

**Due data:** 10/13/2019, end of the day. **Please submit a word file or a PDF file:**

Question 1: Please answer the following questions related to Machine Learning concepts:

- 1) [6 points] Explain what is the bias-variance trade-off? Describe few techniques to reduce bias and variance respectively.
- 2) [4 points] What is k-fold cross-validation? Why do we need it?

Question 2: [6 points] Assume the following confusion matrix of a classifier. Please compute its

- 1) precision,
- 2) recall, and
- 3)  $F_1$ -score.

		Predicted results	
Actual values		Class 1	Class 2
	Class 1	50	30
	Class 2	40	60

Question 3:

- 1) [10 points] Build a decision tree using the following training instances (using information gain approach):

Day	Outlook	Temperature	Humidity	Wind	PlayTennis
D1	Sunny	Hot	High	Weak	No
D2	Sunny	Hot	High	Strong	No
D3	Overcast	Hot	High	Weak	Yes
D4	Rain	Mild	High	Weak	Yes
D5	Rain	Cool	Normal	Weak	Yes
D6	Rain	Cool	Normal	Strong	No
D7	Overcast	Cool	Normal	Strong	Yes
D8	Sunny	Mild	High	Weak	No
D9	Sunny	Cool	Normal	Weak	Yes
D10	Rain	Mild	Normal	Weak	Yes

- 2) [4 points] Decide the p-value (i.e.,  $p_{\text{chance}}$ ) of the **root** node using Chi-square test.

[ Hint: Please refer to page 41 – 45 of Lecture 5 slides for Chi-square test. After you have obtained the critical value  $CV$  (or  $Q$  as we used in lecture slides), using the following online tool to obtain the p-value, i.e.,  $P(X^2 > CV)$  (you need to enter degree of freedom and the critical value  $CV$ ): <https://stattrek.com/online-calculator/chi-square.aspx>]

4. [10 points] In ensemble learning, there are several popular fusion methods for Class Label type classifiers, e.g., majority vote, weighted majority vote, and naïve Bayes methods. Assuming we have 3 classifiers, and their predicted results are given in the table 1. The confusion matrix of each classifier is given in table 2. Please give the final decision using **Naïve Bayes** as the fusion method:

Table 1 Predicted results of each classifier

Sample x	Result
Classifier 1	Class 1
Classifier 2	Class 1
Classifier 3	Class 2

Table 2 Confusion matrix of each classifier

i) Classifier 1

	Class1	Class2
Class1	40	10
Class2	30	20

ii) Classifier 2

	Class1	Class2
Class1	20	30
Class2	20	30

iii) Classifier 3

	Class1	Class2
Class1	50	0
Class2	40	10