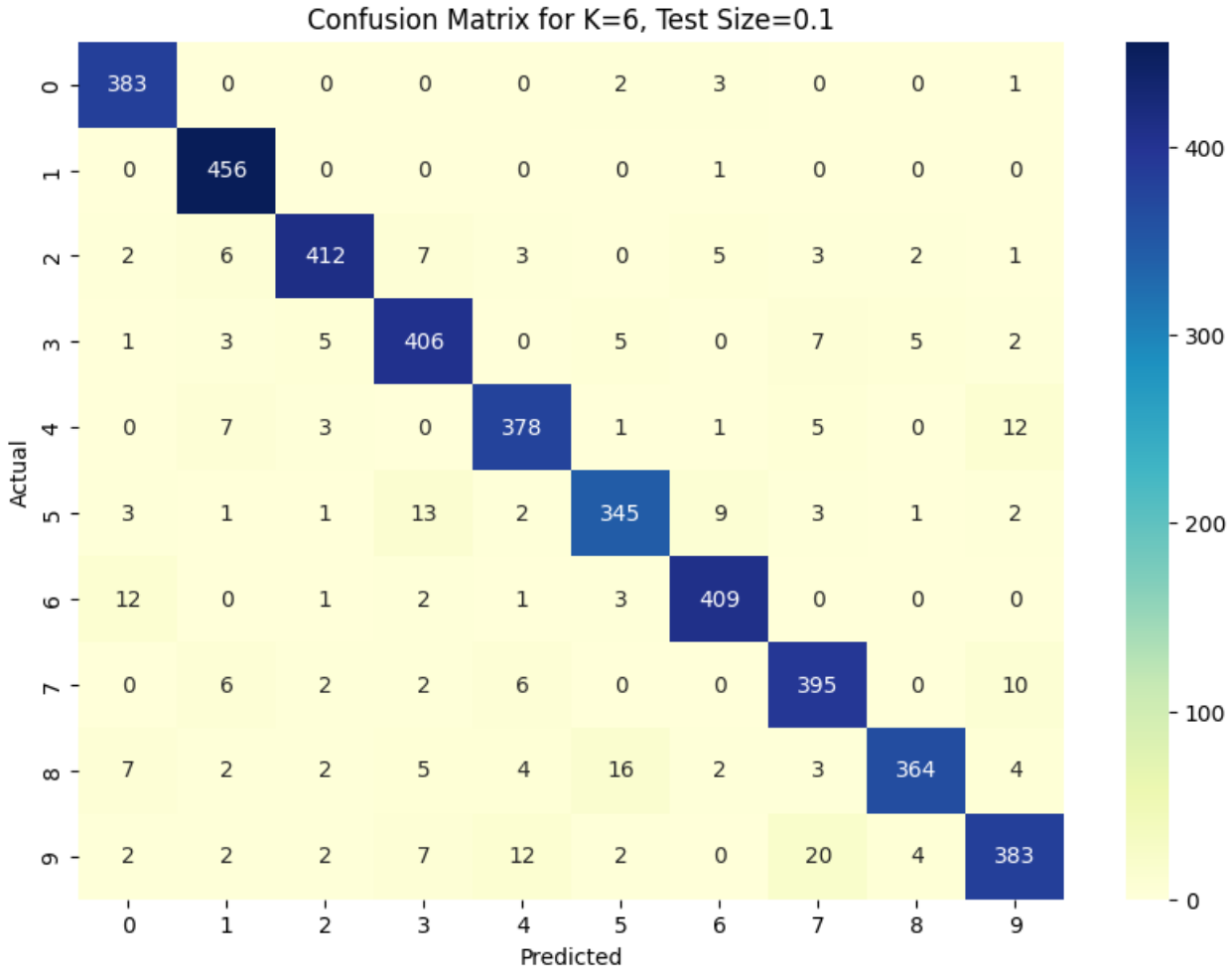
5.3 K=5

```
K=5, Test Size=0.1
Accuracy: 0.9378571428571428
Confusion Matrix:
 [[383   0   0   0   0   2   3   0   0   1]
 [  0 456   0   0   0   0   1   0   0   0]
 [  2   7 410   8   4   0   5   3   1   1]
 [  1   3   5 404   0   7   0   6   6   2]
 [  0   7   3   0 376   1   1   5   0  14]
 [  3   1   1  10   2 349   8   2   1   3]
 [  9   0   2   2   1   3 411   0   0   0]
 [  0   4   2   2   7   0   0 394   0  12]
 [  5   3   3   5   4  14   1   3 368   3]
 [  2   2   2   9  10   2   0  15   4 388]]
```



