Submission Date: 8th November 2023

1 Bias-Variance Trade-off

1. "Bias" and "Variance" are terms which can carry many different meanings. Define what they mean in the context of Bias-Variance trade-off. What else can they refer to?

2. How does regularization prevent overfitting?

3. Let us say now you have 500 MRI images and you have tested 4 different machine learning models whose error metrics are as follows:

	Model 1	**Model 2**	**Model 3**	**Model 4**
Train error	0.1%	25%	15%	0.2%
Test error	13%	19%	40%	3%

   Report the following for each model:

   (a) Bias and Variance (High or Low)

   (b) Under fitting, over fitting or good fit

   (c) In case of model 2, what could be the reason that the test error is lower than the training error?

2 Overfitting and Underfitting in Linear Regression (Use Python)

You are given the following train data

x_1	x_2	y
-0.8	2.8	-8.5
0.3	-2.2	12.8
1.5	1.1	3.8

and test data:

x_1	x_2	y
-2	2	-7
-4	15	-63

(a) Transform the input features (x_1, x_2) so that a polynomial prediction model overfits. Find the parameters and explain why it overfits.

(b) Transform the input features so that a polynomial prediction model underfits. Find the parameters and explain why it underfits.

(c) Transform the input features so that a polynomial prediction is adequate given the data (does not overfit nor underfit). Find the parameters and explain.

Hint: Typical ways to transform the input features are by selecting a subset of features or by performing operations among them. For instance a new feature $x_3 = x_1 * x_2$. Additionally notice that the polynomial prediction model is a linear regression model.