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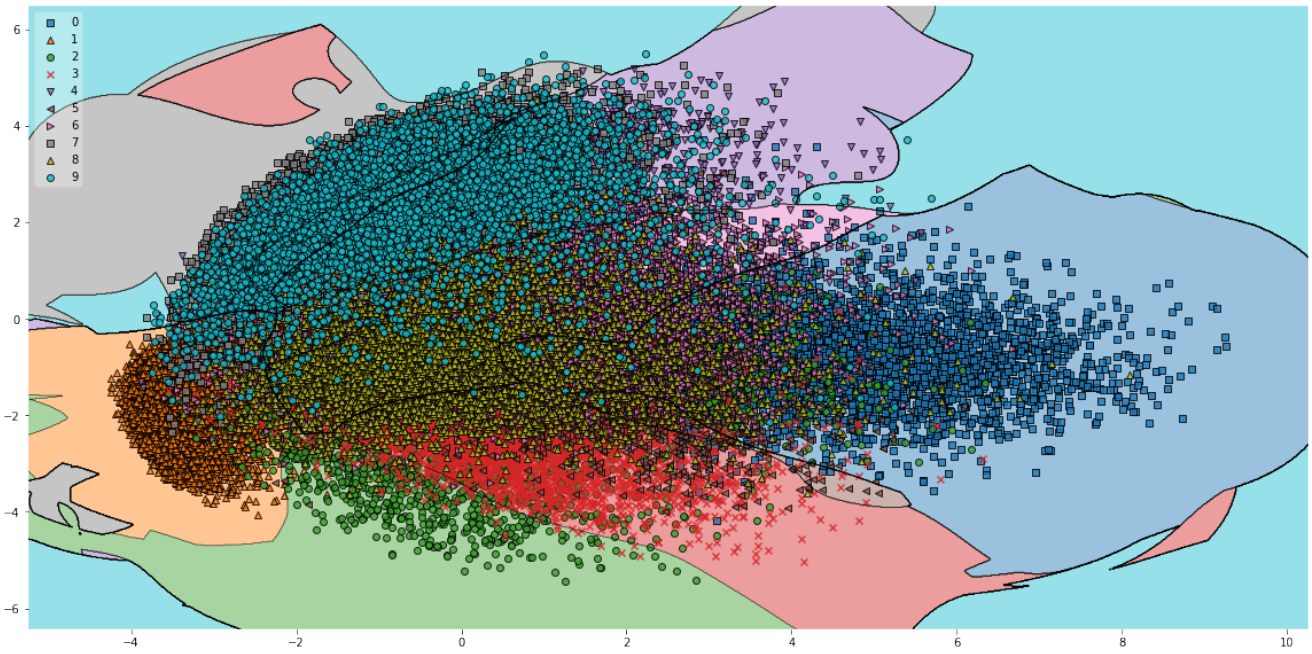
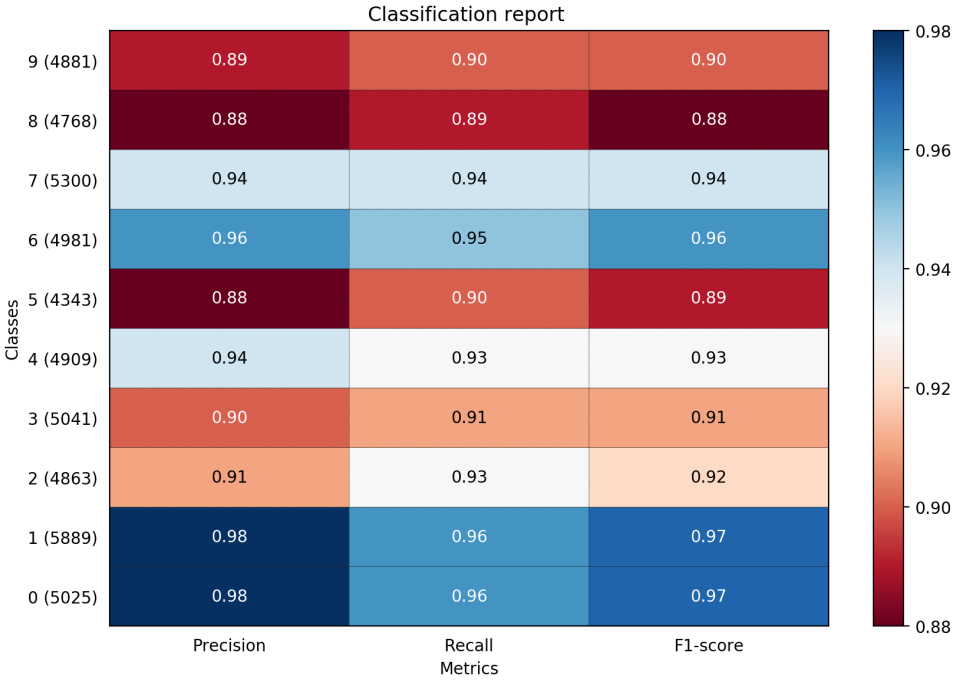
Outlook of the data:

Following is the boundary regions for the MNIST data.