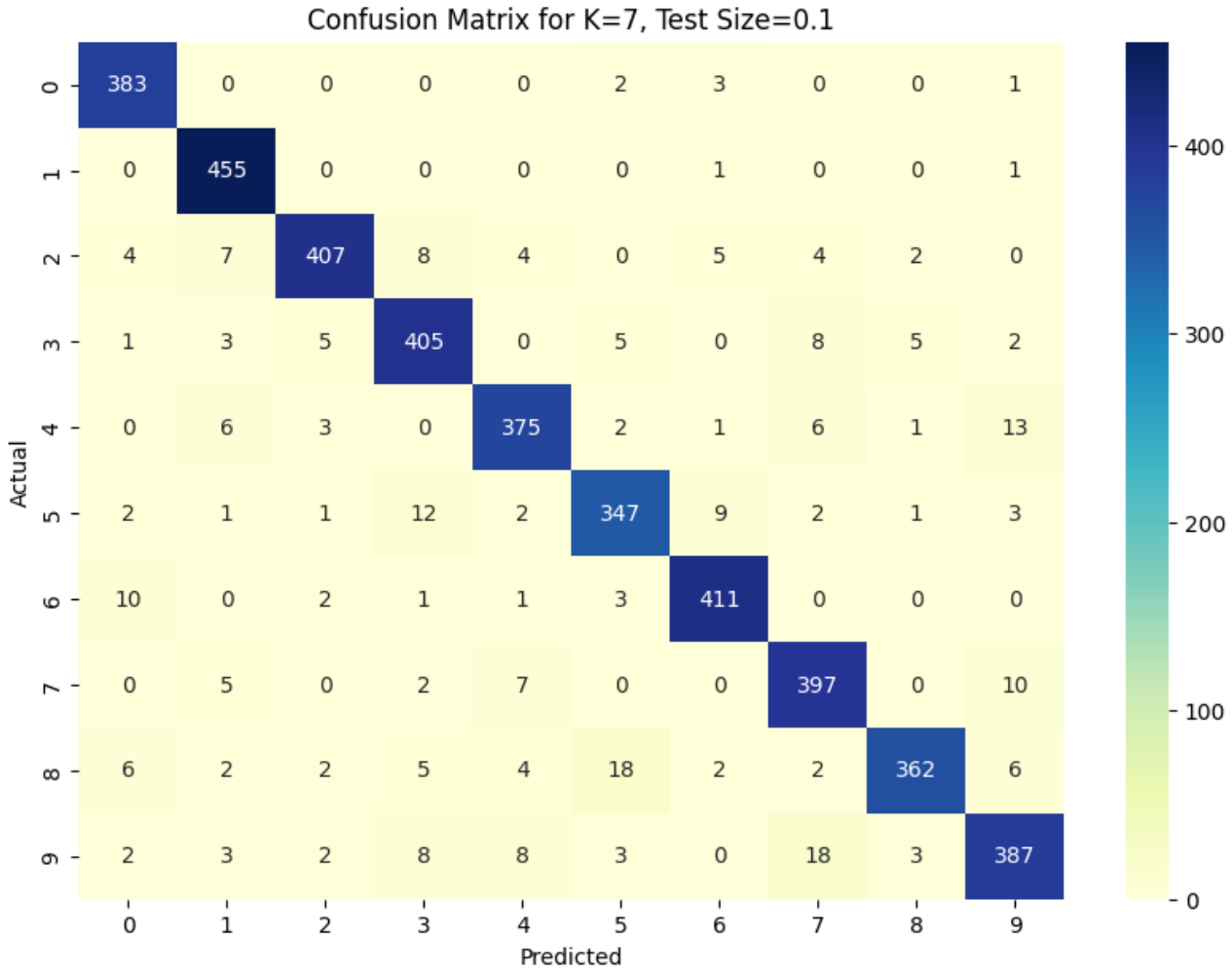
5.4 K=6

```
K=6, Test Size=0.1
Accuracy: 0.935952380952381
Confusion Matrix:
 [[383   0   0   0   0   2   3   0   0   1]
 [  0 456   0   0   0   0   1   0   0   0]
 [  2   6 412   7   3   0   5   3   2   1]
 [  1   3   5 406   0   5   0   7   5   2]
 [  0   7   3   0 378   1   1   5   0  12]
 [  3   1   1  13   2 345   9   3   1   2]
 [ 12   0   1   2   1   3 409   0   0   0]
 [  0   6   2   2   6   0   0 395   0  10]
 [  7   2   2   5   4  16   2   3 364   4]
 [  2   2   2   7  12   2   0  20   4 383]]
```



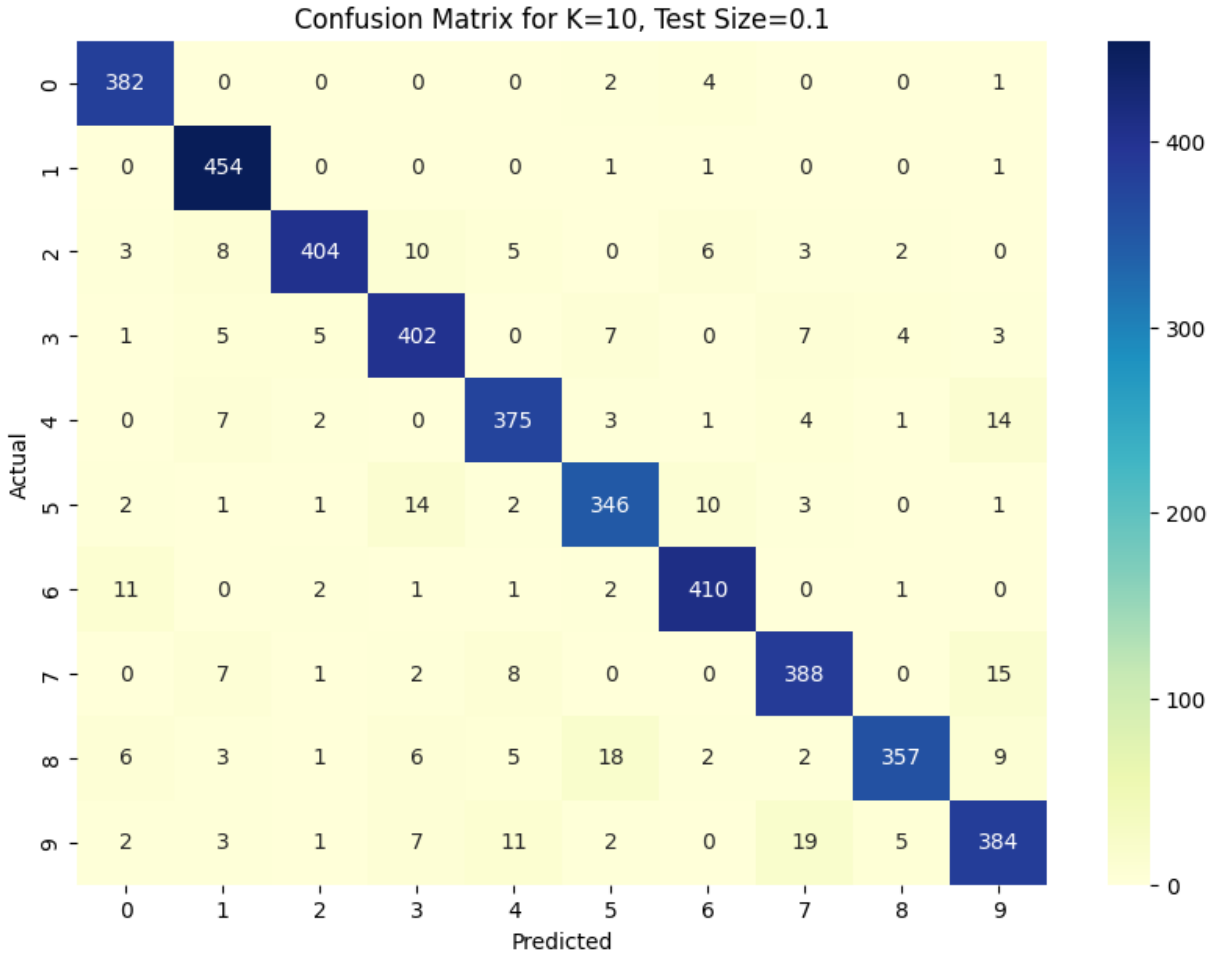
5.5 K=7

```
K=7, Test Size=0.1
Accuracy: 0.9354761904761905
Confusion Matrix:
 [[383   0   0   0   0   2   3   0   0   1]
 [  0 455   0   0   0   0   1   0   0   1]
 [  4   7 407   8   4   0   5   4   2   0]
 [  1   3   5 405   0   5   0   8   5   2]
 [  0   6   3   0 375   2   1   6   1  13]
 [  2   1   1  12   2 347   9   2   1   3]
 [ 10   0   2   1   1   3 411   0   0   0]
 [  0   5   0   2   7   0   0 397   0  10]
 [  6   2   2   5   4  18   2   2 362   6]
 [  2   3   2   8   8   3   0  18   3 387]]
```



