

## ML PP4 Report

**DATASET: artsmall**

**KERNEL: LINEAR**

Value of **alpha** after convergence: **143.83708956072442**

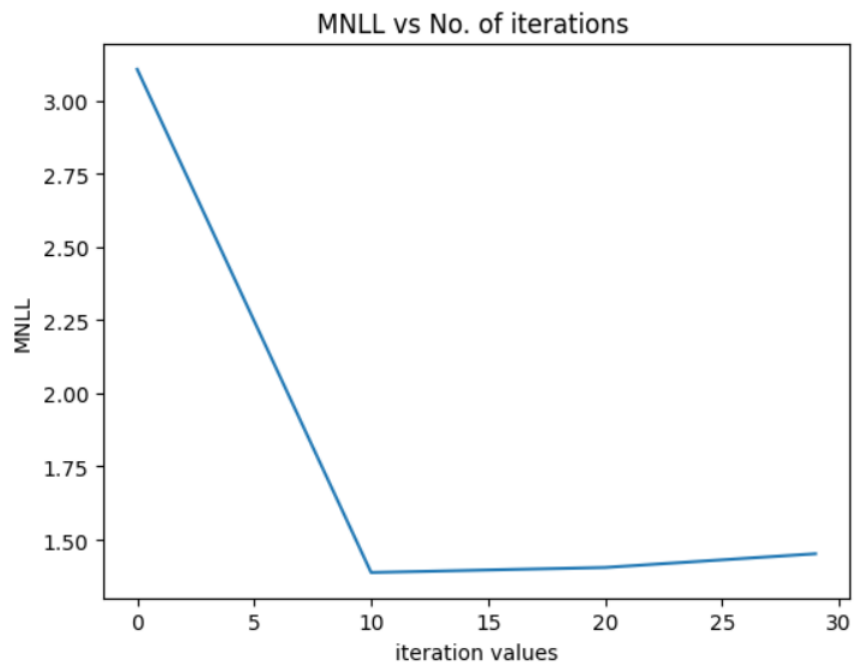
Value of **beta** after convergence: **4.138171016965101**

no of iterations: **30**

MSE: **0.7096827392160092**

```
"C:\Users\Abhishek Sharma\PycharmProjects\pp4\venv\Scripts\python.exe" "C:/Users/Abhishek Sharma/PycharmProjects/pp4/main.py"  
convergence condition met.  
LINEAR KERNEL: Final value of alpha: 143.83708956072442, beta: 4.138171016965101 and no of iterations: 30  
MSE: 0.7096827392160092  
  
Process finished with exit code 0
```

**MNLL vs Iterations Plot:**



### KERNEL: RBF

Value of **alpha** after convergence: **0.42420765**

Value of **beta** after convergence: **6.4933422**

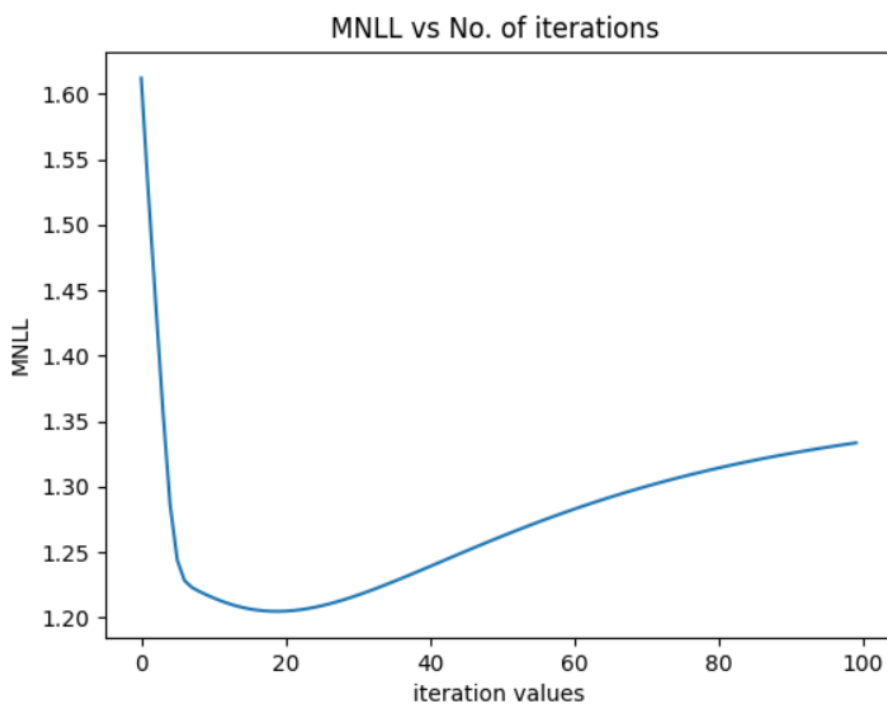
Value of **s** after convergence: **16.21435596**