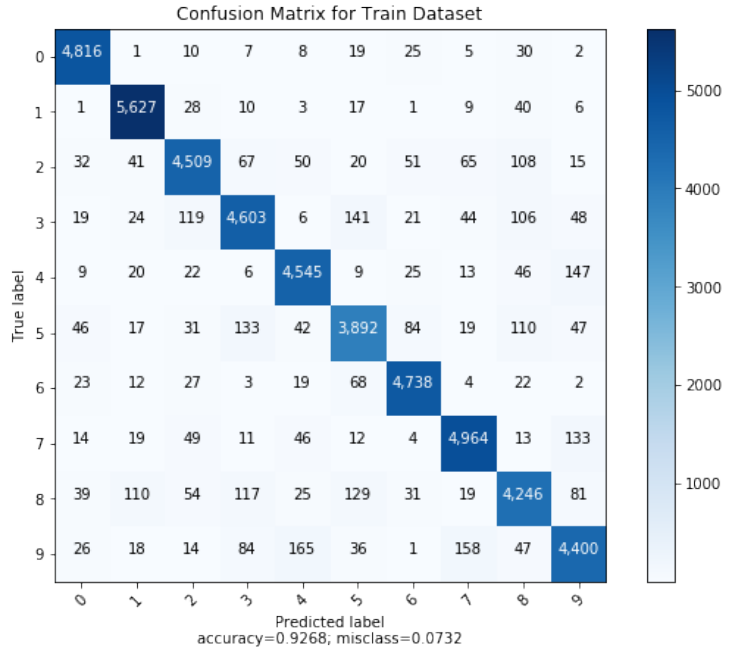


Inference: We can see which digits are closer to each other in a 2D space. For example, 3,5,8 seems to be closer to each other.

Following are the results for training set of Blr.