5.6 K=10

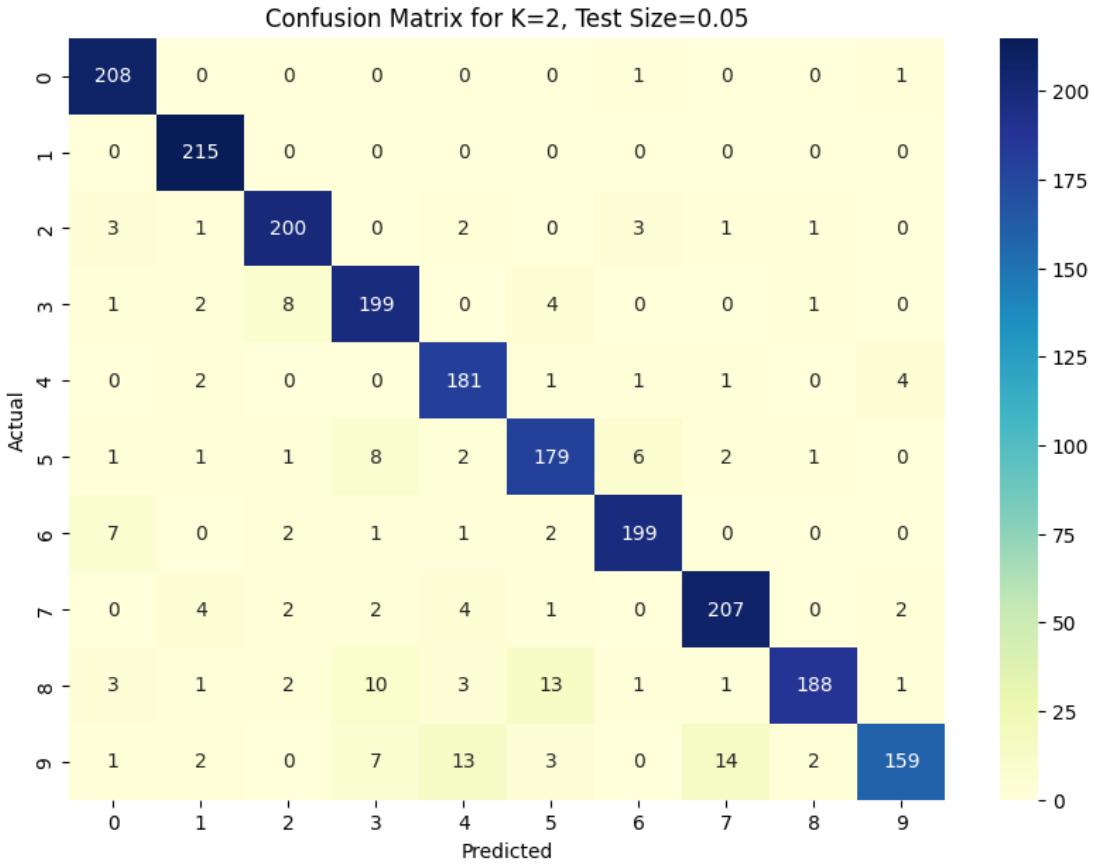
```
K=10, Test Size=0.1
Accuracy: 0.929047619047619
Confusion Matrix:
 [[382   0   0   0   0   2   4   0   0   1]
 [  0 454   0   0   0   1   1   0   0   1]
 [  3   8 404  10   5   0   6   3   2   0]
 [  1   5   5 402   0   7   0   7   4   3]
 [  0   7   2   0 375   3   1   4   1  14]
 [  2   1   1  14   2 346  10   3   0   1]
 [ 11   0   2   1   1   2 410   0   1   0]
 [  0   7   1   2   8   0   0 388   0  15]
 [  6   3   1   6   5  18   2   2 357   9]
 [  2   3   1   7  11   2   0  19   5 384]]
```