no of iterations: **100**

MSE: **0.6780432335752934**

```
"C:\Users\Abhishek Sharma\PycharmProjects\pp4\venv\Scripts\python.exe" "C:/Users/Abhishek Sharma/PycharmProjects/pp4/main.py"  
convergence condition met.  
RBF KERNEL: Final value of alpha: [[0.42420765]], beta: [[6.4933422]], s: [[16.21435596]] and no of iterations: 100  
MSE: 0.6780432335752934  
  
Process finished with exit code 0
```

### MNLL vs Iterations Plot:



**DATASET: crime**

**KERNEL: LINEAR**

Value of **alpha** after convergence: **353.3792778969971**

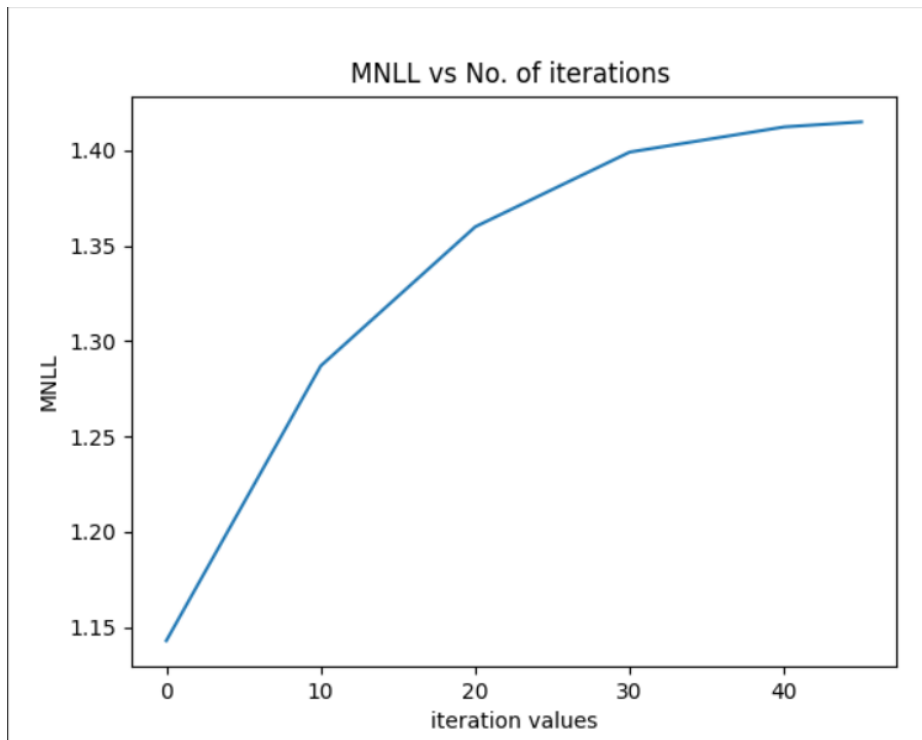
Value of **beta** after convergence: **2.604925838601953**

no of iterations: **46**

MSE: **0.5026610661299366**

```
"C:\Users\Abhishek Sharma\PycharmProjects\pp4\venv\Scripts\python.exe" "C:/Users/Abhishek Sharma/PycharmProjects/pp4/main.py"  
convergence condition met.  
LINEAR KERNEL: Final value of alpha: 353.3792778969971, beta: 2.604925838601953 and no of iterations: 46  
MSE: 0.5026610661299366  
  
Process finished with exit code 0
```

