Machine Learning
Programming Assignment-2

Classification and Regression

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Problem 1- Experiment with the Gaussian Discriminents

Accuracy of LDA was around **97%.** The plot of the boundaries is given below.

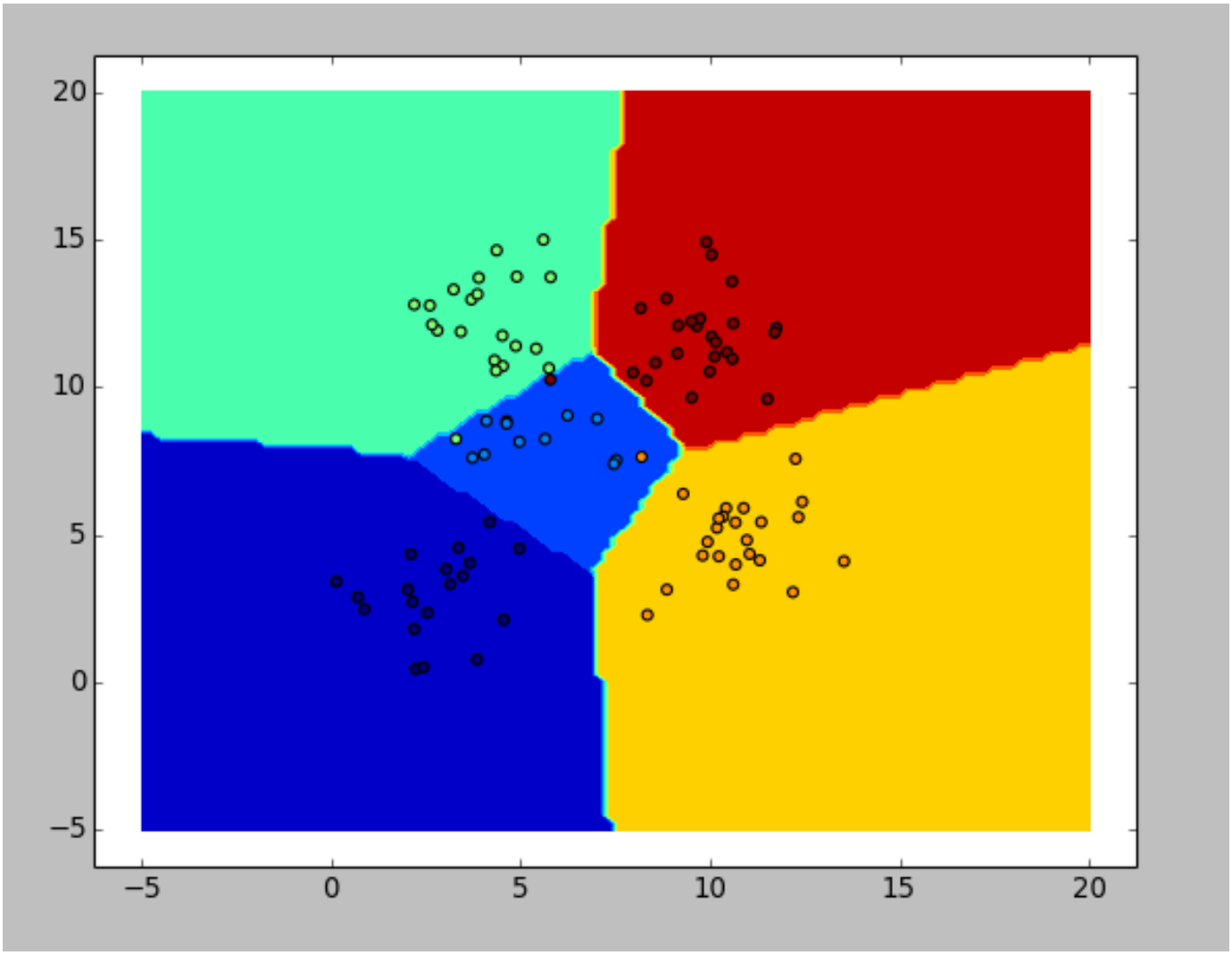

Fig-1: Plot of discriminating boundaries for Linear Discriminant Analysis