CASE – 6 : (Train:Test) Split Ratio = 95:5

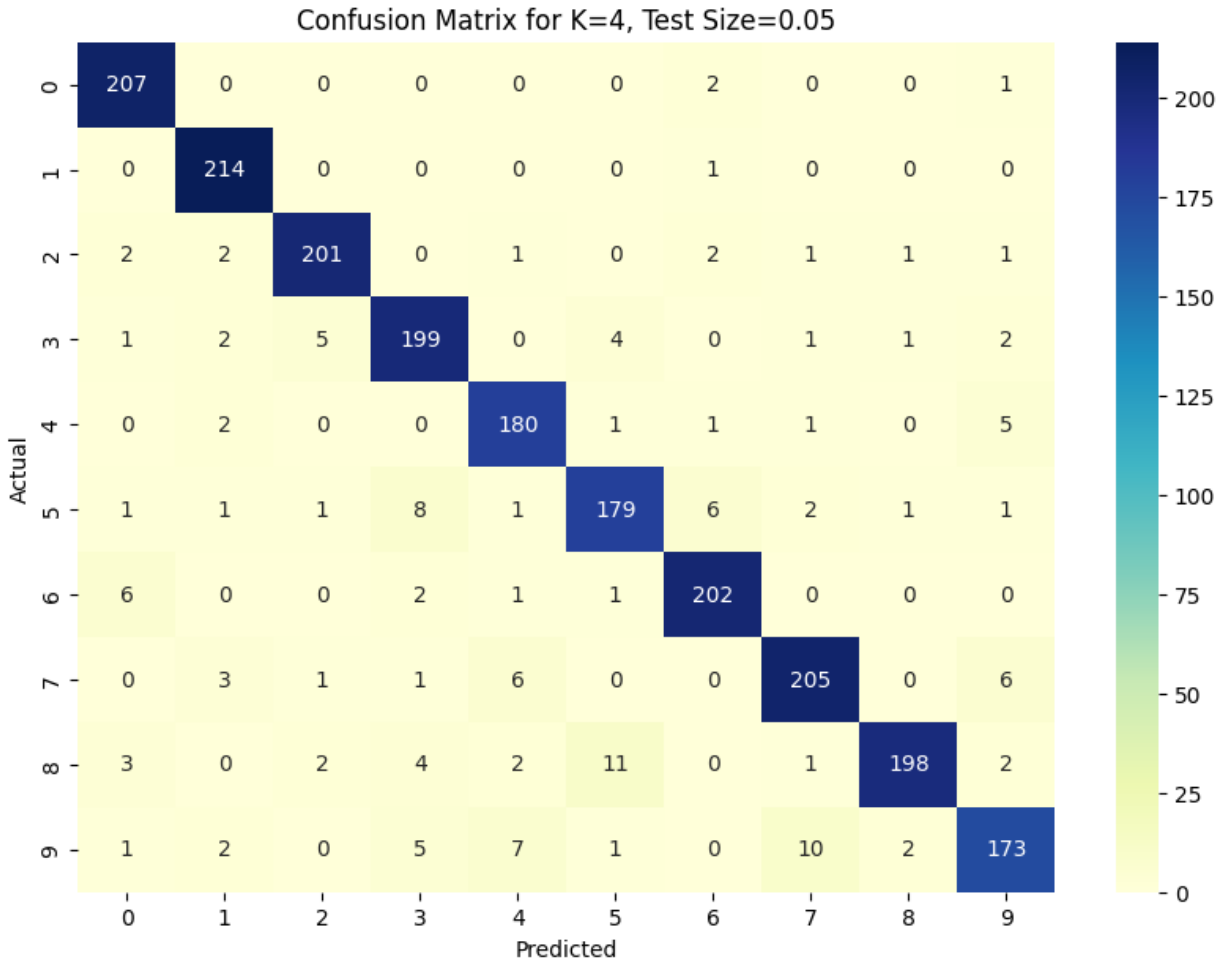
6.1 K=2

```
K=2, Test Size=0.05
Accuracy: 0.9214285714285714
Confusion Matrix:
 [[208   0   0   0   0   0   1   0   0   1]
 [  0 215   0   0   0   0   0   0   0   0]
 [  3   1 200   0   2   0   3   1   1   0]
 [  1   2   8 199   0   4   0   0   1   0]
 [  0   2   0   0 181   1   1   1   0   4]
 [  1   1   1   8   2 179   6   2   1   0]
 [  7   0   2   1   1   2 199   0   0   0]
 [  0   4   2   2   4   1   0 207   0   2]
 [  3   1   2  10   3  13   1   1 188   1]
 [  1   2   0   7  13   3   0  14   2 159]]
```



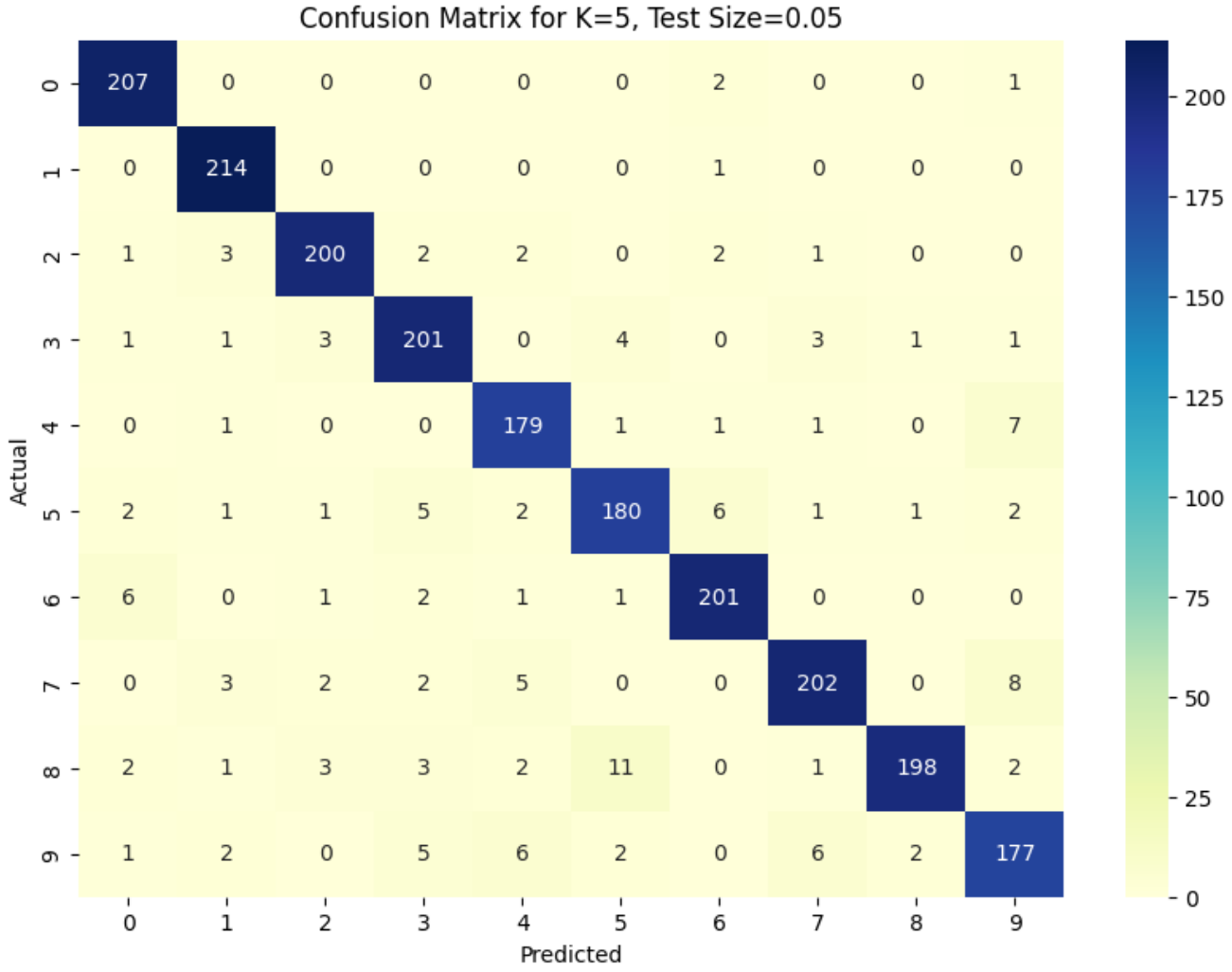
6.2 K=4

```
K=4, Test Size=0.05
Accuracy: 0.9323809523809524
Confusion Matrix:
 [[207   0   0   0   0   0   2   0   0   1]
 [  0 214   0   0   0   0   1   0   0   0]
 [  2   2 201   0   1   0   2   1   1   1]
 [  1   2   5 199   0   4   0   1   1   2]
 [  0   2   0   0 180   1   1   1   0   5]
 [  1   1   1   8   1 179   6   2   1   1]
 [  6   0   0   2   1   1 202   0   0   0]
 [  0   3   1   1   6   0   0 205   0   6]
 [  3   0   2   4   2  11   0   1 198   2]
 [  1   2   0   5   7   1   0  10   2 173]]
```