**MNLL vs Iterations Plot:**



### KERNEL: RBF

Value of **alpha** after convergence: **0.65813614**

Value of **beta** after convergence: **2.76193131**

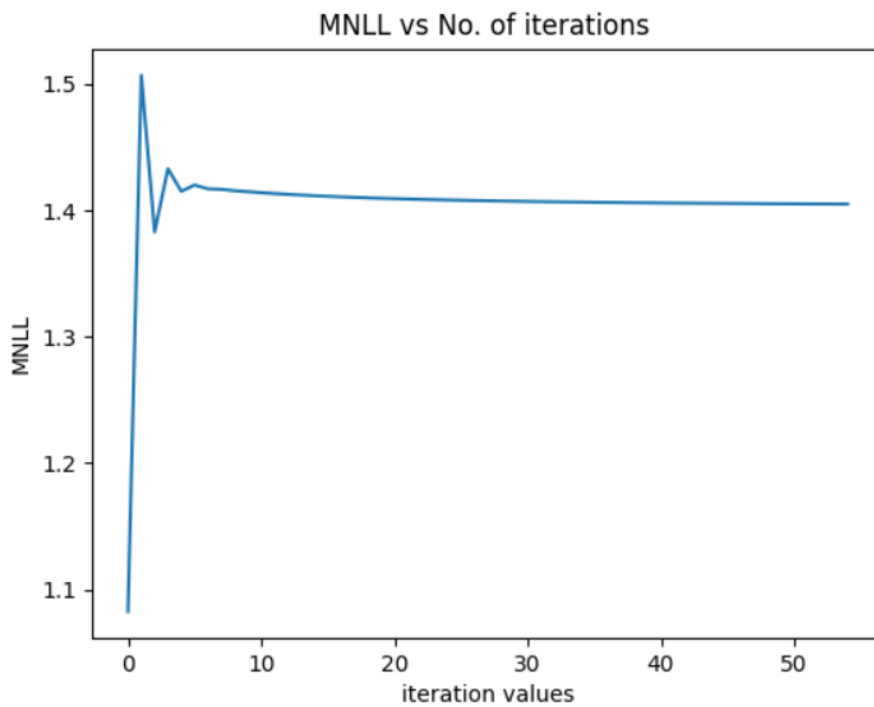
Value of **s** after convergence: **21.25812348**

no of iterations: **55**

MSE: **0.49932365931240286**

```
"C:\Users\Abhishek Sharma\PycharmProjects\pp4\venv\Scripts\python.exe" "C:/Users/Abhishek Sharma/PycharmProjects/pp4/main.py"  
convergence condition met.  
RBF KERNEL: Final value of alpha: [[0.65813614]], beta: [[2.76193131]], s: [[21.25812348]] and no of iterations: 55  
MSE: 0.49932365931240286
```

### MNLL vs Iterations Plot:



**DATASET: housing**

**KERNEL: LINEAR**

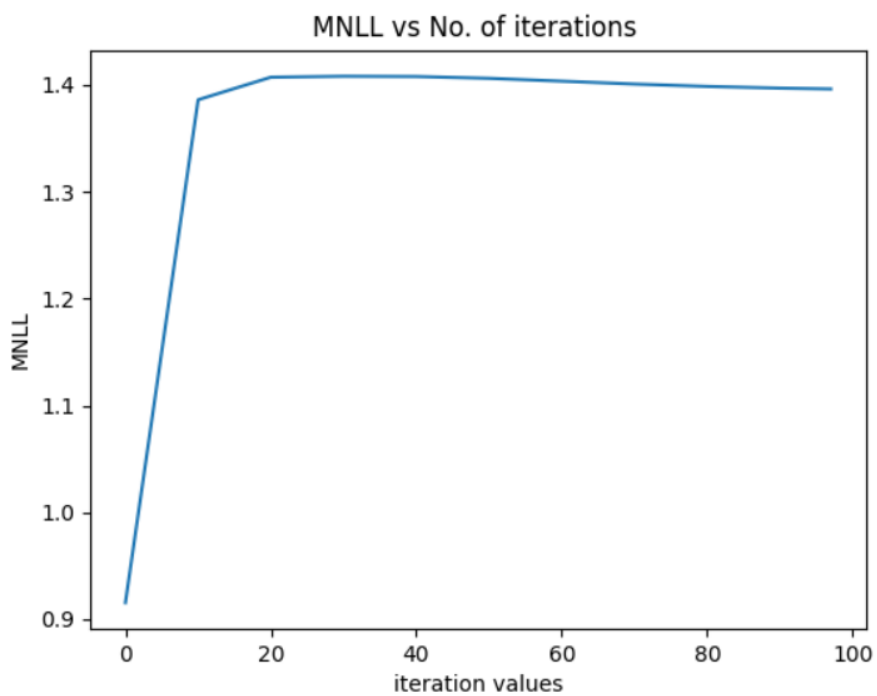
Value of **alpha** after convergence: **21.243840386172003**

