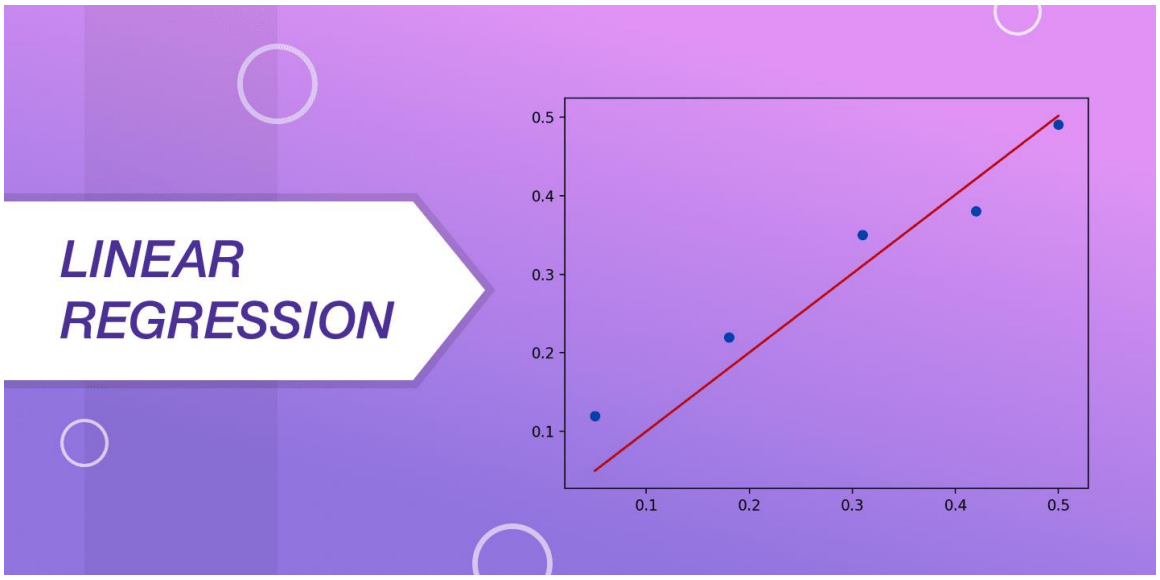


Linear Regression

HW1

109511276 練鈞揚 |Machine Learning | 3/18/2023

Discuss About the Linear Regression

For my first machine learning homework (HW1), I gained valuable insights on creating a linear regression model using mathematical equations. In Part I of the assignment, I observed that as the degree of the polynomial (M) increased, the model tended to overfit the training data. However, by introducing regularization, I was able to mitigate overfitting. Additionally, I found that the mean squared error (MSE) of the testing data was higher than that of the training data. However, when M was large, both MSEs decreased (as seen in the attached image). Finally, I learned that the proper use of basic functions is crucial, as even a small error like forgetting to include brackets can have significant impacts on the model's performance.

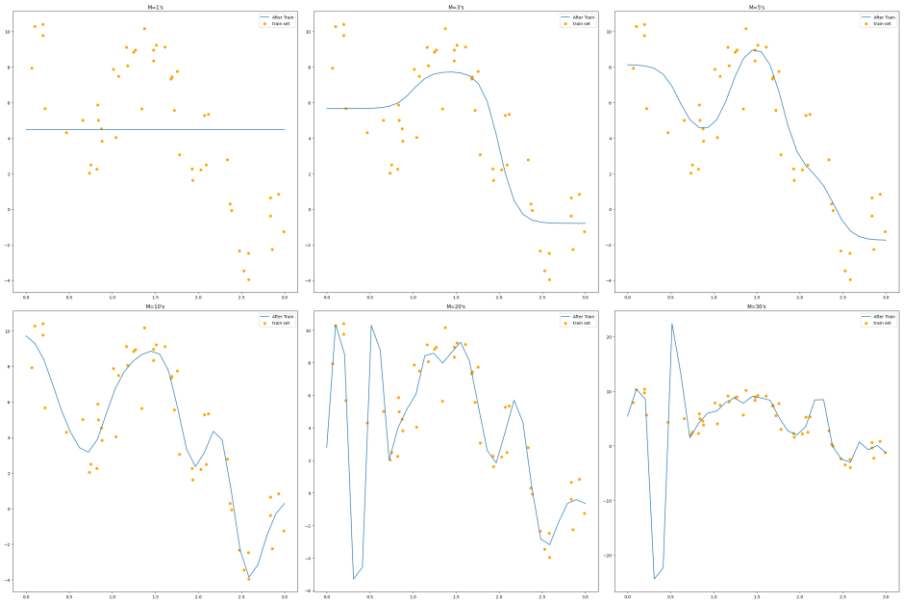
```
self.logistic_sigmoid((x - self.mui_function(j)) / self.S) if j != 0 else np.ones(len(x))
```

