ELL 409 Assignment 1

- **Jay kishan,2018ee10469**

Part1

1. **Using 20 points only**

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********** RESULTS ***************
Min Linear Regression RMSE: 1.274
Min Degree:  2
[6.659480288158489, 6.659480288158489, -5.823433896427728]
Min Moore-Penrose RMSE: 0.083
Min Degree: 10
[ 5.74025918e+00  2.77778416e+01  1.39970404e+03 -2.44561309e+04
  1.66646909e+05 -6.17690274e+05  1.37762849e+06 -1.90158573e+06
  1.59076743e+06 -7.38906069e+05  1.46167021e+05]
Min Moore-Penrose RMSE with Regularisation: 0.162
Min Degree: 34
[    5.58166404    88.15148295  -662.2714406   1705.74606548
  -720.45273941 -2759.01306048  1578.94057846  2603.70815429
   566.50409262 -1456.85151851 -2012.65663911 -1291.62000375
   -80.81324554   943.79380948  1449.05377823  1406.05117103
   964.02648981   332.41455033  -296.93004254  -787.47593466
 -1066.9122754  -1119.47728063  -971.12206782  -673.51156732
  -290.07659989   114.61182909   482.02705099   763.80955438
   923.57929657   937.04176703   791.03428498   481.94400117
    13.90529837  -603.07101437 -1354.79525865]
```

Moore penrose without regularisation gives best results with minimum RMSE=0.083 for 10 degree polynomial

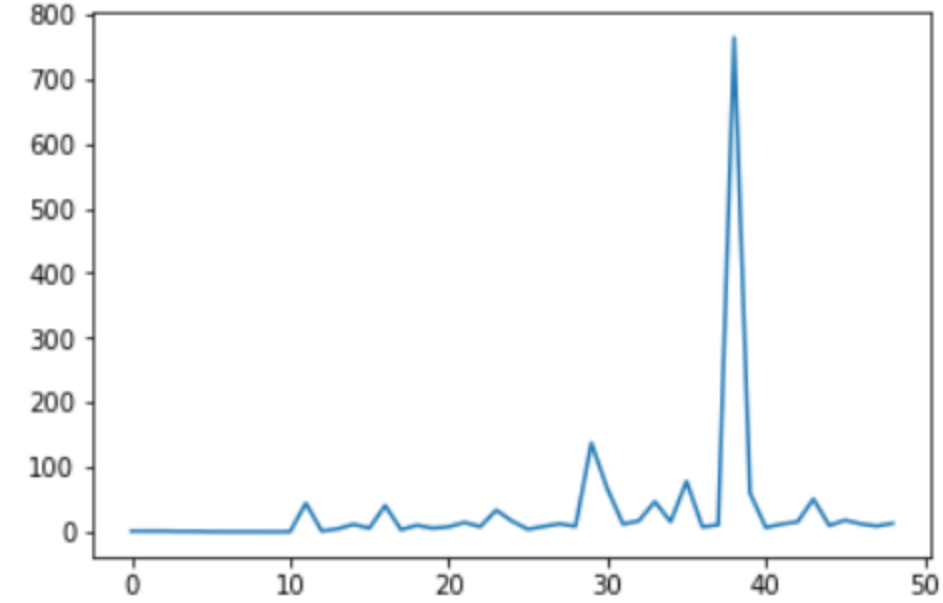

