Two hours

QUESTION PAPER MUST NOT BE REMOVED FROM THE EXAM ROOM AND MUST BE RETURNED

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Foundations of Machine Learning

Date: Thursday 23rd January 2014
Time: 14:00 - 16:00

Please answer ALL Questions

Section A should be answered in an Answer book.

Section B is multiple choice and should be answered directly on the exam paper.
Only answers written in the boxes on the exam paper will be marked.

This is a CLOSED book examination

The use of electronic calculators is permitted provided they are not programmable and do not store text.
Section A

Answer all questions.

1. The accuracy and error rate, on both the training and testing datasets, is the most commonly used way of evaluating a model. Other than these, state two (2) additional factors that could be used to assess the performance of a model and the efficiency of its learning algorithm. (2 marks)

2. What is the technical term for the type of classification problem that can be solved by a Nearest Neighbour model, but cannot be fully solved by a Logistic Regression? (2 marks)

3. Explain the idea of Leave-One-Out Cross Validation. (2 marks)

4. State the formula for the entropy. Using whatever log base you wish, calculate the entropy of the feature \( x = \{1, 1, 1, 1, 2, 2, 2, 3, 3\} \). (2 marks)

5. Explain the Bagging algorithm. Marks are given for a concise and correct answer. (2 marks)
6. For each of the FOUR models below, state ONE parameter that controls the fit of the model, and state what effect it has (e.g. as you increase/decrease the parameter value, the model forms decision boundaries that are more/less complex.

- Decision Tree,
- Support Vector Machine with a Gaussian kernel,
- K-nearest neighbour,
- Bayesian Network.

(8 marks)

7. State the assumption made by the Naive Bayes model, in the form of an equation (1 mark) and its meaning in words (1 mark). Now draw the Bayesian Network corresponding to this assumption (1 mark).

(3 marks)

8. Given the data in the table below, list all the probabilities that a Naive Bayes would calculate during training. Use these probabilities to calculate what probability the model will predict for $p(y = 1 | x)$, given input $x = \{1, 0, 0\}$.

(4 marks)

<table>
<thead>
<tr>
<th>$x_1$</th>
<th>$x_2$</th>
<th>$x_3$</th>
<th>$y$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Section B of this examination is restricted