Moving on to Part 2, I tackled Bayesian Linear Regression. This was a more challenging task as it required dealing with upper and lower bounds, which couldn't be easily implemented in my code.

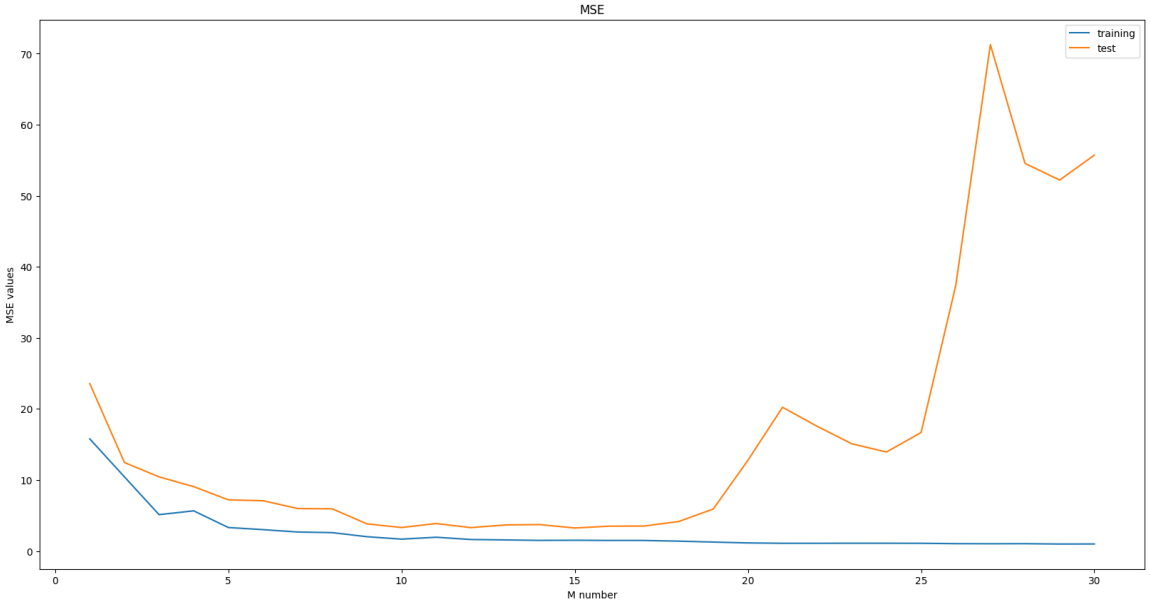
Overall, this homework assignment has sparked my interest in machine learning even further.

PART I

Please plot the data points(only the Training Set) and the fitting curve for M=1,3,5,10,20 and 30, respectively.



Please plot the Mean Square Error evaluated on the Training Set and the Testing Set separately for M from 1 to 30.



	MSE Train	MSE Test
1	15.78014	23.55387
3	5.120135	10.43653
5	3.30722	7.203639
10	1.673749	3.308359
20	1.141267	12.76993
30	0.993166	55.71021

Please apply the 5-fold cross-validation in your training stage to select the best order M and then evaluate the mean square error on the Testing Set. Plot the fitting curve and data points (only the Training Set). You should briefly express how you select the best order M step-by-step.