Accuracy of QDA was around **94%**. The plot of the boundaries is given below

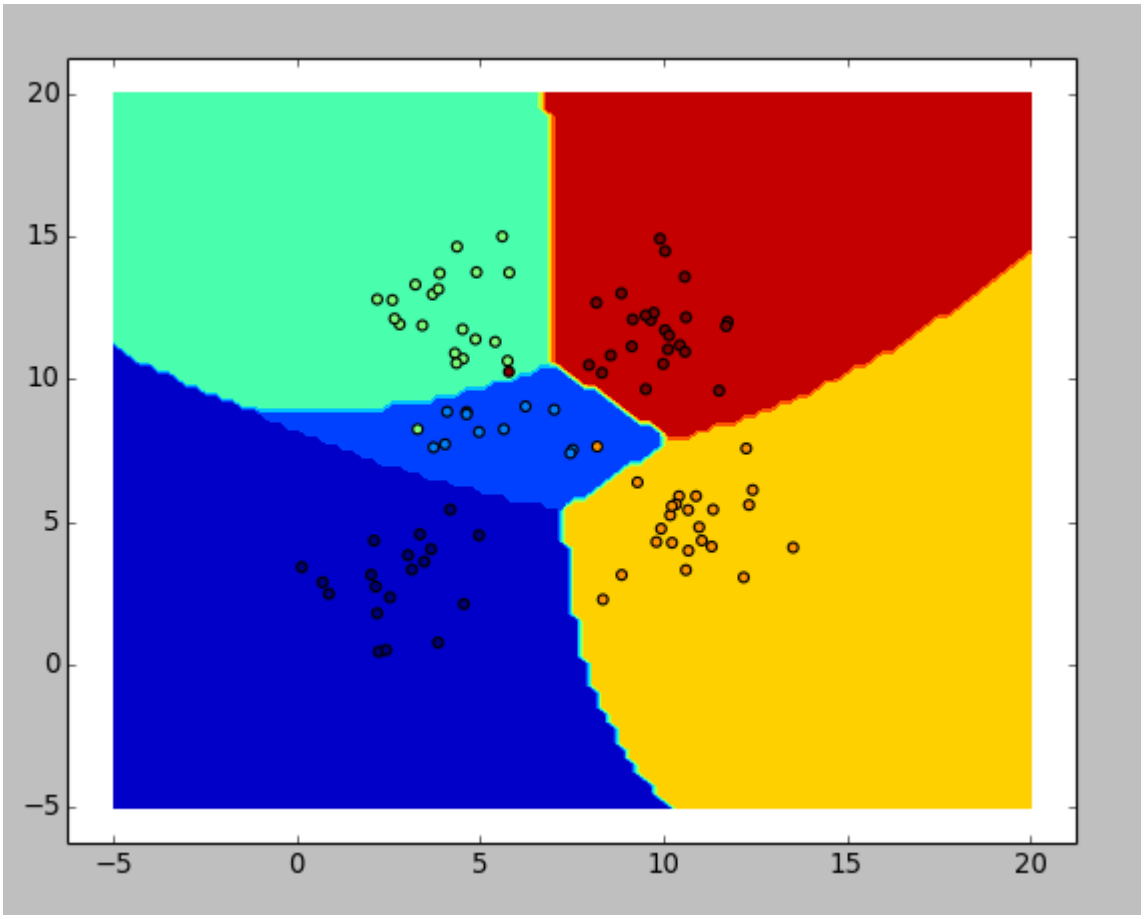

Fig-2: Plot of discriminating boundaries for Quadratic Discriminant Analysis

In LDA, the covariance is calculated using whole data. In QDA, the covariance is calculated for each class. The fact that there is difference in the plots of LDA and QDA is because of this precise reason of calculating the covariance.

