

# KNN FOR HANDWRITTEN DIGIT RECOGNITION:

## FIVE-FOLD CROSS VALIDATION

- At each fold, the training data is divided into two sets.
- The first set has 33600 images for training purpose
- The second set has 8400 images for testing.
- Five-fold cross validation was performed by taking  $K = 3$  and  $K = 5$ . The results were very similar.

\*\*\* FOLD 1 \*\*\*

```
Training_index: [ 8400 8401 8402 ... 41997 41998 41999]
Testing_index:  [  0    1    2 ... 8397 8398 8399]
Size of the training data: 33600
Size of the testing data: 8400
```

\*\*\* FOLD 2 \*\*\*

```
Training_index: [    0    1    2 ... 41997 41998 41999]
Testing_index:  [ 8400 8401 8402 ... 16797 16798 16799]
Size of the training data: 33600
Size of the testing data: 8400
```

\*\*\* FOLD 3 \*\*\*

```
Training_index: [    0    1    2 ... 41997 41998 41999]
Testing_index:  [16800 16801 16802 ... 25197 25198 25199]
Size of the training data: 33600
Size of the testing data: 8400
```

\*\*\* FOLD 4 \*\*\*

```
Training_index: [    0    1    2 ... 41997 41998 41999]
Testing_index:  [25200 25201 25202 ... 33597 33598 33599]
Size of the training data: 33600
Size of the testing data: 8400
```

\*\*\* FOLD 5 \*\*\*

```
Training_index: [    0    1    2 ... 33597 33598 33599]
Testing_index:  [33600 33601 33602 ... 41997 41998 41999]
Size of the training data: 33600
Size of the testing data: 8400
```

# Evaluation Metrics over Five-Folds

➤ Accuracy, Precision, Recall and F1 score over five-folds when  $K = 3$  and  $K = 5$

➤  $K = 3$ :

KNN Evaluation Metrics:

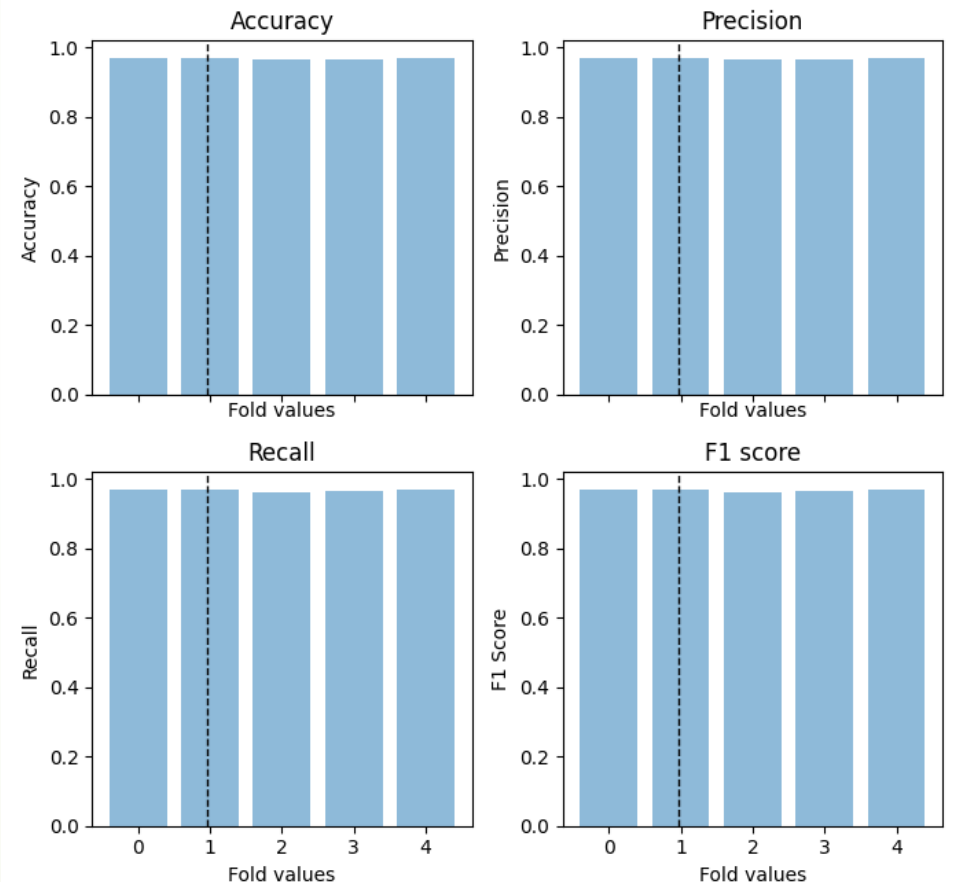
Accuracy	Precision	Recall	F1 Score
0.97	0.970315	0.9696	0.969857
0.967262	0.967701	0.966725	0.966979
0.962738	0.963169	0.9623	0.962517
0.96381	0.964318	0.963501	0.963685
0.969524	0.970346	0.968673	0.969279