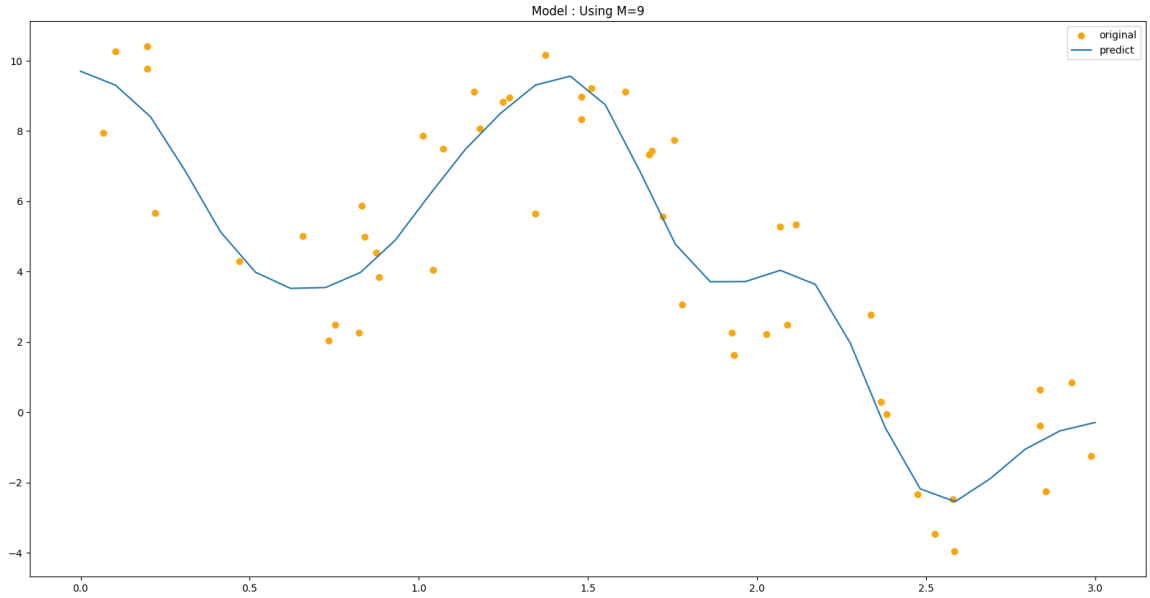
Step :