Problem 2: Experiment with Linear Regression

Root Mean Square Error (RMSE) with intercept and without intercept were calculated. The values of both the errors are given below

For Training data:
RMSE without intercept: 138.20074835
RMSE with intercept: 46.7670855937

For Testing data:
RMSE without intercept: 326.764994196
RMSE with intercept: 60.8920370905

Smaller the RMSE, better the prediction. Therefore OLE with using intercept is better than without using intercept. It can be seen that RMSE for training and testing data with intercept is less than without intercept

Problem 3: Experiment with Ridge Regression

Root Mean Square Error(RMSE) with intercept were calculated. Here the value of Lambda was taken to be 0.06. This value gave least RMSE.

For Ridge Regression:
RMSE for Training Data: 49.5129123628
RMSE for Testing Data: 53.3978483971

Plot of RMSE with different lambda is given below.

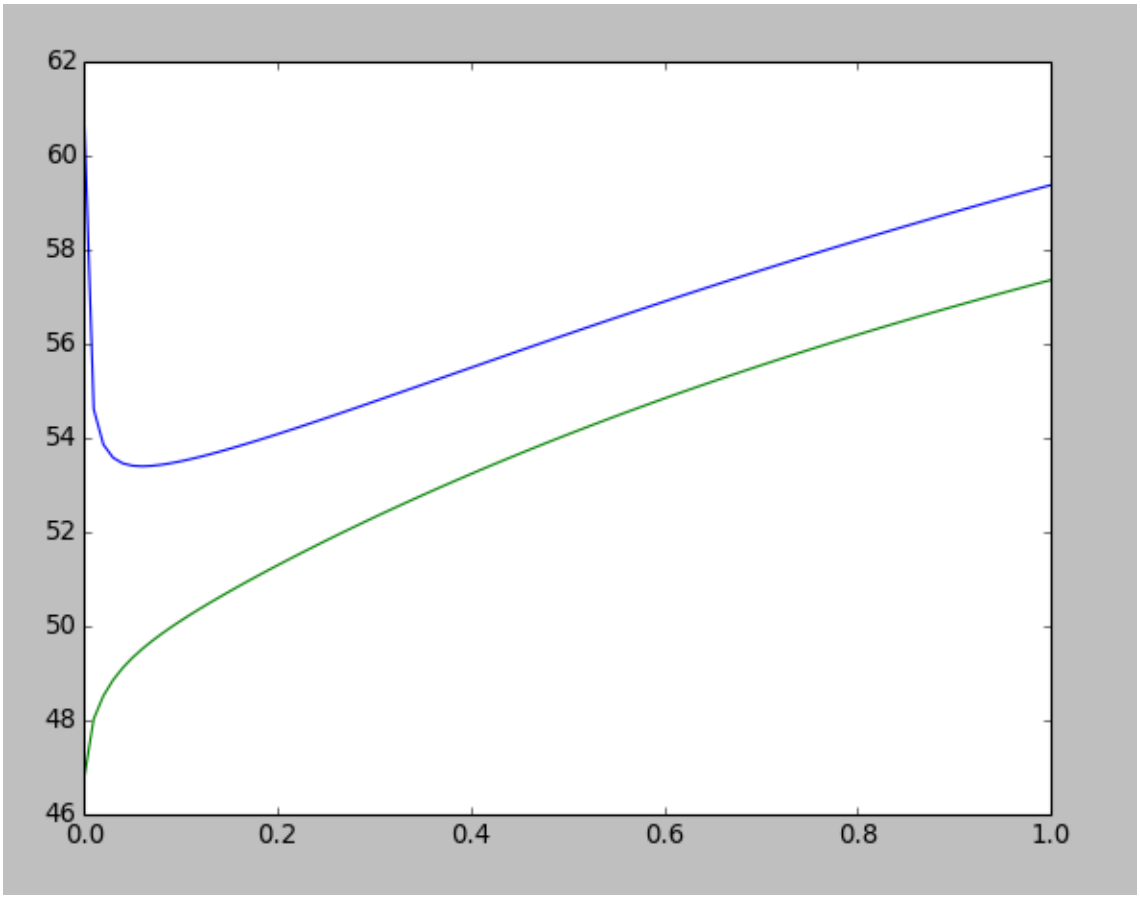

Fig 3: Plot of RMSE with different values of lambdas for training and testing data

Here blue curve represents RMSE for testing data and green curve is RMSE for training data.