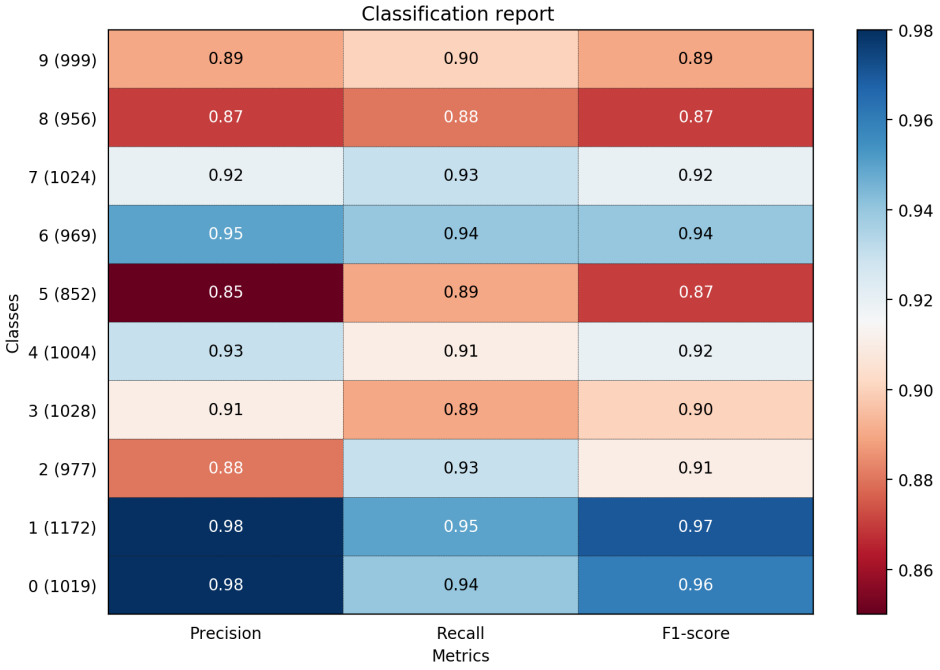
The confusion matrix is as follows,



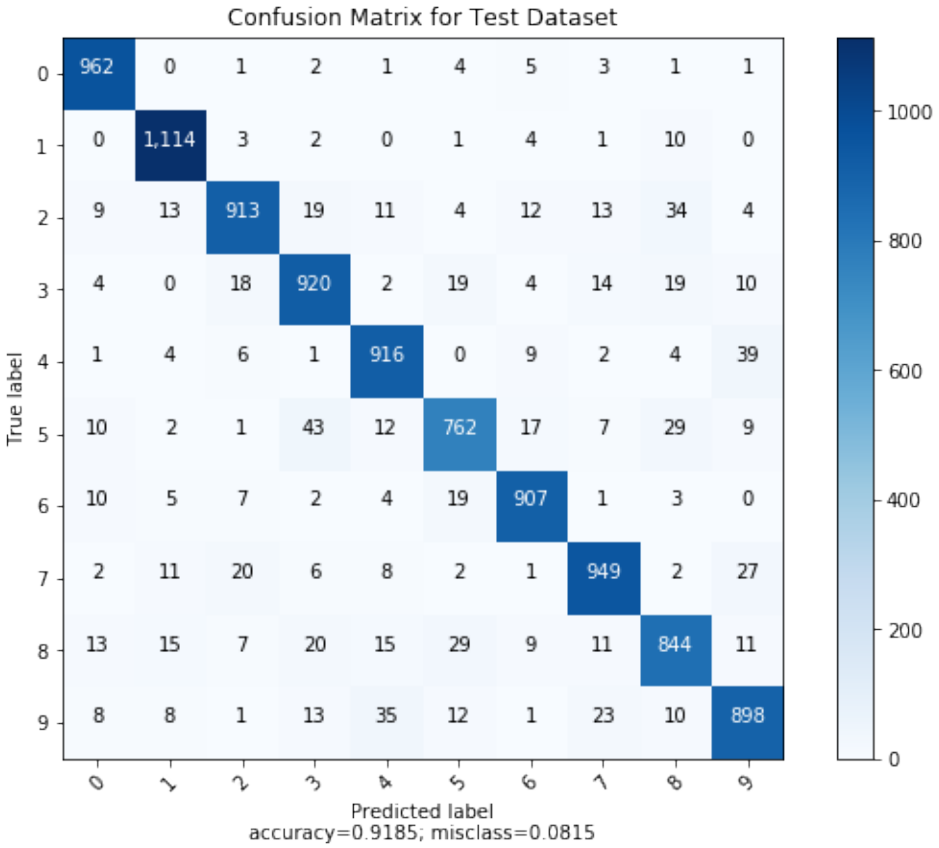
Inference:
The best results are obtained for class – 0, 1 for both precision and recall. And the worst results are obtained for class – 8, 5.

Looking at the confusion matrix for further investigation, we can see that the model is getting confused in learning the differences between 8 and 5,2 (218 misclassifications in total). Since those are the targets it is misinterpreting. And for class 5, it is misinterpreting 3,8 (270 misclassifications in total)

Following are the results for testing set of Blr.



The confusion matrix is as follows,



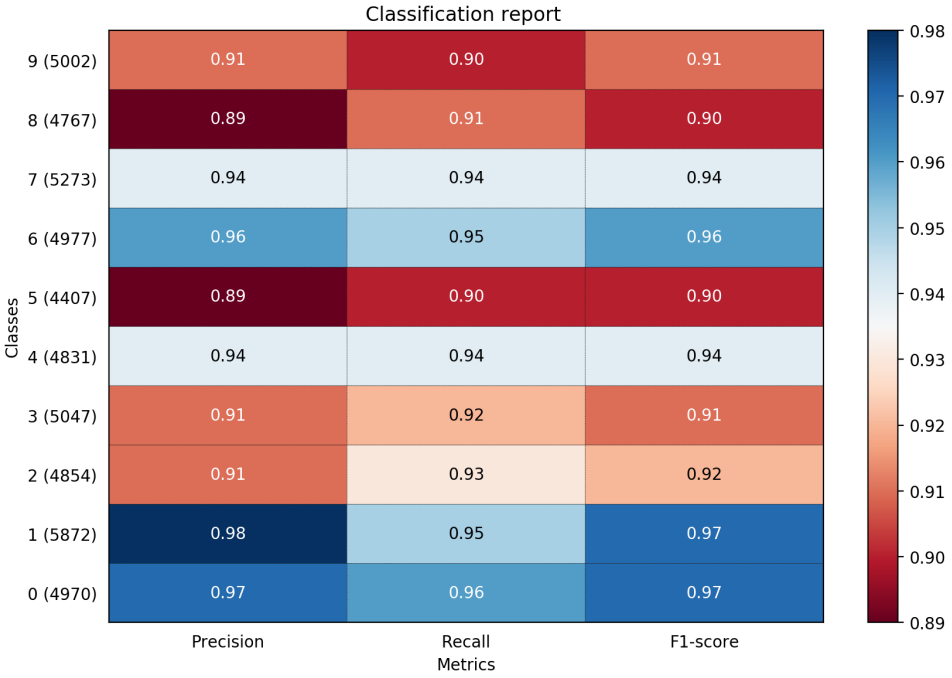
Inference: Just like in the training set we can observe that the best results are obtained for class 0,1. The worst results are obtained for class 5,8.