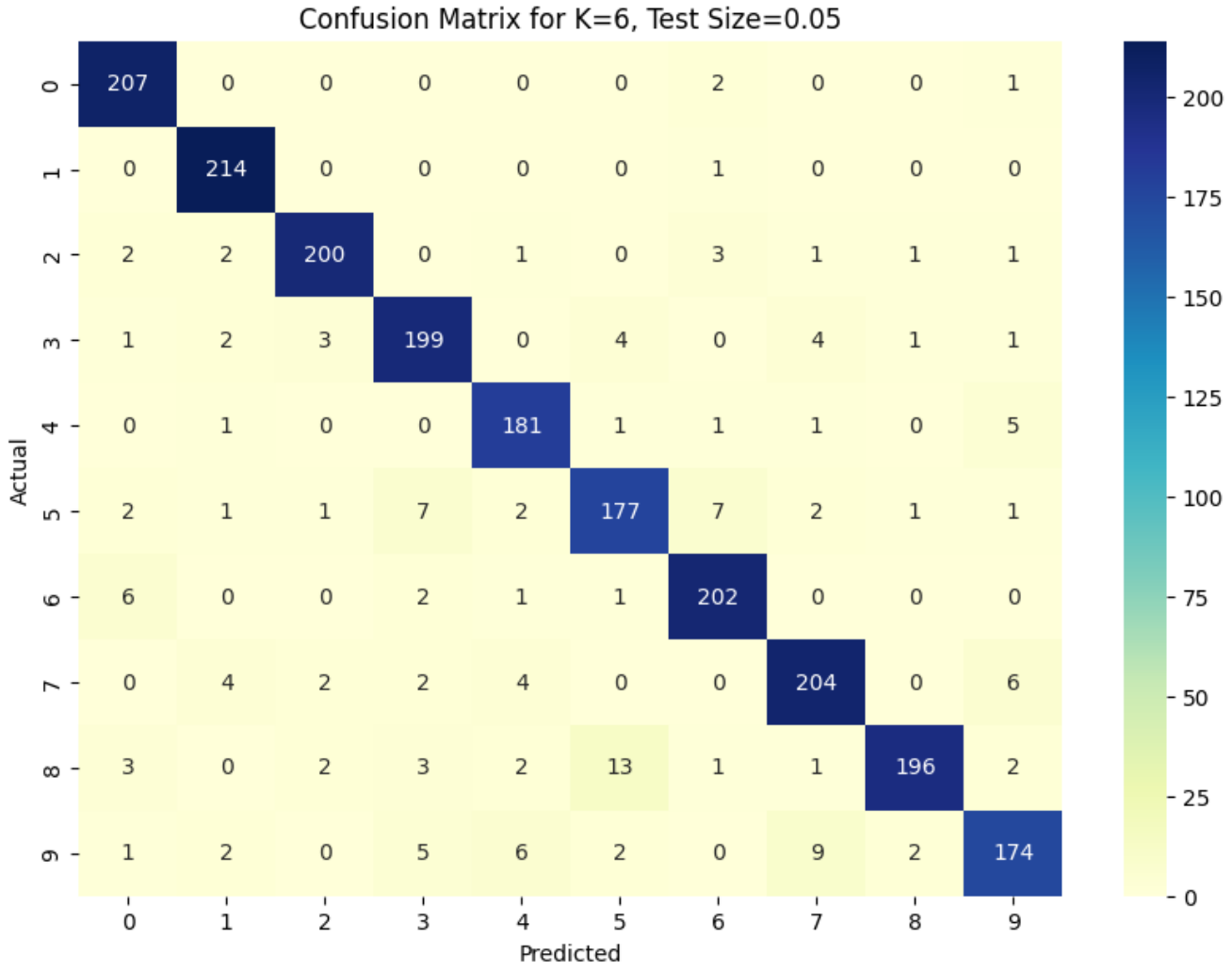
6.3 K=5

```
K=5, Test Size=0.05
Accuracy: 0.9328571428571428
Confusion Matrix:
 [[207   0   0   0   0   0   2   0   0   1]
 [  0 214   0   0   0   0   1   0   0   0]
 [  1   3 200   2   2   0   2   1   0   0]
 [  1   1   3 201   0   4   0   3   1   1]
 [  0   1   0   0 179   1   1   1   0   7]
 [  2   1   1   5   2 180   6   1   1   2]
 [  6   0   1   2   1   1 201   0   0   0]
 [  0   3   2   2   5   0   0 202   0   8]
 [  2   1   3   3   2  11   0   1 198   2]
 [  1   2   0   5   6   2   0   6   2 177]]
```