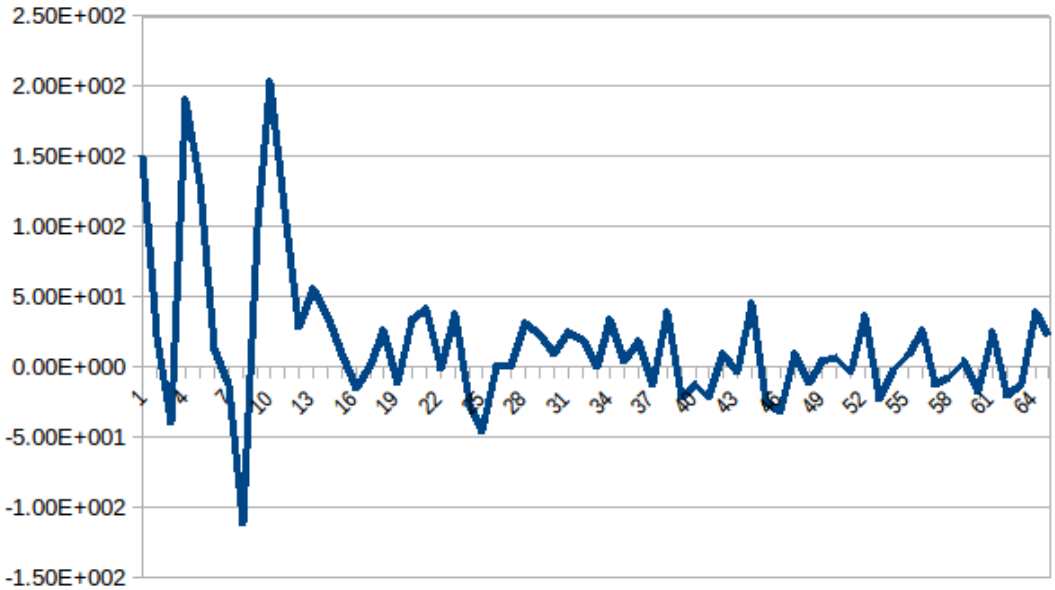

Fig4: Weights learn't using Ridge Regression

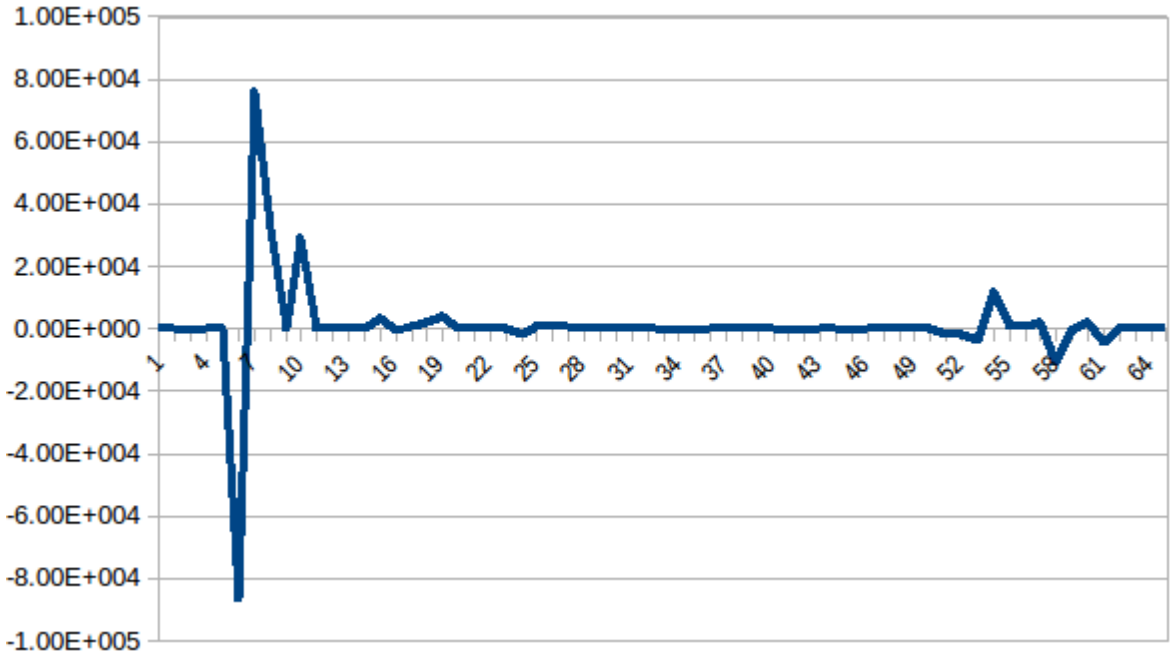

Fig 5: Weights learn't using OLE Regression

Mean of weights learn't during OLE regression:883
Mean of weights learn't during Ridge Regression :13.26

If we look at the means of weights learn't in OLE Regression and Ridge Regression it can be said that Ridge Regression is better that OLE Regression. Means for Ridge Regression is less than OLE regression making it better to calculate weights.

Table1: RMSE of Testing data of Ridge Regression with corresponding lambda

Testing Data		lambda
60.89203709		0
54.61177638		0.01
53.86068684		0.02
53.58116823		0.03
53.46026945		0.04
53.41035232		0.05
53.3978484		**0.06**
53.40739644		0.07
53.43107466		0.08
53.46442201		0.09
53.50474691		0.1
53.55033062		0.11
53.60002129		0.12
53.65301361		0.13
53.70872289		0.14
53.76671005		0.15
53.82663522		0.16
53.88822809		0.17
53.95126849		0.18
54.01557335		0.19
54.08098762		0.2
54.147378		0.21

Looking at the above table consisting of RMSEs with respect to the corresponding lambda, we can thereby say that the optimal value of lambda is 0.06 as this gives least RMSE for testing data.

Problem 4: Ridge Regression with Gradient Descent

Plot of RMSE with different lambdas is given below:

