IE406 Final Exam (Take-home)

Due Date: 11:59 PM, June 17th (Friday)

1. Please use naïve Bayes with Laplace smoothing to predict the class label for the test sample "sale price discount". (10 points)

Record	Document	Class
1	price	non-spam
2	sale price	non-spam
3	discount	spam
4	sale sale discount	spam
5	sale sale discount discount	spam

2. Please circle "True" if the statement is true and explain the reason. Otherwise, please circle "False" and explain the reason.

(1) Low bias and high variance classifiers are better than high bias and low variance classifiers for a small-size dataset. (True/False) (5 points)

(2) Low bias and high variance classifiers are better than high bias and low variance classifiers for a large-size dataset. (True/False) (5 points)

3. Please explain what *overfitting* is and why overfitting is a problem. In addition, please provide an example of an approach how to reduce the risk of overfitting. (10 points)

4. When the data includes numerical features, in random forests, each tree node typically involves a comparison to a threshold value and the left or right branch is selected depending on whether the feature's value is greater than or less than this threshold. In the standard random forest algorithm, we find the best threshold for each feature by computing a homogeneity criterion with splits

defined by different thresholds. However, we would like to try a variant of the random forest algorithm. In particular, when we consider a feature that takes numerical values, we will use a randomly selected threshold instead of the best threshold. The threshold is selected uniformly randomly between the minimal and maximal value of the feature in the training set.

(1) Please explain how this randomness will affect the algorithm's behavior compared to the standard random forest algorithm. (5 points)

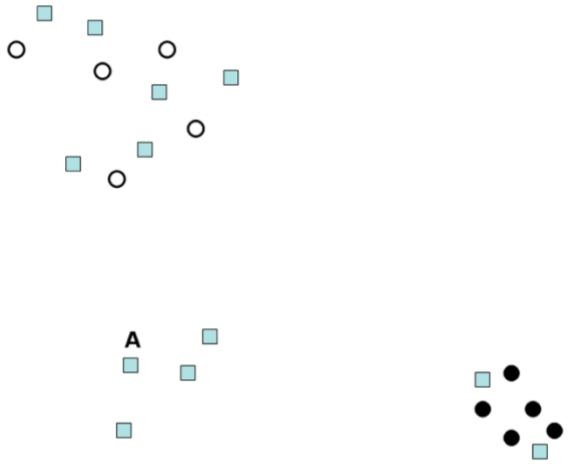
(2) Propose a novel type of random forest algorithm with considering this randomness into the training process in some new way. (5 points)

5. Consider the following table containing three binary input X_1, X_2, and X_3 and a binary output Y. Suppose that a simple classifier is proposed using AdaBoost, which simply selects for its learned model the lowest-numbered feature that has not been used yet and decides whether or not to negate this feature depending on which option works best. (e.g., this classifier returns either X_1 or $\sim X_1$ as its model.) Please use the classifier above with the table below and illustrate the steps to classify a new instance (i.e., X_1=1, X_2=1, and X_3=1) until all feature (i.e., X_1, X_2, and X_3) have been selected. (10 points)

X_1	X_2	X_3	Y
1	1	0	Positive
0	1	1	Positive
1	0	1	Positive
0	1	0	Negative
0	0	1	Negative

6. Please explain the difference between <u>self-training</u> and <u>co-training</u>. (5 points)

7. Consider the figure in a two-dimensional space below, where black circles, hollow circles, and squares indicate Class Y_1, Class Y_2, and unlabeled data, respectively. The objective is to classify the unlabeled point A. Please explain how we can use <u>co-training</u> for this problem. (5 points)



8. Please explain the difference between reinforcement learning and supervised learning. (5 points)

9. Please provide at least three real-world examples of exploitation and exploration in reinforcement learning. (5 points)

10. An agent receives $5 every time she moves into State (D). She pays $1 every time she takes any action (-$1 reward). Her possible moves are North, South, East, or West. If she receives more than one reward on a given action, the rewards are summed. (E.g., if she moves into State (D), she receives $5 – $1 = $4 (i.e., $5 for State (D) and −$1 for the action). At each time step, she takes an action, gets a reward(s), observes her new state, and updates her Q matrix according to the equation below, where the learning rate α is 1 and the discount factor γ is 0.5.

$$Q(s,a) \leftarrow Q(s,a) + \alpha[r + \gamma \max_{a} Q(s',a') - Q(s,a)]$$

(A) Agent	(B)
(C)	(D) $5

(1) Suppose that the values of the Q matrix are initialized to all zeros. The agent starts from State (A) and takes the following two actions, which are East and South. Please provide the values of the Q matrix after the agent has taken these two actions. The Q matrix is updated after each action. (5 points)

(2) Please use the Q matrix that is derived from Problem 10. (1). The agent starts from State (A) and takes the following two actions, which are East and South. (The starting point and two actions are the same as Problem 10. (1)). Please provide the values of the Q matrix after the agent has taken these two actions. The Q matrix is updated after each action. (5 points)

11. Suppose that you want to design a recommender system for an online bookstore, which has been launched recently.

(1) The online bookstore has over one million books, but its rating database has only 10,000 ratings. Which of the following would be better for designing a recommender system, (a) collaborative filtering or (b) content-based filtering? Please explain. (5 points)

(2) After several years, the online bookstore has enough ratings, so it starts to use a more advanced recommender system. Suppose that the mean rating of books is 3.8 stars. Ms. Kim, who is a faithful customer, has rated 500 books and her average rating is 0.5 stars higher than the average users' ratings. "Pattern Recognition and Machine Learning" is a book in the online bookstore with 500,000 ratings whose average rating is 1.0 higher than global average. What would be an estimate of Ms. Kim's rating for "Pattern Recognition and Machine Learning"? Please explain. (5 points)

12. It has been discussed that introducing news recommender systems can cause clustering of users and leads to an increased level of political polarization in society. For example, people who tend to view online news articles with a left-wing orientation will do so to an even larger extent after the news recommender system has been provided. It has been also discussed that news recommender systems will tend to expose users to online news articles with a more extreme angle than what they would otherwise prefer. For example,

people who have viewed some online news articles with a center-right orientation will be recommended to view far-right news articles after the news recommender system has been running for a long time. Please explain why recommender systems for online new articles may have these effects, which are discussed above. (10 points)