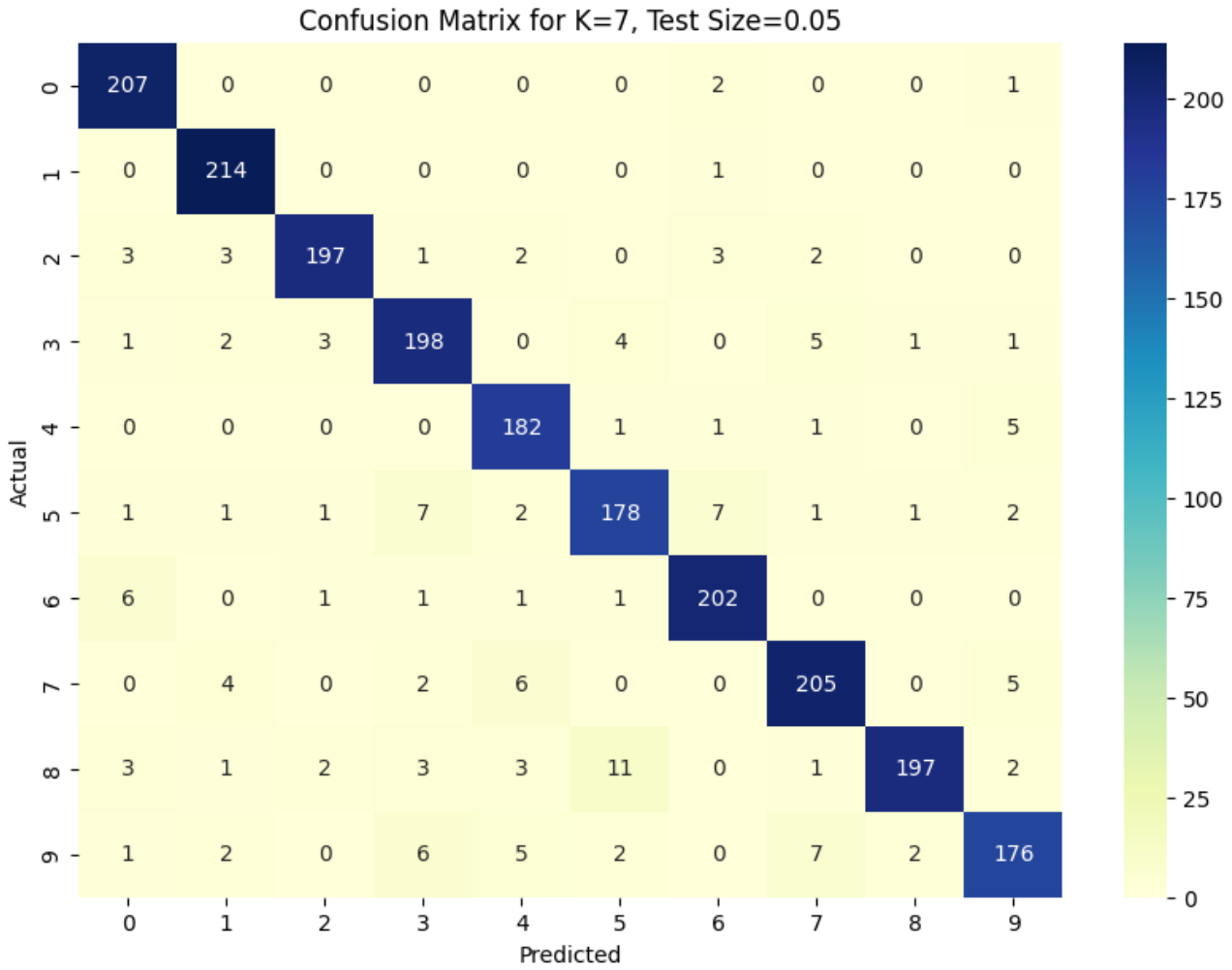
6.4 K=6

```
K=6, Test Size=0.05
Accuracy: 0.9304761904761905
Confusion Matrix:
 [[207   0   0   0   0   0   2   0   0   1]
 [  0 214   0   0   0   0   1   0   0   0]
 [  2   2 200   0   1   0   3   1   1   1]
 [  1   2   3 199   0   4   0   4   1   1]
 [  0   1   0   0 181   1   1   1   0   5]
 [  2   1   1   7   2 177   7   2   1   1]
 [  6   0   0   2   1   1 202   0   0   0]
 [  0   4   2   2   4   0   0 204   0   6]
 [  3   0   2   3   2  13   1   1 196   2]
 [  1   2   0   5   6   2   0   9   2 174]]
```



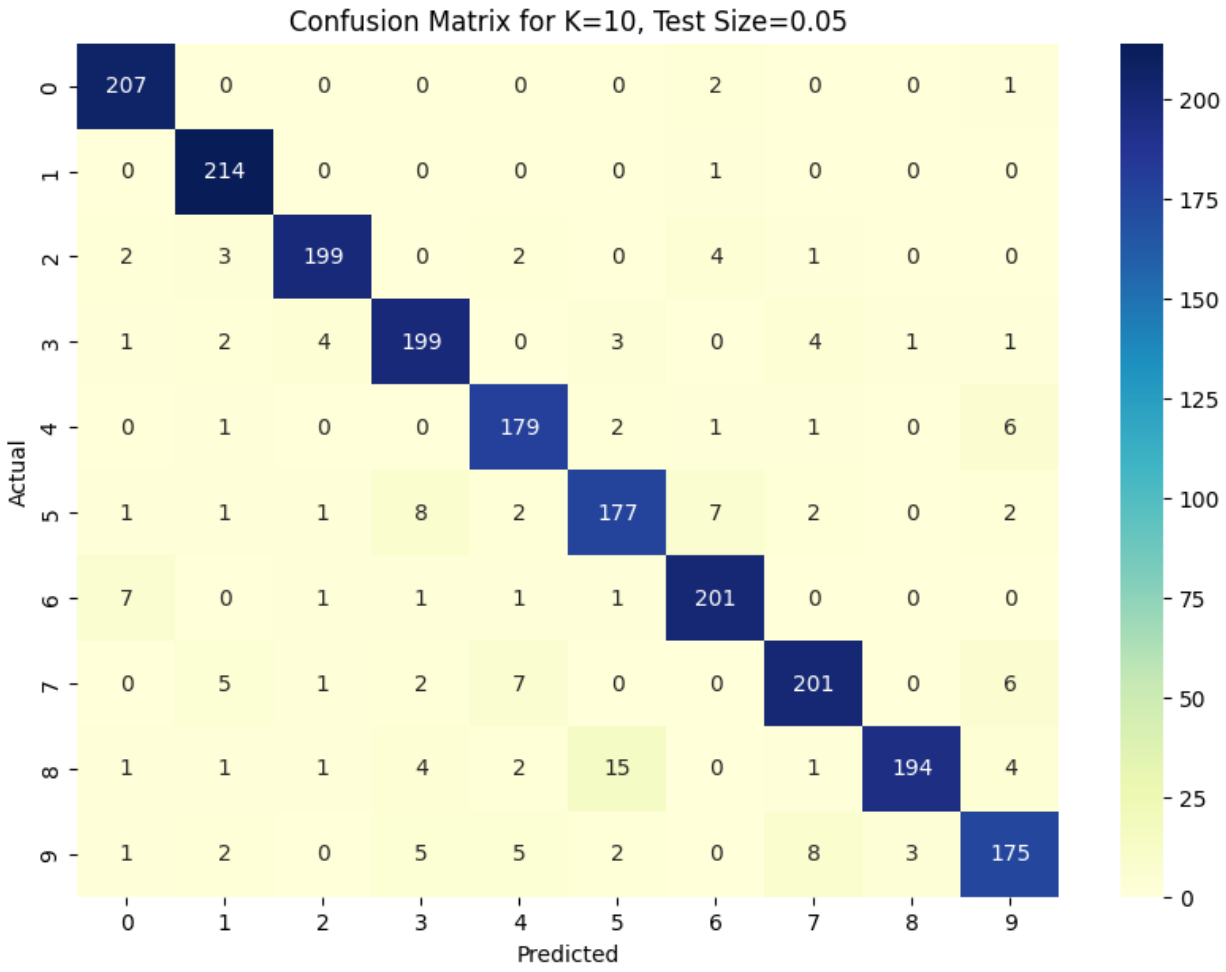
6.5 K=7

```
K=7, Test Size=0.05
Accuracy: 0.9314285714285714
Confusion Matrix:
 [[207   0   0   0   0   0   2   0   0   1]
 [  0 214   0   0   0   0   1   0   0   0]
 [  3   3 197   1   2   0   3   2   0   0]
 [  1   2   3 198   0   4   0   5   1   1]
 [  0   0   0   0 182   1   1   1   0   5]
 [  1   1   1   7   2 178   7   1   1   2]
 [  6   0   1   1   1   1 202   0   0   0]
 [  0   4   0   2   6   0   0 205   0   5]
 [  3   1   2   3   3  11   0   1 197   2]
 [  1   2   0   6   5   2   0   7   2 176]]
```