Value of **beta** after convergence: **3.9957954472355377**

no of iterations: **98**

MSE: **0.2883918769478013**

**MNLL vs Iterations Plot:**



**KERNEL: RBF**

Value of **alpha** after convergence: **0.31272331**

Value of **beta** after convergence: **12.7608653**

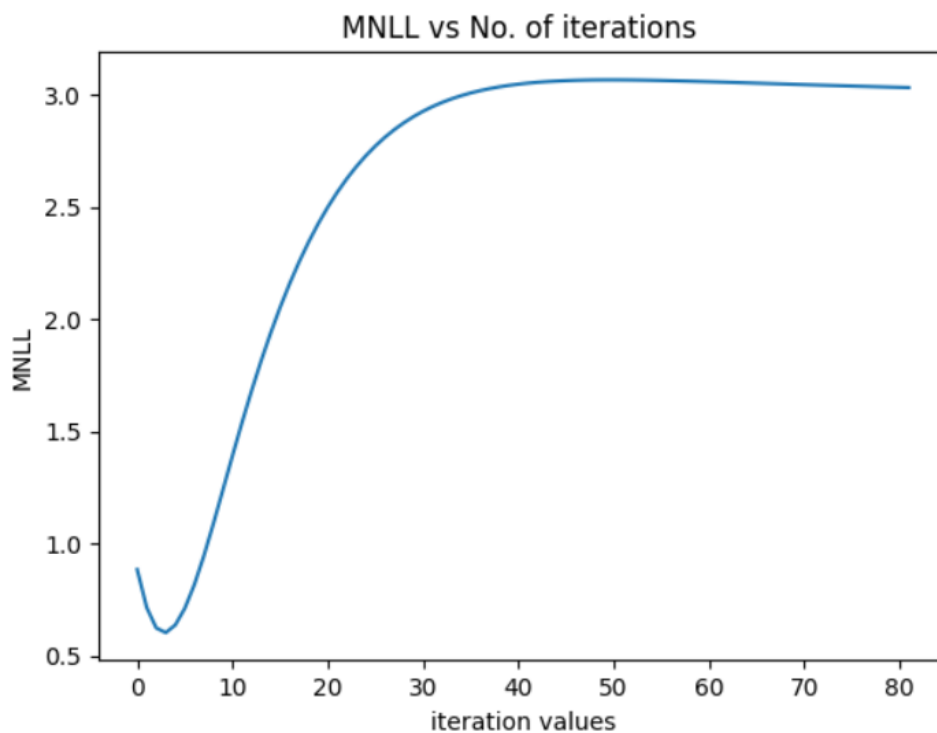
Value of **s** after convergence: **4.80903028**

no of iterations: **82**

MSE: **0.17759333674640404**

```
"C:\Users\Abhishek Sharma\PycharmProjects\pp4\venv\Scripts\python.exe" "C:/Users/Abhishek Sharma/PycharmProjects/pp4/main.py"  
convergence condition met.  
RBF KERNEL: Final value of alpha: [[0.31272331]], beta: [[12.7608653]], s: [[4.80903028]] and no of iterations: 82  
MSE: 0.17759333674640404
```

