Assignment 1 | Machine, Data and Learning

Task 1

The function ***LinearRegression().fit()*** is a combination of two statements:

- ***LinearRegression()*** creates an instance of the class LinearRegression which is used as our Regression model.
  Usage: ***model = LinearRegression()***
- ***fit()*** is used to fit the model to the given dataset
  Usage: ***model.fit(input, output)***

So ***model = LinearRegression().fit(input, output)*** creates a linear regression model and fits it to a given input and output dataset.

LinearRegression().fit() fits a linear model with coefficents w = (w1, ..., wp) to minimize the residual sum of squares between the observed targets and the targets predicted by the linear approximation, i.e. Minimise the Sum of Squared Errors.

Task 2

Output Table

degree	bias	variance
1	1002.12	36428.8
2	977.711	59290.5
3	93.5627	63145.2
4	87.1109	103549
5	83.2309	117957
6	83.0022	151206
7	89.8943	174210
8	88.472	192695
9	90.6972	223986
10	95.293	220355
11	95.498	247029
12	143.416	245812
13	109.394	262235
14	175.741	248456
15	236.005	263460

degree	bias	variance
16	250.452	274580
17	329.727	289574
18	340.982	302814
19	432.912	320972
20	442.321	333111

Analysis

As functional classes change, with incresing degree we observe:

- Bias trend-
  - For degree *3*, the bias graph takes deep dive, then gradually reduces till degree *6*.
  - After that the bias unevenly increases till degree *14*.
  - Then it keeps increasing from there.
  - **Note that** just the general trend of bias falling till approximately degree *7* and then increasing is common, while the other details are case dependent.
- Variance trend:
  - It keeps increasing with some troughs till degree *11*.
  - Then it oscillates in a range of *5000* till degree *15*.
  - Then it again increases monotonicalls.
  - **Note that** just the general trend of variance rising till approximately degree *13*, not varying for another *3-4* degrees and then increasing is common, while the other details are case dependent.

Task 3

Output Table

degree	error
1	2.32831e-10
2	1.16415e-10
3	1.45519e-11
4	0
5	0
6	0
7	0
8	2.91038e-11
9	2.91038e-11

degree	error
10	5.82077e-11
11	2.91038e-11
12	5.82077e-11
13	0
14	1.16415e-10
15	0
16	0
17	0
18	5.82077e-11
19	1.16415e-10
20	0

Analysis and Reasoning

Observations:

- Running the program several times shows that no general trend is followed by the irreducible error
- All the values for the irreducible error are extremly close to each other
- Changes in the irreducible error of a particular model after every run is extremly small

Conclusions:

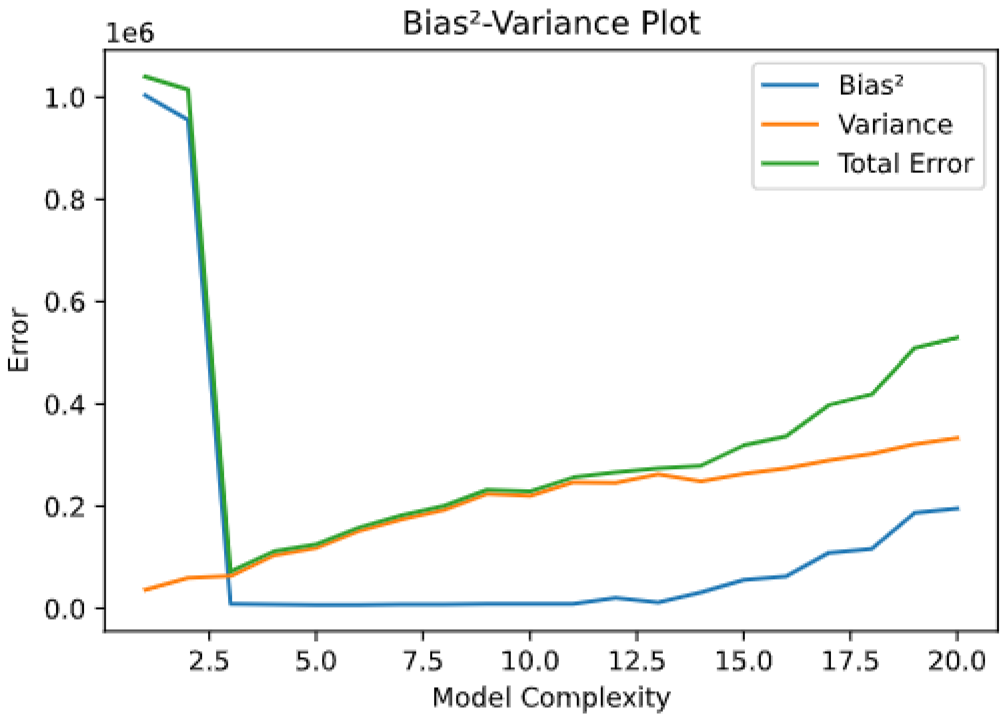
- The small changes in the irreducible error values are caused by rounding errors
- The irreducible error is equal to some value which is the same for all models

Reasons:

- Irreducible errors are errors which can't be removed by any model used for prediction. These errors are caused by unknown variables that are affecting the independent/output variable, i.e. the noise in the data, but are not one of the dependent/input variable while designing the model.
- Therefore, the irreducible error represents the inherent noise in the data, and hence is irrelevant and independant of the model.

Task 4

Output Graph



Analysis and Reasoning

From the graph plotted we can observe the following:

- Bias^2 has a local minima around degree *3* and variance gradually increases, and since irreducible error is almost same, we can see that the the toal error, or mean squared error, is the least aound degree *3*.
- Therefore, the optimal model complexity is a polynomial of degree *3*.
- This would mean that for degree *1*,*2* the model underfits and from degree *4* onwards, the model overfits.
- Hence, we can say the the given data approximately forms a 3rd degree curve in the 2D Plane.