1. Make a k_cross_validation function (Machine Learn Useful class (github.com))

2. For loop from 1 to 30 put in dict

3. Find the minimum MSE in the dict

Find result M = 9

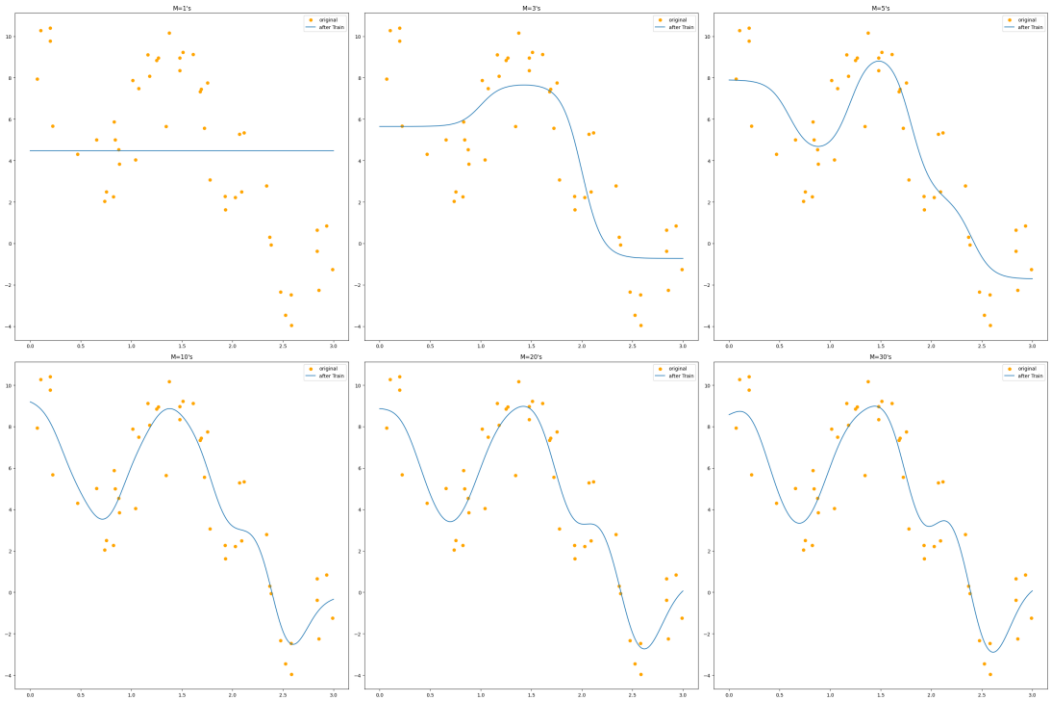


Considering regularization, please use the modified error function

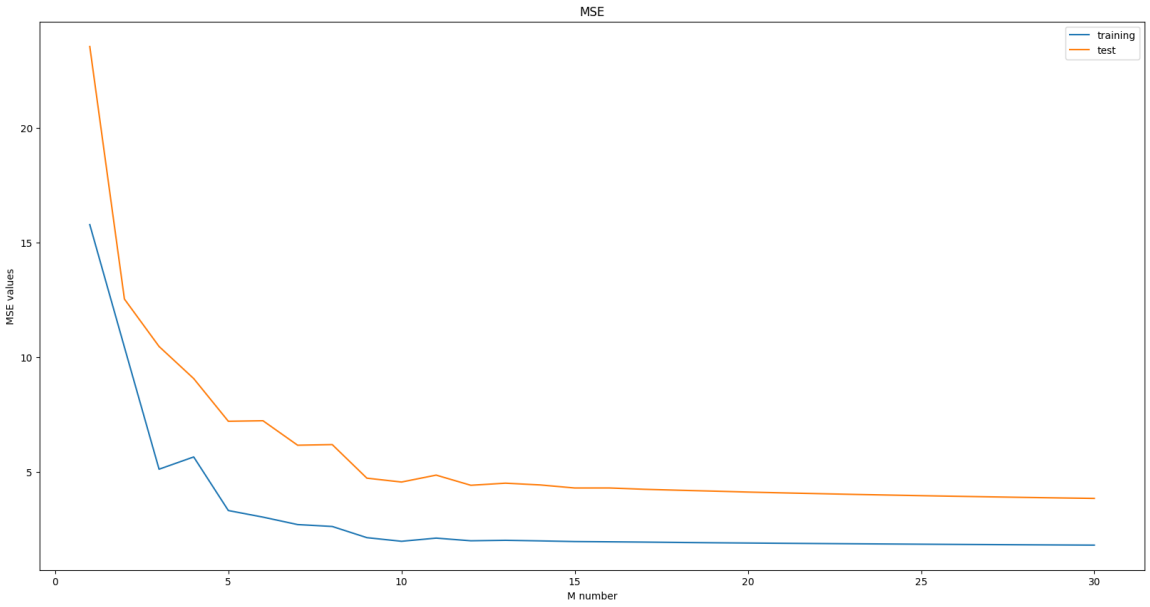
$$\widetilde{E}(\mathbf{w}) = \frac{1}{2}\sum_{i=1}^{N}\{y(x_i,\mathbf{w}) - t_i\}^2 + \frac{\lambda}{2}\|\mathbf{w}\|^2$$

where $\|\mathbf{w}\|^2 \equiv w_1^2 + w_2^2 + \ldots + w_M^2$. Repeat *Part I -1. and Part I-2.* with $\lambda = \frac{1}{10}$.

(You can also try to change the value of λ and discuss what happens under different λ values.)