Looking at the confusion matrix for further investigation, we observe that,
For class 5, the model is getting confused with 8,6,3(67 misclassifications) understandably as they look alike.
For class 8, the model is getting confused with 5,2(63 misclassifications) as they look similar.

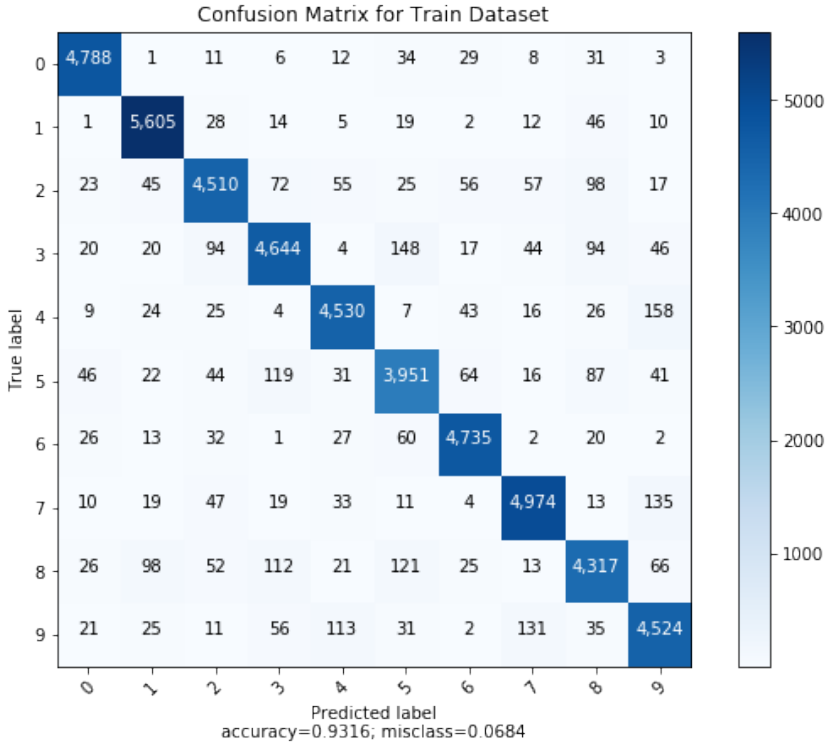
The final performance of Blr on the MNIST dataset is as follows,

```
Training set Accuracy:92.67999999999999%

Validation set Accuracy:91.49000000000001%

Testing set Accuracy:91.85%
```

Following are the results of the training set for MLR.