6.6 K=10

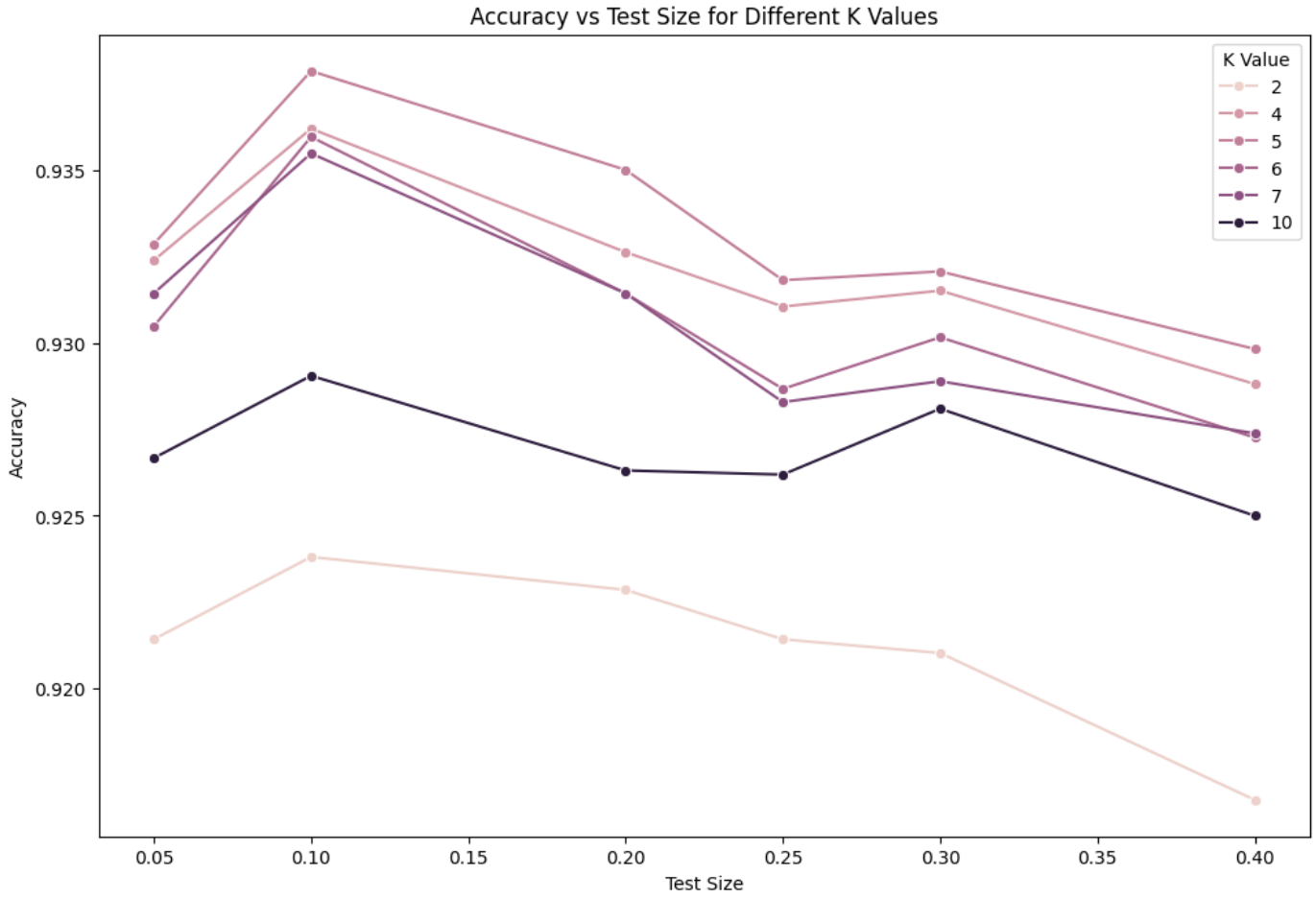
```
K=10, Test Size=0.05
Accuracy: 0.9266666666666666
Confusion Matrix:
 [[207   0   0   0   0   0   2   0   0   1]
 [  0 214   0   0   0   0   1   0   0   0]
 [  2   3 199   0   2   0   4   1   0   0]
 [  1   2   4 199   0   3   0   4   1   1]
 [  0   1   0   0 179   2   1   1   0   6]
 [  1   1   1   8   2 177   7   2   0   2]
 [  7   0   1   1   1   1 201   0   0   0]
 [  0   5   1   2   7   0   0 201   0   6]
 [  1   1   1   4   2  15   0   1 194   4]
 [  1   2   0   5   5   2   0   8   3 175]]
```