**MNLL vs Iterations Plot:**



**DATASET: 1D**

**KERNEL: LINEAR**

Value of **alpha** after convergence: **2.3836990764543935**

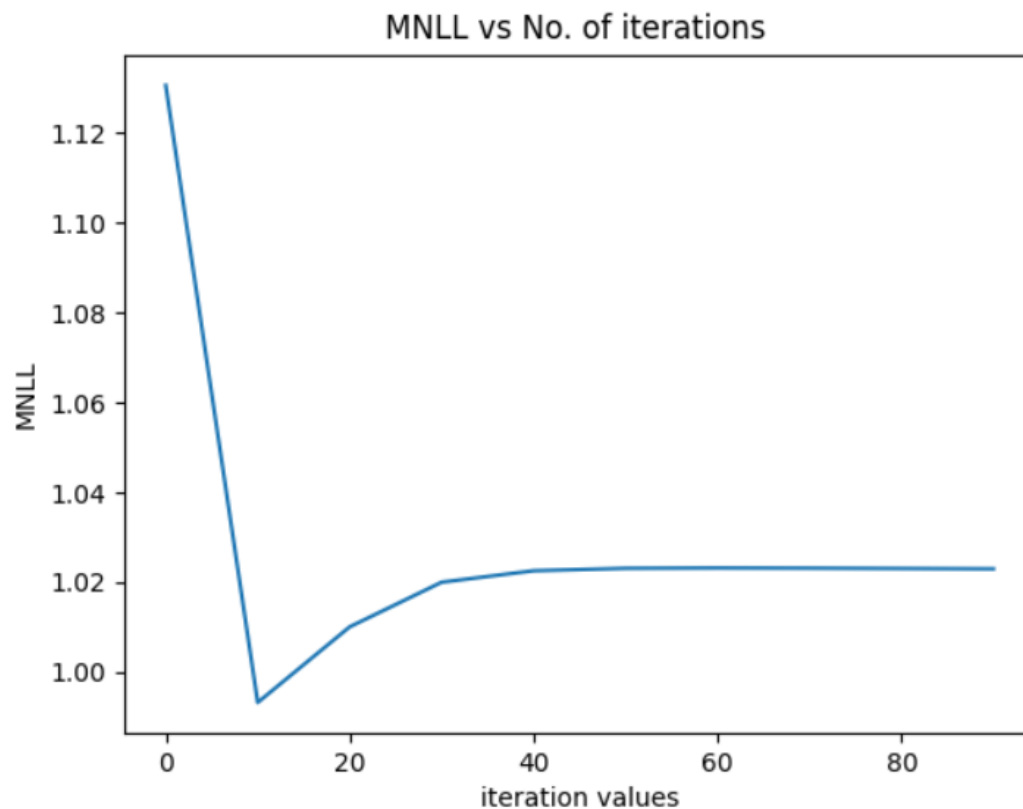
Value of **beta** after convergence: **1.926161713110879**

no of iterations: **100**

MSE: **0.41146991047994314**

```
"C:\Users\Abhishek Sharma\PycharmProjects\pp4\venv\Scripts\python.exe" "C:/Users/Abhishek Sharma/PycharmProjects/pp4/main.py"  
LINEAR KERNEL: Final value of alpha: 2.3836990764543935, beta: 1.926161713110879 and no of iterations: 100  
MSE: 0.41146991047994314
```