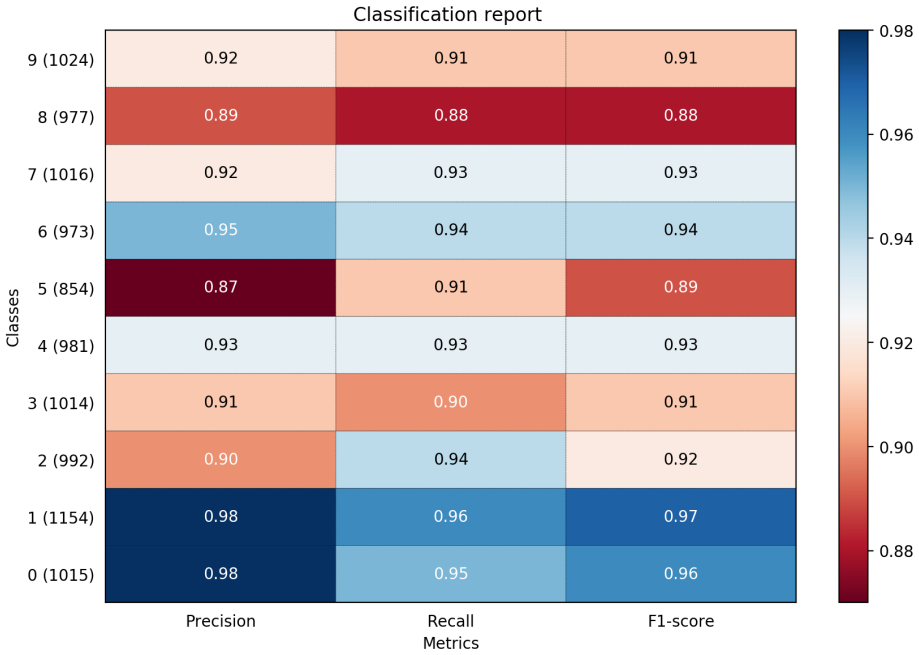


The confusion matrix is as follows,

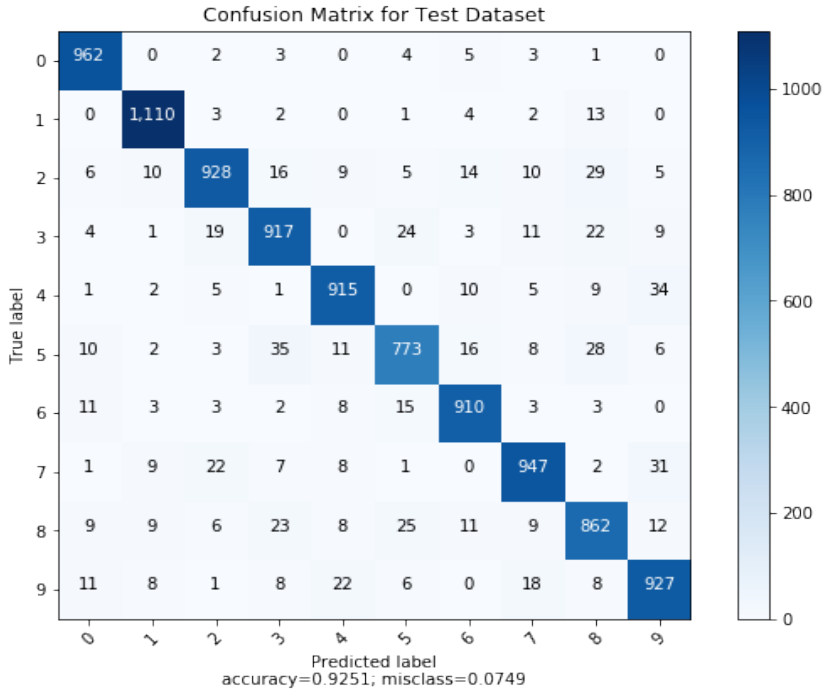


Inference: Just like in Blr, the best results are obtained for class 0,1(F1 score) while the worst results are obtained for class 5 and 8.
The model is getting confused between 3,8 (269 misclassifications)for class 5 and 2,3 (192 misclassifications)for class 8 since they look similar respectively.

Following are the results of the testing set for MLR.



The confusion matrix is as follows,



Inference: The best results are obtained for class 0,1(F1 score) while the worst results are obtained for class 5 and 8.
The model is getting confused between 3,8(49 misclassifications) for class 5 and 2,3(41 misclassifications) for class 8 since they look similar respectively.

The final performance of Mlr on MNIST dataset is as follows,

```
Training set Accuracy:93.156%

Validation set Accuracy:92.49000000000001%

Testing set Accuracy:92.51%
```

MLR vs BLR :
The test accuracy of BLR using one-vs-all strategy is 91.5% while the test accuracy of MLR with multi class strategy is 92.5%
Hence in this case, Multi-class strategy is better.

SVM :
Following are the results obtained using Support Vector Machines with accuracies and the methods respectively.