$K = 5$ :

KNN Evaluation Metrics:

Accuracy	Precision	Recall	F1 Score
0.967857	0.968478	0.967389	0.967724
0.965238	0.965893	0.964614	0.965009
0.963571	0.964114	0.963134	0.963401
0.963214	0.963774	0.962926	0.96307
0.969048	0.969859	0.968245	0.968836

KNN Five Fold Metrics



# Average Five-Fold Values

➤ The average values of accuracy, precision, recall and F1 score for  $K = 3$  and  $K = 5$  are shown.

➤  $K = 3$

Average metrics over five folds:

The average accuracy is: 0.9667  
The average precision is: 0.9672  
The average recall is: 0.9662  
The average f1\_score is: 0.9665

➤  $K = 5$

Average metrics over five folds:

The average accuracy is: 0.9658  
The average precision is: 0.9664  
The average recall is: 0.9653  
The average f1\_score is: 0.9656

$K = 3$

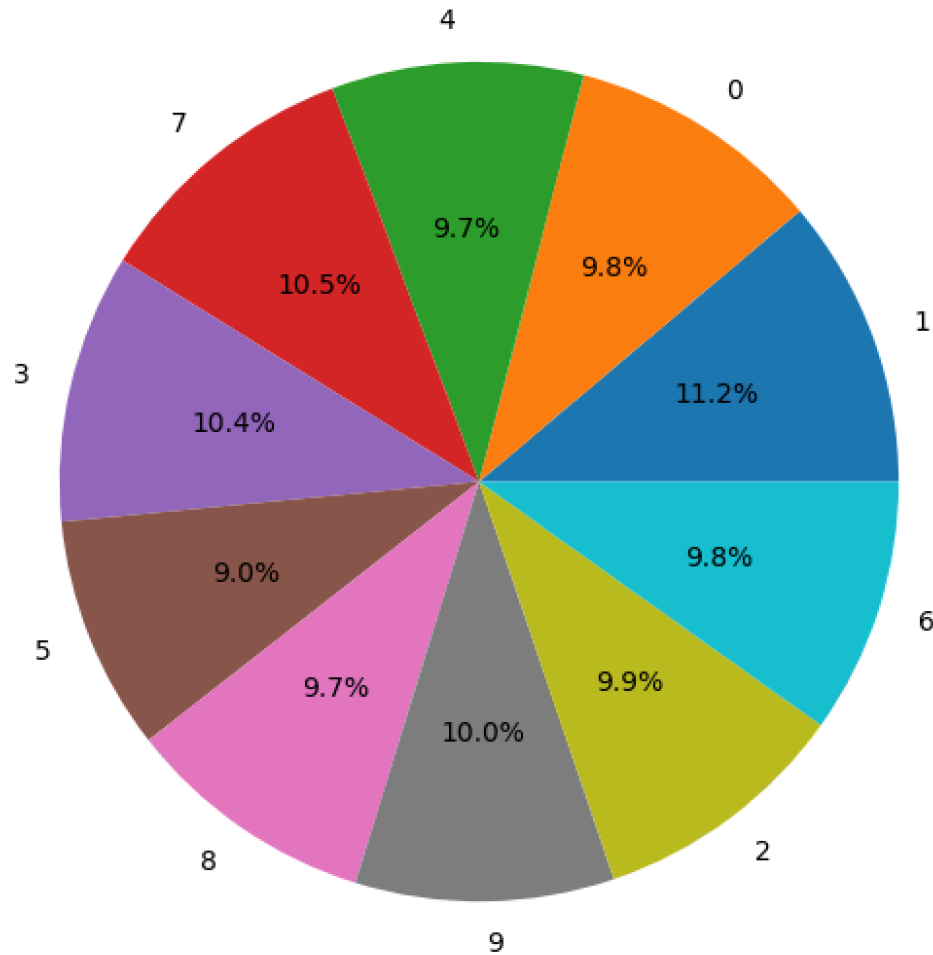
Actual Digit Frequencies	
Digit	Count
0	4132
1	4684
2	4177
3	4351
4	4072
5	3795
6	4137
7	4401
8	4063
9	4188
Predicted Digit Frequencies	
Digit	Count
0	4213
1	4869
2	4094
3	4383
4	4000
5	3790
6	4172
7	4466
8	3790
9	4223