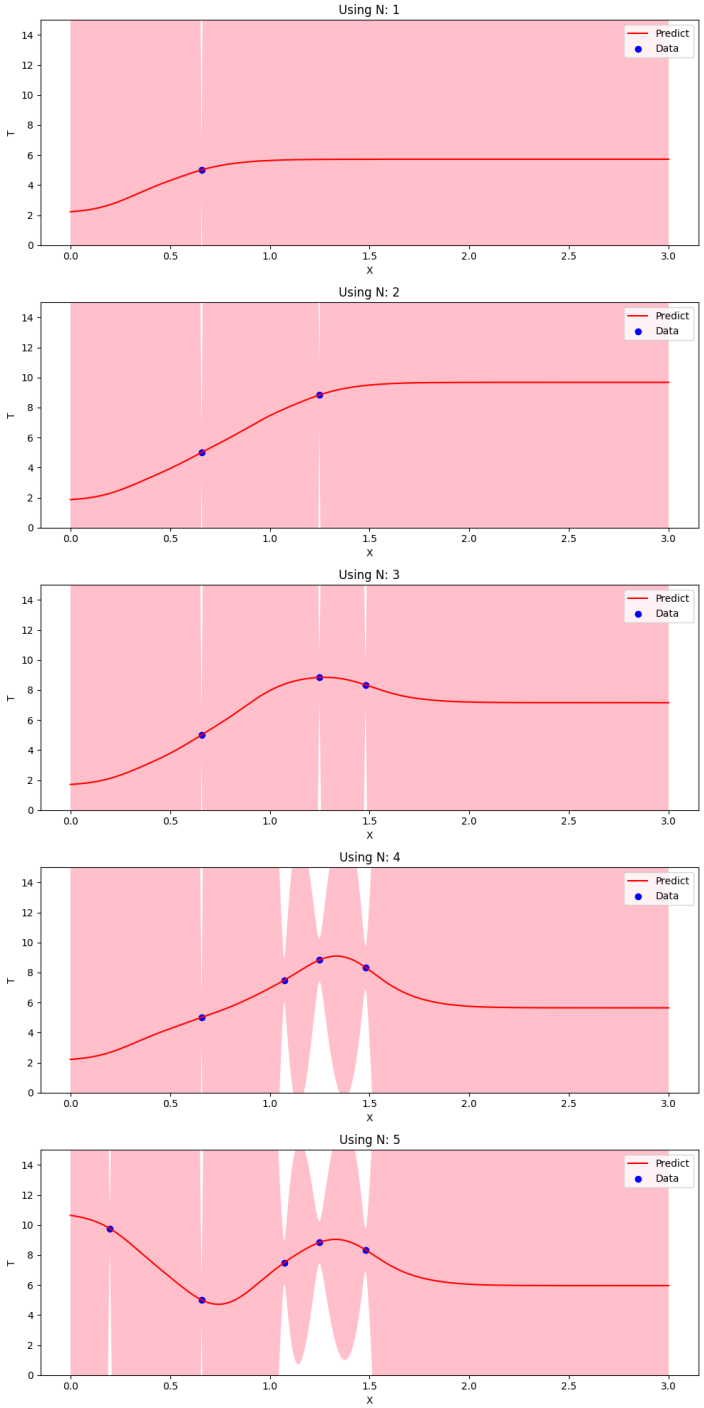
Regularization MSE Train	Regularization MSE Test
15.78022	23.54146
5.122922	10.47126
3.322108	7.211422
1.982251	4.564011
1.906961	4.127242
1.81508	3.85019

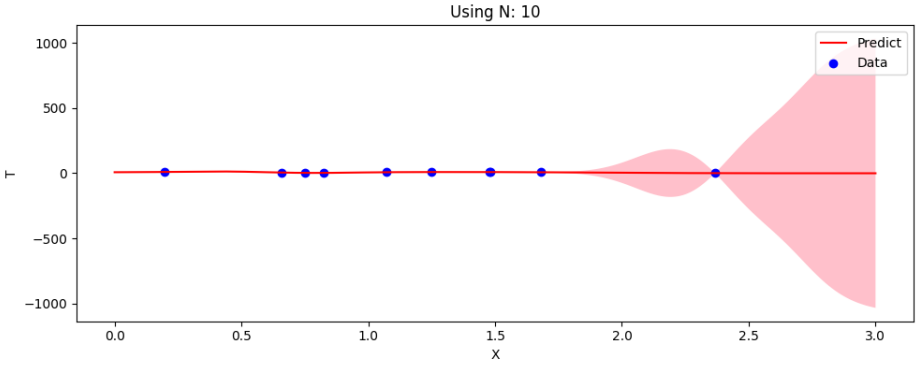


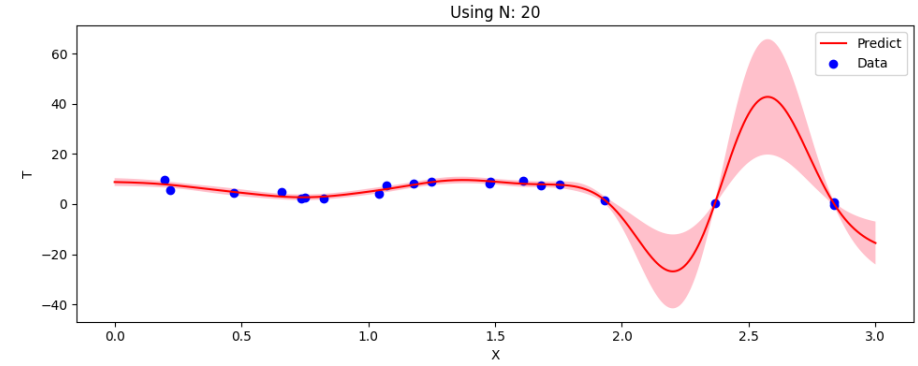
The lambda parameter controls the model elasticity, if Lambda becomes larger, it will make the model no elasticity or overfitting, otherwise, it becomes more elastic or overfitting.