- Using Linear Kernel :
  The test accuracy obtained is 93.7%

- Using RBF kernel with Gamma = 1:
  The test accuracy obtained is 17%. We can conclude that the model is overfitting since the training accuracy is 100%

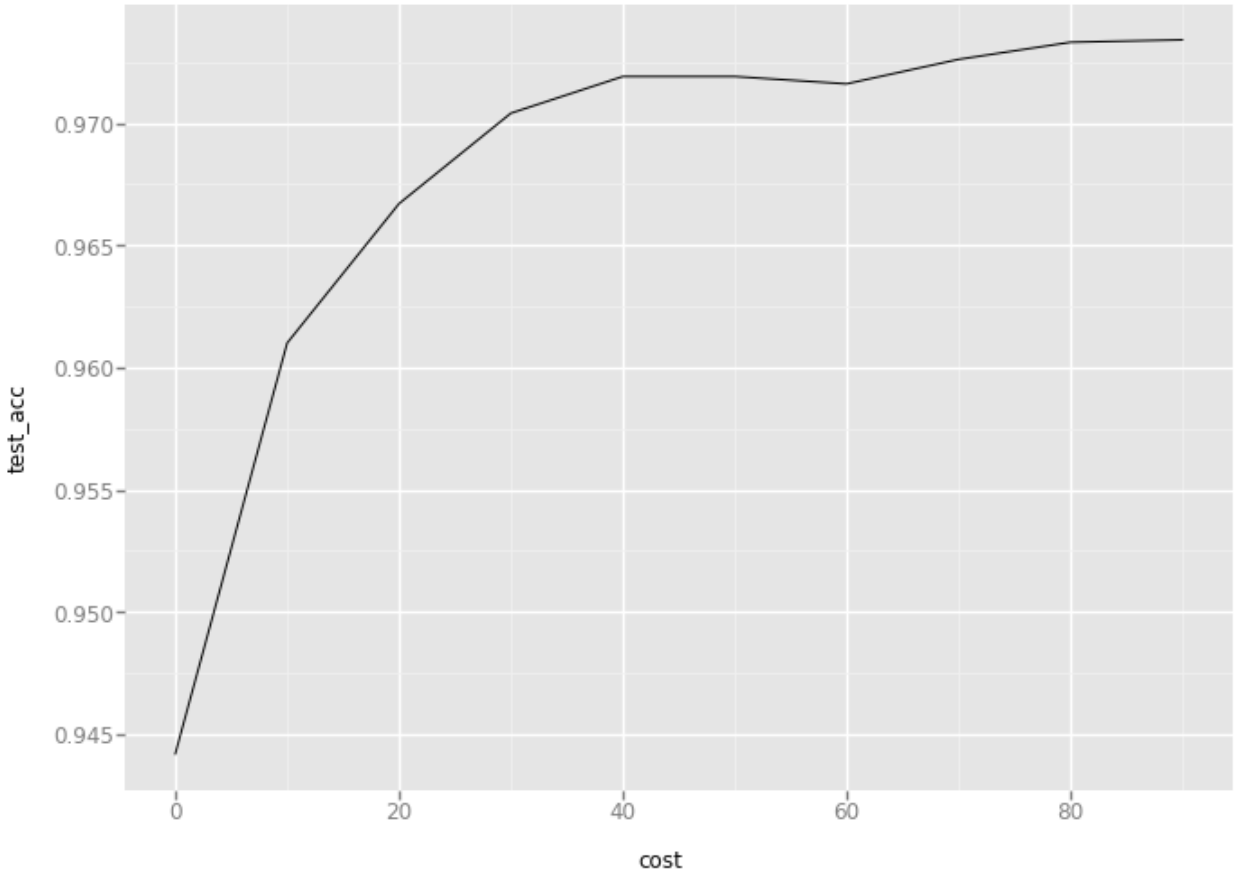
- Using RBF kernel with Gamma = 0 (Default)
  The test accuracy obtained is 94.4%

Varying the cost parameter and keeping the kernel as RBF, following are the results that are obtained.

	cost	gamma	kernel	test_acc	train_acc	validation_acc
0	0	0	Linear	0.9378	0.97286	0.9364
1	0	1	RBF	0.1714	1.00000	0.1548
2	0	0	RBF	0.9442	0.94294	0.9402
3	10	0	RBF	0.9610	0.97132	0.9618
4	20	0	RBF	0.9667	0.97952	0.9690
5	30	0	RBF	0.9704	0.98372	0.9710
6	40	0	RBF	0.9719	0.98706	0.9723
7	50	0	RBF	0.9719	0.99002	0.9731
8	60	0	RBF	0.9716	0.99196	0.9738
9	70	0	RBF	0.9726	0.99340	0.9736
10	80	0	RBF	0.9733	0.99438	0.9739
11	90	0	RBF	0.9734	0.99542	0.9736
12	100	0	RBF	0.9740	0.99612	0.9741

Inference : From the above table we can infer that Linear kernel performs not well. With RBF kernel with cost setting 100 performs the best.

The graphical representation of the same is as follows,



Inference : We can infer that with increase in cost the test accuracy increases for this dataset.