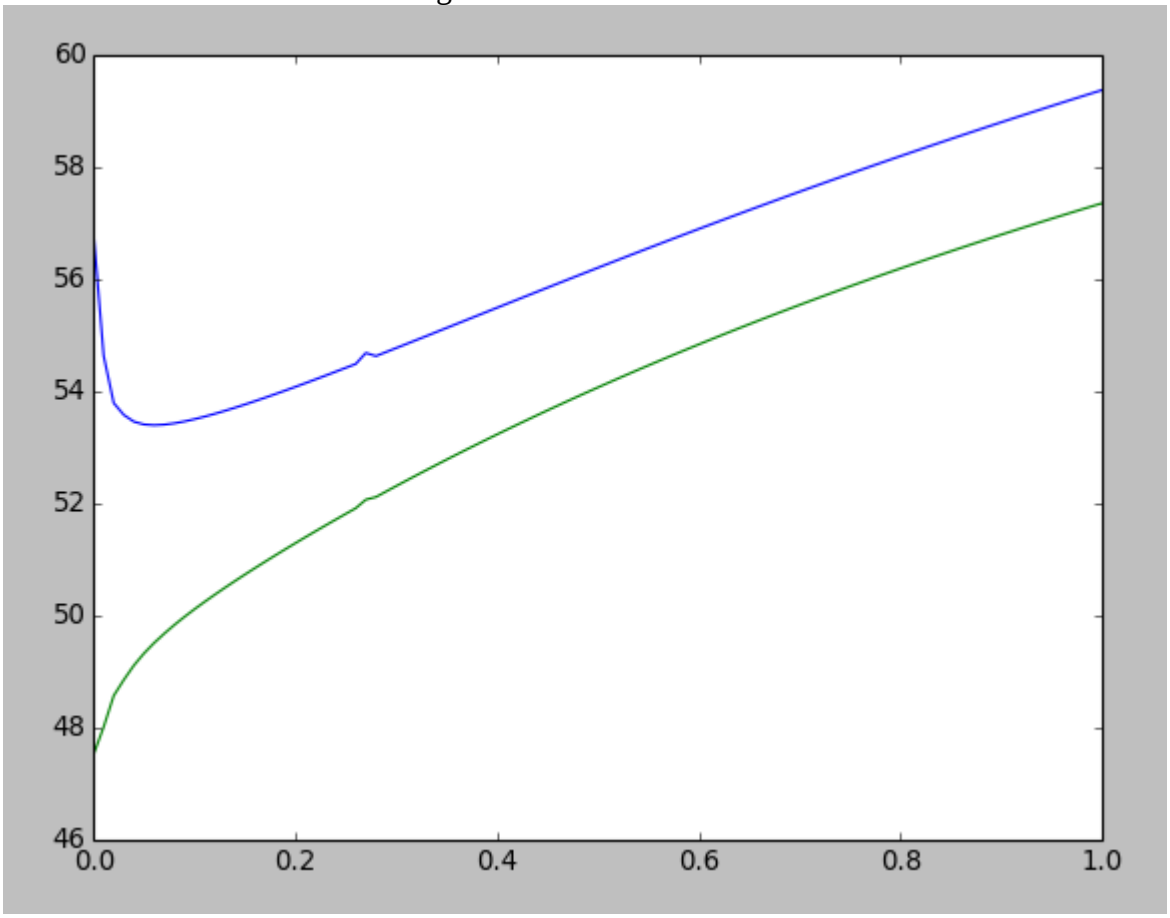

Fig 6: RMSE with lambda for Ridge Regression with Gradient Descent

It can be seen that there is not major difference in lambda val and RMSE when compared to Ridge Regression.

Problem 5: Non Linear Regression

The table given below is of RMSE of Testing data for lambda 0 and 0.06(optimal)

Table2: RMSE of Testing Data for lamda=0.06 and lambda=0 for different values of P

P	Lambda=0	Lambda=0.06
0	79.286851317	79.2898604296
1	62.008344037	62.416796333
2	62.507024398	62.4146141215
3	62.353632919	62.4146033867
4	66.658291996	62.4146030051
5	67.489483458	62.4146030085
6	82.664739452	62.4146030086