**MNLL vs Iterations Plot:**



### KERNEL: RBF

Value of **alpha** after convergence: **0.95347473**

Value of **beta** after convergence: **1.85243098**

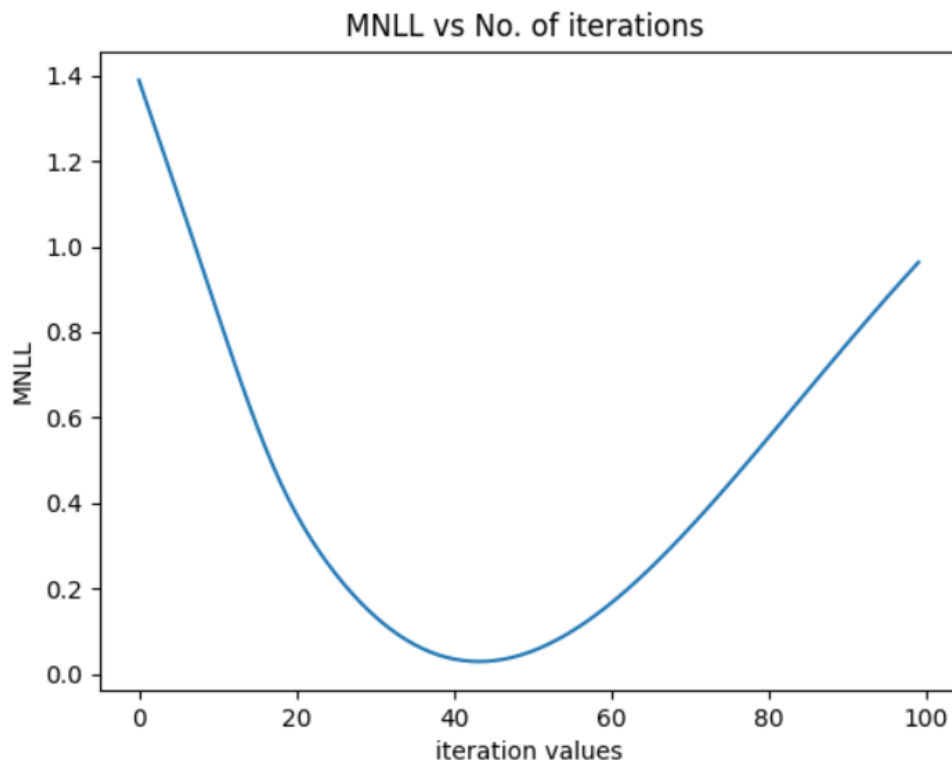
Value of **s** after convergence: **4.26539792**

no of iterations: **35**

MSE: **0.42856226814020515**

```
"C:\Users\Abhishek Sharma\PycharmProjects\pp4\venv\Scripts\python.exe" "C:/Users/Abhishek Sharma/PycharmProjects/pp4/main.py"  
convergence condition met.  
RBF KERNEL: Final value of alpha: [[0.95347473]], beta: [[1.85243098]], s: [[4.26539792]] and no of iterations: 35  
MSE: 0.42856226814020515
```

