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SUB GROUP: CS4

ELC ASSIGNMENT

Handwritten Digit Recognition

Following are the results where K varies as [2,4,5,6,7,10] and test size [60:40, 70:30, 75:25, 80:20, 90:10, 95:5].

ANALYSIS:-

Best Combination:

The combination with the highest validation accuracy is Test Size: 0.2 and K: 5, with a validation accuracy of 0.935. This means that when using 20% of the data for testing and 5 for the number of neighbours in the k-nearest neighbours algorithm, the model achieved the highest accuracy on the validation set.

Worst Combination:

The combination with the lowest validation accuracy is Test Size: 0.25 and K: 2, with a validation accuracy of 0.921. This means that when using 25% of the data for testing and 2 for the number of neighbours in the k-nearest neighbours algorithm, the model achieved the lowest accuracy on the validation set.

Accuracy & Confusion Matrix:-

Test Size: 0.4 K: 2
Validation 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]]
```

Test Size: 0.4 K: 4
Validation 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 2 3]
[13 6 8 20 59 6 0 92 12 1480]]

Test Size: 0.4 K: 5
Validation 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]]

Test Size: 0.4 K: 6
Validation 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 2 2]
[11 9 7 24 50 4 0 83 10 1498]]

Test Size: 0.4 K: 7
Validation 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 2 4]
[12 10 6 23 43 6 0 73 8 1515]]

Test Size: 0.4 K: 10 Validation 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]

Test Size: 0.3 K: 2
Validation 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]]

Test Size: 0.3 K: 4
Validation 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]]

Test Size: 0.3 K: 5 Validation 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 10 117 1 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]]

Test Size: 0.3 K: 6

Validation 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]]

Test Size: 0.3 K: 7
Validation 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]]

Test Size: 0.3 K: 10 Validation 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]]

Test Size: 0.25 K: 2
Validation 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]]

Test Size: 0.25 K: 4 Validation 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]]

Test Size: 0.25 K: 5
Validation 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]]

Test Size: 0.25 K: 6
Validation 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]]

Test Size: 0.25 K: 7

Validation 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]]

Test Size: 0.25 K: 10 Validation
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]]

Test Size: 0.2 K: 2
Validation 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]]

Test Size: 0.2 K: 4
Validation 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]]

Test Size: 0.2 K: 5 Validation 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]]

Test Size: 0.2 K: 6
Validation 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]]

Test Size: 0.2 K: 7
Validation 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]]

Test Size: 0.2 K: 10 Validation 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]]

Test Size: 0.1 K: 2
Validation 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]]

Test Size: 0.1 K: 4
Validation 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]]

Test Size: 0.1 K: 5
Validation 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]]

Test Size: 0.1 K: 6 Validation 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]]

Test Size: 0.1 K: 7
Validation 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]]

Test Size: 0.1 K: 10
Validation 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]]

Test Size: 0.05 K: 2
Validation 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]]

Test Size: 0.05 K: 4
Validation 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]]

Test Size: 0.05 K: 5
Validation 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]]

Test Size: 0.05 K: 6
Validation 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]]

Test Size: 0.05 K: 7
Validation 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]]

Test Size: 0.05 K: 10 Validation 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]]