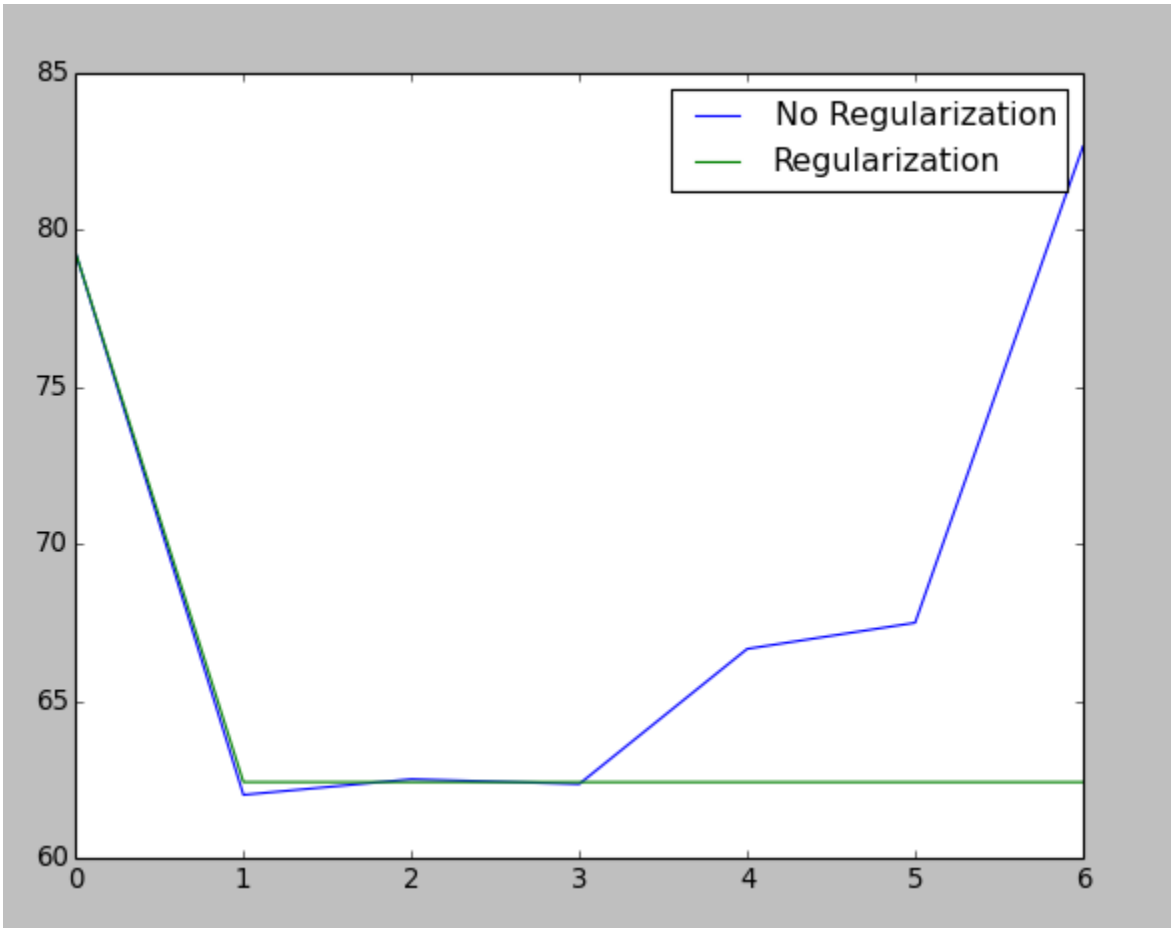

Fig 7:RMSE values for testing data with and without regularization for different values of P

If we look at the table with different RMSE for various values of P for both lambda=0 and lambda=0.06, we can say that when **p=1,** RMSE is least for non regularization(lambda=0) and for **p=4,** RMSE is least for regularization(lambda=0.06).

Problem 6: Interpreting Results

OLE Regression:

For Training data:
RMSE without intercept: 138.20074835
RMSE with intercept: 46.7670855937

For Testing data:
RMSE without intercept: 326.764994196
RMSE with intercept: 60.8920370905

Ridge Regression(optimal lambda=0.06):
RMSE for Training Data: 49.5129123628
RMSE for Testing Data: 53.3978483971

Non Linear Regression:
RMSE for Training Data with regularization(p=4):62.4146030051
RMSE for Training Data without regularization(p=1):62.0083440367

CONCLUSION:
From the above results we can conclude that OLE regression with intercept is best for training data. Ridge regression is best for Testing data. Looking at all other methods we can conclude that Ridge regression and Ridge regression with gradient descent is best for this data in terms of Root mean square error.