### MNLL vs Iterations Plot:

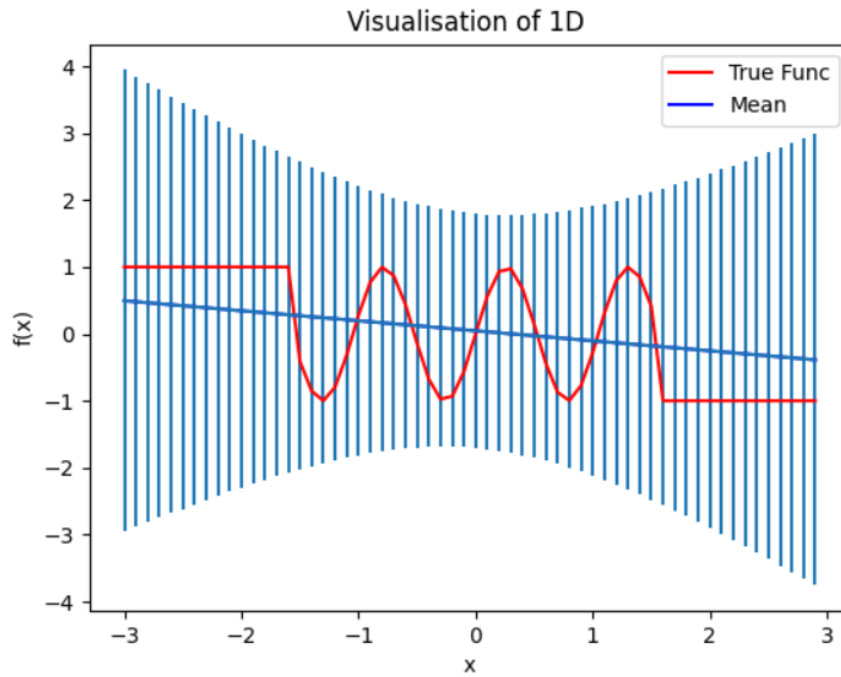




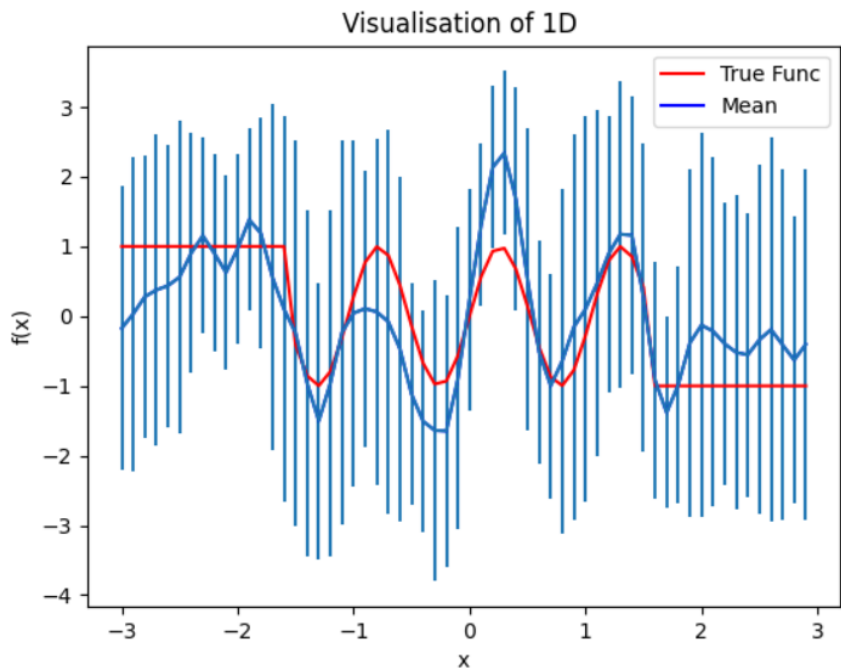
## VISUALISATION OF PERFORMANCE OF 1D DATASET

-PLOT OF TRUE FUNCTION VS THE MEAN

### LINEAR KERNEL:



### RBf:



## Comparison to Bayesian Linear Regression

### LINEAR KERNEL:

<u>DATASET</u>	<u>MSE</u>	<u>ALPHA</u>	<u>BETA</u>
<u>Crime</u>	0.5026610661299366	353.3792778969971	2.604925838601953
<u>Housing</u>	0.2883918769478013	21.243840386172003	3.9957954472355377
<u>Artsmall</u>	0.7096827392160092	143.83708956072442	4.138171016965101
<u>1D</u>	0.41146991047994314	2.3836990764543935	1.926161713110879

### RBF KERNEL:

<u>DATASET</u>	<u>MSE</u>	<u>ALPHA</u>	<u>BETA</u>
<u>Crime</u>	0.49932365931240286	0.65813614	2.76193131
<u>Housing</u>	0.17759333674640404	0.31272331	12.7608653
<u>Artsmall</u>	0.7096827392160092	0.42420765	6.4933422
<u>1D</u>	0.42856226814020515	0.95347473	1.85243098

The values of alpha and beta in case of Linear Kernel are quite close to the corresponding values in the table given in the assignment.

In case of RBF kernel, the values are different. This is because Linear and RBF are both different feature spaces and there need not be any relation between the two.

The test set MSE in both Linear and RBF is almost similar to the values given in the table. This shows that the MSE is not affected by the choice of Kernel.

### Discussion of results

#### **Q1. Are the BLR and GP with linear kernel behaving similarly w.r.t. $\alpha, \beta$ , MSE as expected?**

Ans. As seen from the tables above, the values of alpha, beta and MSE are almost similar to the expected values. Thus, the BLR and GP with linear kernel behave similarly w.r.t.  $\alpha, \beta$ , MSE.

#### **Q2. How does the performance of GP compare when changing RBF vs. linear kernel?**

Ans. The performances with RBF and Linear kernel vary wrt the running times and prediction accuracy.

The RBF kernel takes much longer to run than a Linear kernel. Also, the no of iterations for convergence of Log(Ev) in Linear are less compared to that of RBF.

However, in terms of prediction accuracy, as observed in the visualisation of performance of 1D dataset, the prediction mean is more close to the true function in case of RBF kernel and not much close in case of a linear kernel. This shows that RBF provides more accurate predictions.

#### **Q3. What are potential advantages or disadvantages of each method?**

Ans. The advantages of a linear kernel is that it provides results faster and therefore can be beneficial in case of large datasets.

A disadvantage of Linear is that it might not provide the most accurate predictions, though, a good prediction nonetheless.

Advantage of RBF is that it provides more accurate solutions and is therefore useful in models that require high precision and accuracy.

The disadvantage is the longer running times which might not be beneficial with large datasets.