Figure: Moore Penrose RMSE vs Polynomial degree

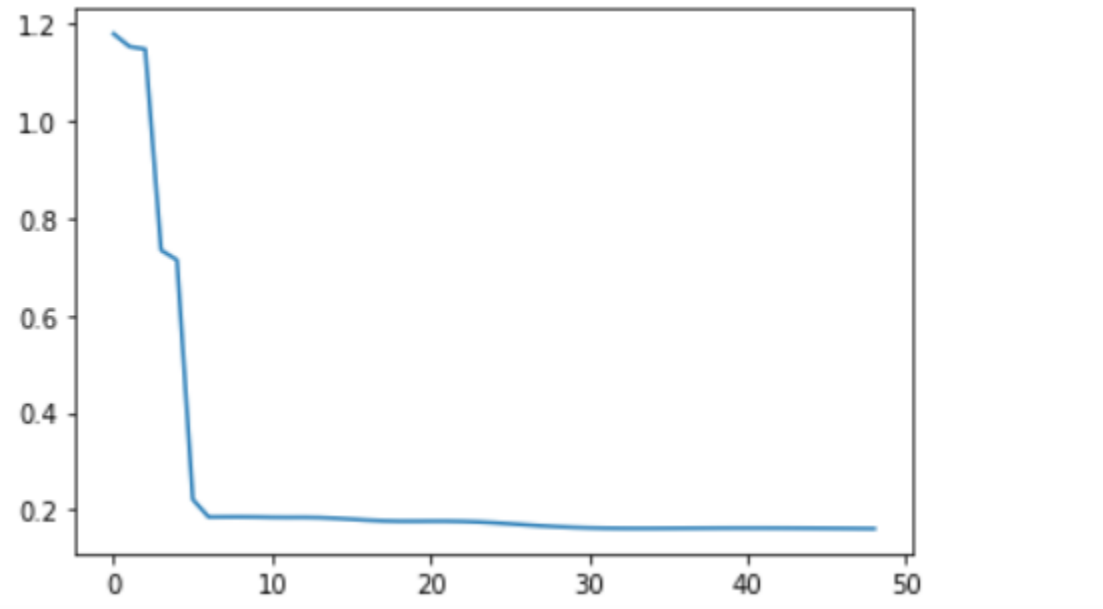

Figure: Moore Penrose RMSE with regularization vs Polynomial degree

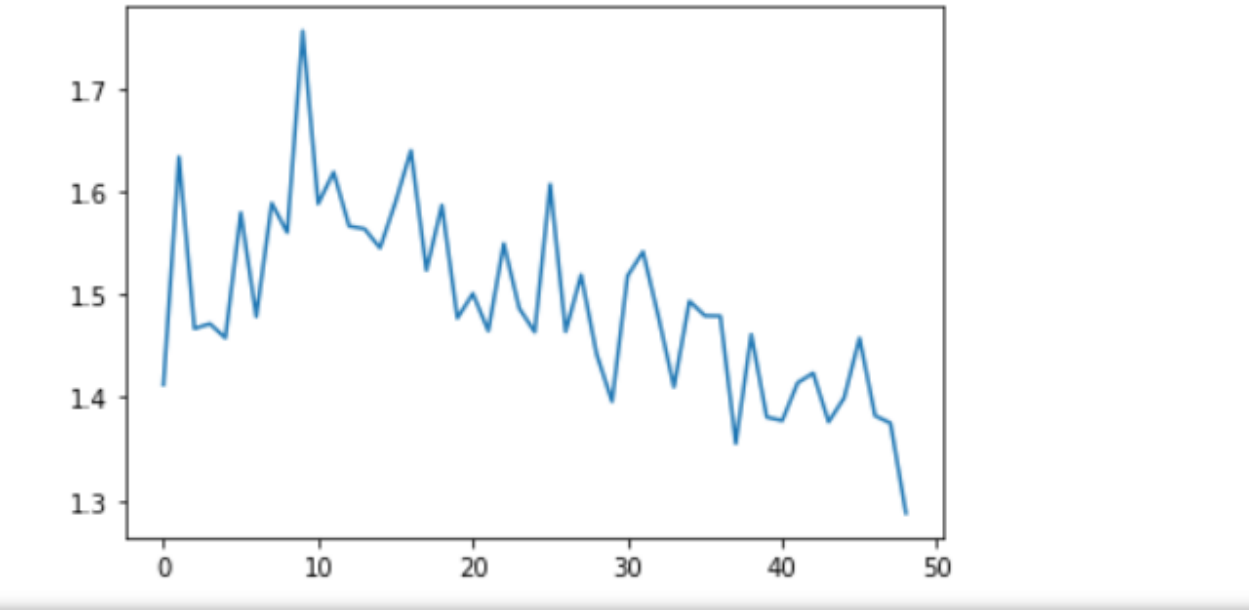

Figure: GD rmse vs Polynomial degree

2. With 100 points

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********** RESULTS ***************
Min Linear Regression RMSE: 1.251
Min Degree:  9
[6.587038404268702, 6.587038404268702, -2.285900480140294, -1.942903527347004, -1.2148776363872185, -0.7941553454857284, -0.604
4241248131417, -0.5438776983383609, -0.5482561566643565, -0.5811152105136939]
Min Moore-Penrose RMSE: 0.111
Min Degree: 10
[ 8.08126985e+00 -2.21113264e+02  6.84544680e+03 -7.77114397e+04
  4.57290833e+05 -1.59028606e+06  3.45378054e+06 -4.73966874e+06
  3.99476943e+06 -1.88716111e+06  3.82362296e+05]
Min Moore-Penrose RMSE with Regularisation: 0.377
Min Degree: 24
[ 6.28921397e+00  1.09969320e+01  5.30533860e+02 -5.51938397e+03
  1.98427477e+04 -2.80796164e+04  4.06102669e+03  1.78740738e+04
  4.50147911e+03 -9.57075989e+03 -1.15830831e+04 -4.43483851e+03
  4.12747445e+03  8.64784800e+03  7.76166196e+03  3.11501930e+03
 -2.44690464e+03 -6.34565409e+03 -7.09541063e+03 -4.56654677e+03
  1.25601594e+02  4.92598158e+03  7.20426054e+03  4.10147431e+03
 -7.18611553e+03]
```

