

Sem 1 2022-23 End Sem Exam, BITS Pilani KK Birla Goa Campus

Instructor in Charge: Harikrishnan N B

Student:

READ THE FOLLOWING CAREFULLY:

- **Honour Code for Students:** I shall be honest in my efforts and will make my parents proud. Write the oath and sign it on the answer sheet.
- **Duration: three hours**
- **Max. Marks = 50.**
- **Students can use calculator. Mobile phones are strictly prohibited.**
- **Answer all the questions.**

1. Decision Tree

- Find the truth table corresponding to the following Boolean function $[A \text{ AND } B] \text{ OR } [C \text{ AND } D]$.
- Use decision tree to represent the boolean function provided in 1a.
- Find the shannon entropy of the output of the boolean function provided in 1a. **5 marks**

2. MLE and MAP: Consider the following scenario, where we flip a coin n number of times to produce a dataset containing n_H number of Heads and n_T number of Tails. The outcomes of the coin flips are independent and identically distributed. For this setting, solve the following problems:

- find the best estimate of θ using maximum likelihood estimation, where θ is the probability of getting heads.
- find the best estimate of θ using maximum a posteriori probability estimation, where θ is a random variable that follows beta distribution. **4 marks**

3. Bias Variance Noise Decomposition

- Bias Variance Noise Decomposition:** Mathematically express the generalization error of a learning algorithm A in terms of bias, variance and noise (Derivation is not required). Identify the terms corresponding to bias, variance and noise.
- Graphically depict the training and testing error with respect to increasing model complexity. Identify the region in the graph where underfitting and overfitting happens. Identify the region corresponding to optimal model complexity. **7 marks**

4. Bagging and Boosting

- In a table, compare and contrast between bagging and boosting. Write any three points discussed in the ML class.
- Write a pseudocode for AdaBoost for a binary classification setting. **6 marks**

5. Support Vector Machine

- (a) Write the Lagrangian dual formulation of kernel Support Vector Machine (SVM) with soft margin. Show all the steps.
- (b) List out atleast four most commonly used kernels in SVM.
- (c) For $K(x_i, x_j)$ to be a kernel, _____ has to be satisfied and why?

10 marks**6. Least Square Denoising**

- (a) Consider a vector y which is sampled from a noisy signal $y(t)$. Solve the following optimization problem to find a vector x^* (same length as y) which is a denoised version of y .

$$x^* = \arg \min_x \|y - x\|_2^2 + \lambda \|Dx\|_2^2$$

where, D is the forward differencing scheme in matrix form and λ is a positive real number.

4 marks**7. K- Nearest Neighbours**

- (a) In k-NN, what is the value of k corresponding to low bias and high variance?
- (b) What is the hyperparameter in k -NN?

2 marks**8. Classification Metric:**

- (a) Consider a binary classification problem, let the prediction by an algorithm A is as follows: True Positive = 90, True Negative = 9, False Positive = 1, False Negative = 0 .
- (b) For 8a, find Precision, Recall, F1-score, Accuracy?
- (c) Is Accuracy a good metric for this problem? If Yes, why? If No, why?

7 marks**9. Crossvalidation**

- (a) What is the motivation behind doing crossvalidation?
- (b) Explain how to do Five-Fold Crossvalidation?
- (c) Explain how to do Leave One Out Crossvalidation (LOOCV)?

5 marks