$K = 5$

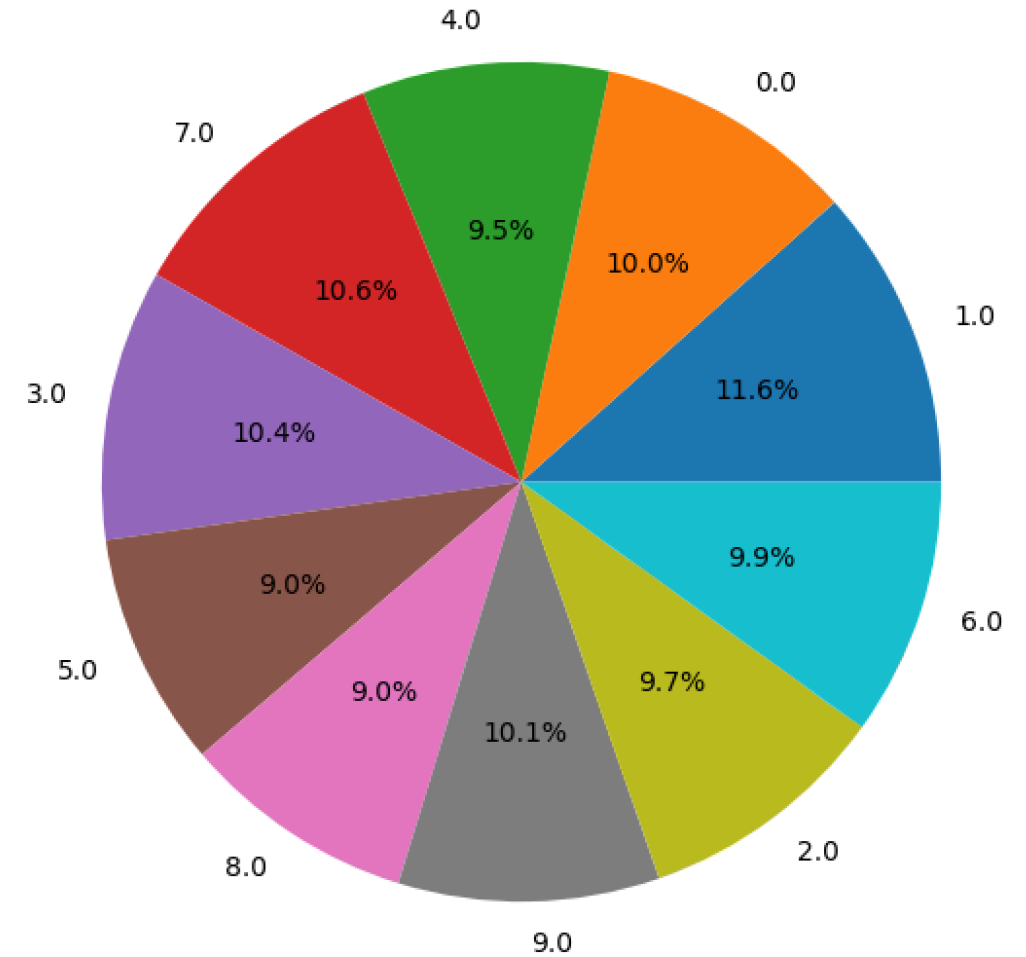
Actual Digit Frequencies	
Digit	Count
0	4132
1	4684
2	4177
3	4351
4	4072
5	3795
6	4137
7	4401
8	4063
9	4188
Predicted Digit Frequencies	
Digit	Count
0	4212
1	4905
2	4055
3	4379
4	4002
5	3786
6	4185
7	4470
8	3780
9	4226

# Digit Frequencies when $K = 3$

Actual digit frequencies



Predicted digit frequencies



# Predictions made on the Testing data:

- Screenshots from the CSV file:
- These screenshots show the first few and last few predictions from the output CSV file when  $K = 3$ .
- Comparing my result with 100% output accuracy, I got an accuracy of 96.80% (first with  $K = 3$  and then  $K = 5$ ) as shown in the screenshot below.

Accuracy of the testing dataset: 96.8036 %

Accuracy of the testing dataset: 96.7000 %

**My GitHub link:** Project\_Checkpoint\_2\_submission

[GitHub Link](#)

ImageId	label
0	2
1	0
2	9
3	9
4	3
5	7
6	0
7	3
8	0
9	3
10	5
11	7
12	4
13	0
14	4
15	3
16	3
17	1
18	9
19	0
20	9
21	1
22	1
23	5
24	7
25	4
26	2
27	7
28	4
29	7
30	7

27969	3
27970	5
27971	0
27972	4
27973	8
27974	0
27975	3
27976	6
27977	0
27978	1
27979	9
27980	3
27981	1
27982	1
27983	0
27984	4
27985	5
27986	2
27987	2
27988	9
27989	6
27990	7
27991	6
27992	1
27993	9
27994	7
27995	9
27996	7
27997	3
27998	9
27999	2