Moore penrose without regularisation gives best results with minimum RMSE=0.111 for 10 degree polynomial

1. Using Moore-Penrose Pseudoinverse Cross without regularization Validation is used to approximate the testing error. The graph between cross validation error and

training error versus degree is shown as below. The random seed is set as 1 for all the subsequent observations.

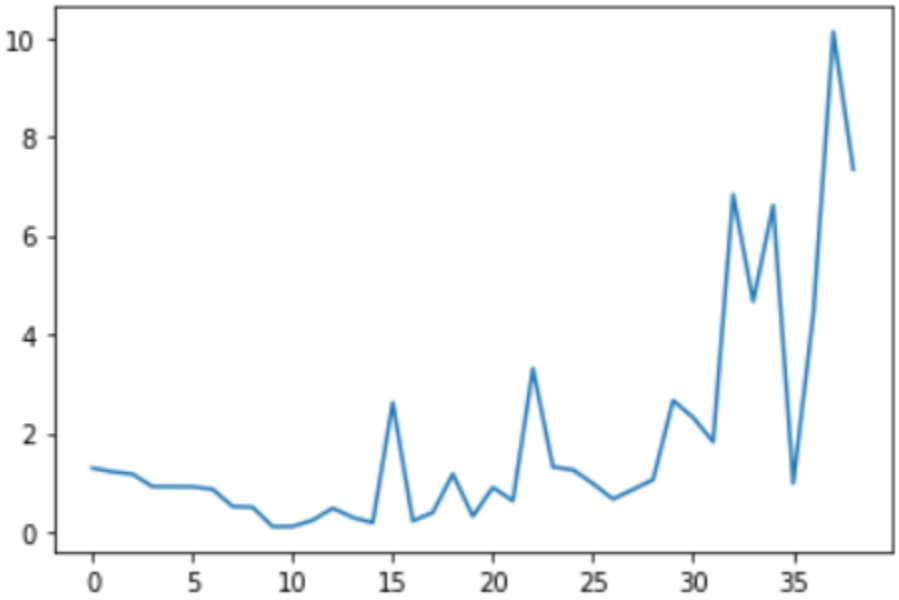


Figure: Moore Penrose RMSE vs Polynomial degree

2. Using Moore-Penrose Pseudoinverse Cross with regularization-Cross Validation is used to approximate the testing error. The graph between cross validation error and training error versus degree is shown as below