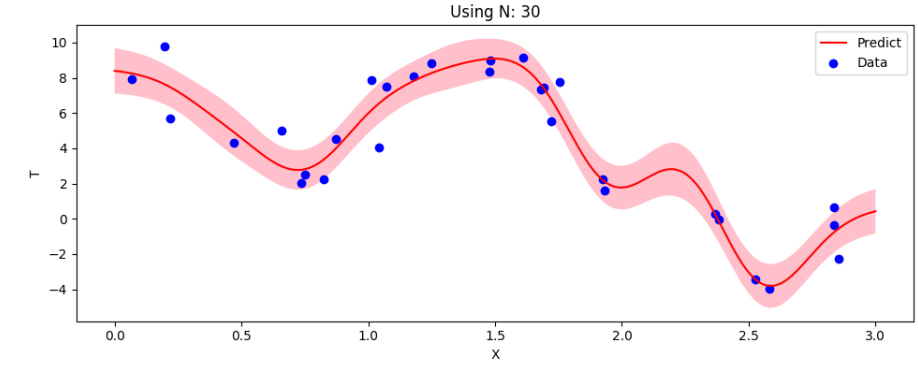
Part II Bayesian Linear Regression

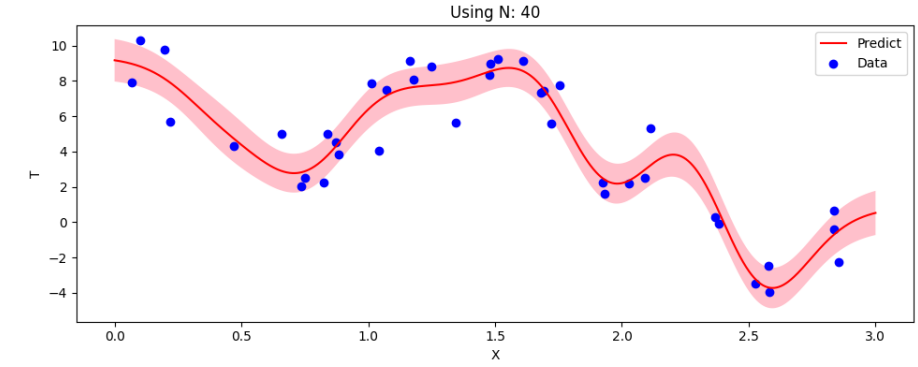
Similar to the following figures, please plot the curve of the posterior mean versus x and the region spanning one standard deviation on either side of the mean curve for N = 1, 2, 3, 4, 5, 10, 20, 30, 40, 50.

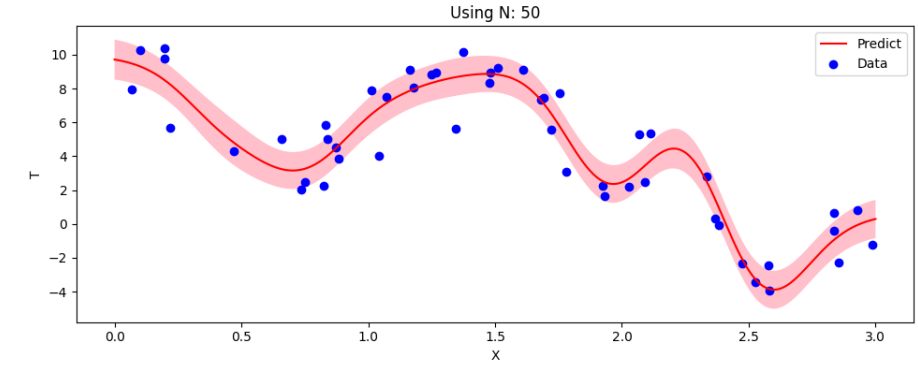



Using N: 10
Predict
Data
T
X


Using N: 20
Predict
Data
T
X


Using N: 30
Predict
Data
T
X


Using N: 40
Predict
Data
T
X


Using N: 50
Predict
Data
T
X