ANALYSIS OF CONFUSION MATRICES

Test_Size	K	Accuracy
0.4	2	0.916786
0.4	4	0.92881
0.4	5	0.929821
0.4	6	0.927262
0.4	7	0.927381
0.4	10	0.925
0.3	2	0.921032
0.3	4	0.931508
0.3	5	0.932063
0.3	6	0.930159
0.3	7	0.928889
0.3	10	0.928095
0.25	2	0.921429
0.25	4	0.931048
0.25	5	0.93181
0.25	6	0.928667
0.25	7	0.928286
0.25	10	0.92619

Test_Size	K	Accuracy
0.2	2	0.922857
0.2	4	0.932619
0.2	5	0.935
0.2	6	0.931429
0.2	7	0.931429
0.2	10	0.92631
0.1	2	0.92381
0.1	4	0.93619
0.1	5	0.937857
0.1	6	0.935952
0.1	7	0.935476
0.1	10	0.929048
0.05	2	0.921429
0.05	4	0.932381
0.05	5	0.932857
0.05	6	0.930476
0.05	7	0.931429
0.05	10	0.926667



From the data shown above , it is clear that the ACCURACY of the KNN Model achieves its maxima for K-Value =5 and the Train-Test Split Ratio of 90:10.

Therefore , we shall evaluate the test data provided in test.csv using these two parameters.

The Output obtained is as follows:

Best K: 5, Best Test Size: 0.1
Predictions on test data: [2 0 9 ... 3 9 2]
Accuracy on test set: 0.9378571428571428
Classification Report:

	precision	recall	f1-score	support
0	0.95	0.98	0.96	389
1	0.94	1.00	0.97	457
2	0.96	0.93	0.94	441
3	0.92	0.93	0.92	434
4	0.93	0.92	0.93	407
5	0.92	0.92	0.92	380
6	0.96	0.96	0.96	428
7	0.92	0.94	0.93	421
8	0.97	0.90	0.93	409
9	0.92	0.89	0.90	434
accuracy			0.94	4200
macro avg	0.94	0.94	0.94	4200
weighted avg	0.94	0.94	0.94	4200

Confusion Matrix:

```
[[383   0   0   0   0   2   3   0   0   1]
 [  0 456   0   0   0   0   1   0   0   0]
 [  2   7 410   8   4   0   5   3   1   1]
 [  1   3   5 404   0   7   0   6   6   2]
 [  0   7   3   0 376   1   1   5   0  14]
 [  3   1   1  10   2 349   8   2   1   3]
 [  9   0   2   2   1   3 411   0   0   0]
 [  0   4   2   2   7   0   0 394   0  12]
 [  5   3   3   5   4  14   1   3 368   3]
 [  2   2   2   9  10   2   0  15   4 388]]
```

INFERENCE

The inference about K values and train-test splits can be drawn from analyzing the results obtained from the various scenarios tested in the assignment. Here are some points that can be considered for a thorough analysis:

1. Impact of K Values

Lower K Values (e.g., K=2, K=3):

- **Pros:**
  - These models are often very sensitive to the training data.
  - They can capture the local structure of the data, potentially making them suitable for datasets with complex and highly variable structures.
- **Cons:**
  - They tend to be more susceptible to noise in the training data.
  - They can overfit the training data, leading to poorer generalization on the test data.

Higher K Values (e.g., K=10):

- **Pros:**
  - These models tend to be more stable and less sensitive to noise.
  - They smooth out the decision boundaries, which can improve generalization.
- **Cons:**
  - They may miss local patterns in the data and may not perform as well on datasets with complex structures.
  - They can underfit if the value of K is too high.

2. Impact of Train-Test Split

Higher Training Size (e.g., 95:5, 90:10):

- **Pros:**
  - More data for training can lead to better model learning and potentially higher accuracy.
  - Reduces the risk of overfitting, as the model has more data to generalize from.
- **Cons:**
  - Less data available for testing, which can sometimes give a less reliable estimate of model performance.

Higher Testing Size (e.g., 60:40, 70:30):

- **Pros:**
  - More data for testing can provide a more robust evaluation of the model's performance.
  - Useful for understanding how the model will perform in real-world scenarios.
- **Cons:**
  - Less data for training can sometimes result in underfitting, especially for complex models.
  - Higher variance in the model performance, as the training set might not be sufficient for the model to learn properly.

Combined Analysis of K Values and Train-Test Split

1. **Lower K Values with Smaller Train Size (e.g., K=2, Train-Test=60:40):**
   - Likely to overfit the training data and underperform on the test data.
   - High variance in performance.
2. **Lower K Values with Larger Train Size (e.g., K=2, Train-Test=90:10):**
   - Better performance than the smaller train size, but still prone to overfitting.
3. **Higher K Values with Smaller Train Size (e.g., K=10, Train-Test=60:40):**
   - May underfit the data, leading to poorer performance on both train and test sets.
   - More stable and less variance in performance.
4. **Higher K Values with Larger Train Size (e.g., K=10, Train-Test=90:10):**
   - Likely to generalize well with good performance on the test set.
   - Balanced trade-off between bias and variance.

Practical Recommendations

- **Balanced Approach**: A moderate K value (e.g., K=5) combined with a balanced train-test split (e.g., 80:20) often provides a good trade-off between bias and variance, leading to robust performance.
- **Dataset Size Matters**: If you have a large dataset, you can afford to use a larger training size and a higher K value to ensure stability and generalization.
- **Tune Hyperparameters**: Always perform cross-validation to fine-tune K and the train-test split for your specific dataset to achieve optimal performance.

Conclusion

From the assignment, the following can be inferred:

- There is no one-size-fits-all solution; the optimal K value and train-test split depend on the specific characteristics of the dataset.
- Lower K values might work well with larger training sizes, whereas higher K values provide more stable performance across different train-test splits.
- Analyzing the performance metrics such as accuracy and confusion matrix across different scenarios helps in understanding how the model's performance varies with changes in K and train-test split, guiding better model selection and tuning decisions.