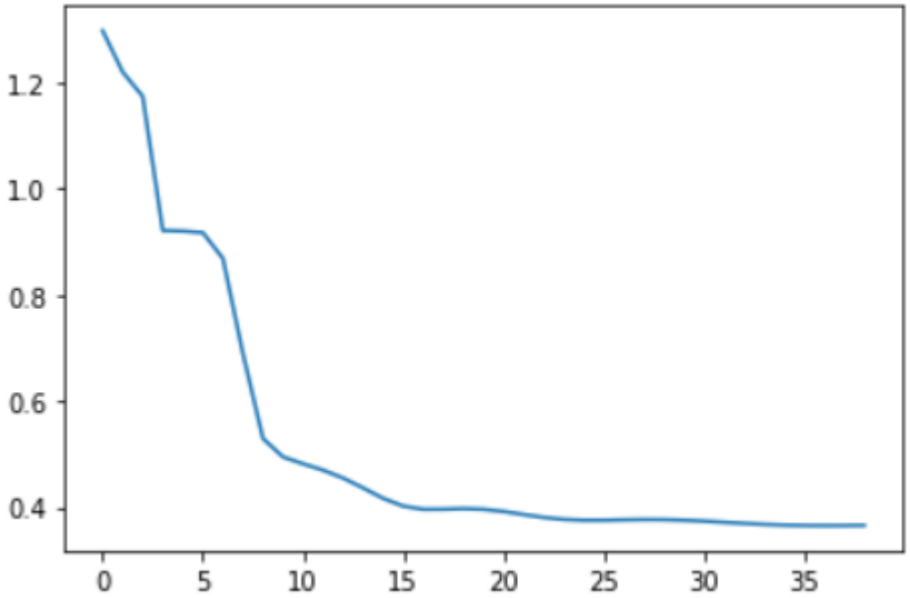
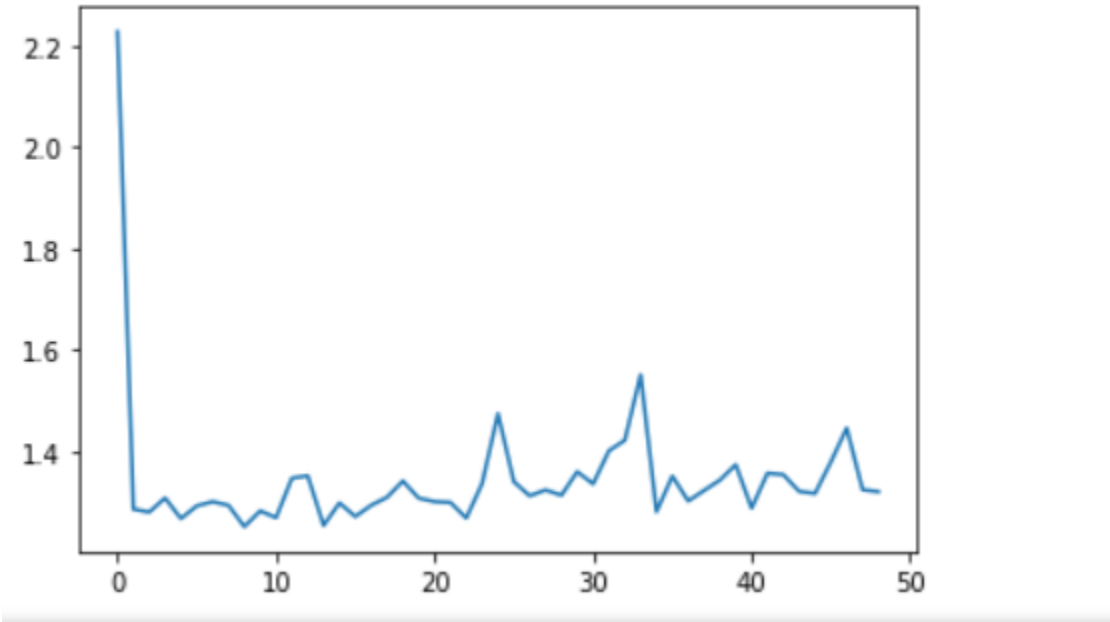


Figure: Moore Penrose RMSE with regularization vs Polynomial degree

3. **Gradient Descent** -The Hyperparameters used to train is shown as below
   • Learning Rate = Fixed at 0.01
   • Epochs = 50
   • Stopping Criterion = 5000 iterations
   • Batch Size = 1 (SGD)
   • No of folds for n-folds cross validation = 5

```
Min Linear Regression GD RMSE: 1.251
Min Degree:  9
[6.587038404268702, 6.587038404268702, -2.285900480140294, -1.942903527347004, -1.2148776363872185, -0.7941553454857284, -0.604
4241248131417, -0.5438776983383609, -0.5482561566643565, -0.5811152105136939]
```



Conclusion:-In both the cases, similar polynomials were obtained finally (both degree 7 and coefficients were also reasonably close). Hence the final results were approximately the same.

1.**Difference between the n=20 and n=100 results**
In both the cases, similar polynomials were obtained finally (both degree 10). Hence the final results were approximately the same.
The main differences were obtained in gradient descent. The iterations required in the case of batch size 1 (SGD) were lower for n=20 than the iterations required for n=100.

2 Final Estimate of the underlying polynomial -The final estimate is chosen (of course in the case of n=100)n from the results of . Following reasons justify this choice -
• The degree for regularisation is very high compared to the degree of non regularisation.
• The cross validation error is lesser in the case of non regularisation. Hence, the final estimate is polynomial has Min Moore-Penrose RMSE: 0.111 Min Degree: 10

Coefficients -

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[ 8.08126985e+00 -2.21113264e+02  6.84544680e+03 -7.77114397e+04
  4.57290833e+05 -1.59028606e+06  3.45378054e+06 -4.73966874e+06
  3.99476943e+06 -1.88716111e+06  3.82362296e+05]
```