**COMP 3710 Artificial Intelligence**

Fall 2017

**Final Exam – 2 Hours**

Student Name: Student Number:

1. (4 marks) Show whether the following argument is valid or not, step-by-step using resolution refutation. (Note: 2 marks for conversion to CNF clause form, and 2 marks for resolution refutation.) You should interpret the resolution result.

If (~*A* ∧ *B*) → *C* is valid and ~*A* ∧ *B* is valid, then *C*  is valid.

1. (2 marks) Decide which one (or ones) in the followings is (or are) directly used for clustering. Decide which one (or ones) in the followings is (or are) directly used for classification.

* Artificial neural network
* The resolution rule
* Posterior probability
* Bayesian network
* Bayes classifier
* Fuzzy controller

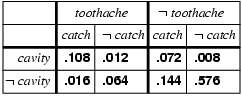
1. (8 marks) Let’s consider a backpropagation neural network.

* This network has **3** nodes in the hidden layer and **2** nodes in the output layer.
* Let ***outputH*** be the array for the output values from the hidden layer to the output layer.
* Let ***deltaH*** be the array for the delta values for the hidden layer.
* Let ***outputO*** be the array for the output values from the output layer.
* Let ***deltaO*** be the array for the delta values for the output layer.
* Let ***weightHO*** be the weight matrix between the hidden layer and the output layer. (2 dimensional array)
* Let the learning rate be 0.1.
* The step function (not sigmoid function) with threshold 0.4 is used as the activation function. (Note that the step function outputs 0 or 1.)
* The expected values from the output layer are 1 and 0.
* Hints:
  + For delta values for the output layer: 
  + For delta values for the hidden layer: 
  + New weights: 

1. (2 marks) Show how to compute ***outputO***[0].
2. (2 marks) Show how to compute ***deltaO***[1].
3. (2 marks) Show how to compute ***deltaH***[0].
4. (2 marks) Show how to compute ***weightHO***[0][1].
5. (2 marks) In artificial neural networks, how are supervised learning and unsupervised learning different?
6. (5 marks) Consider the following fuzzy rules.

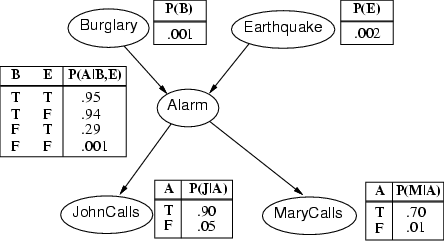
|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | *Theta* | | | | |
| *dTheta* |  | NM | NS | ZE | PS |
| NM |  |  | **PM** |  |
| NS |  |  | **PM** | **PS** |
| ZE | **PM** | **PS** | **PS** | **ZE** |
| PS |  | **ZE** | **NS** | **NS** |
| PM |  |  | **NM** |  |

1. (2 marks) Fuzzification: Let’s assume that PS is defined as a triangle shape membership, (5, 10, 15), over [0, 20]. Decide the PS membership value for 13.5.
2. (3 marks) Inference: Let’s assume the input for *Theta* is fuzzified to PS:0.8 and ZE:0.4. Let’s assume the input for *dTheta* is fuzzified to ZE:0.5 and PS:0.6. Find the output fuzzy sets with their membership values.
3. (5 marks) Fill in the blanks in each of the followings
   1. *P*(*A*) = *P*(*A* ∧ ¬*B*) + \_\_\_\_\_\_\_\_\_\_
   2. *P*(*A* ∧ *B*) = *P*(*A*) \* \_\_\_\_\_\_\_\_\_\_, where *A* and *B* are independent
   3. *P*(*A* ∨ *B*) = \_\_\_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_\_\_ - \_\_\_\_\_\_\_\_\_\_
   4. *P*(*A* | ¬*B*) = 1 - \_\_\_\_\_\_\_\_\_\_
   5. *P*(*A* ∧ *B* | *C*) = \_\_\_\_\_\_\_\_\_\_ \* \_\_\_\_\_\_\_\_\_\_, where *A* and *B* are conditionally independent given *C*.
4. (4 marks) Find the followings from the next ***joint probability distribution***.



* 1. *P*(*toothache*)
  2. *P*(*toothache* ∧ *catch*)
  3. (2 marks) *P*(*toothache* | (*cavity* ∧ ¬*catch*))

1. (5 marks) A Bayesian network is given as follows:



Compute the probability that Mary calls and there is Burglary. You should show how to compute the probability. The final answer should be an arithmetic expression of all numbers.

1. (3 marks) Let *C* be ‘Car won’t start’ and *B* be ‘Bad battery’. We know that when a battery is bad, the car won’t start. What is the probability of having a bad battery when a car won’t start, assuming the following probabilities? You should show not only how to compute the probability but also the probability (i.e., value) itself.

*P*(*C*) = 0.05; *P*(*B*) = 0.01; *P*(*C*|*B*) = 0.9

1. (5 marks) Here is an example of car theft. Attributes are Color, Type, Origin, and the subject, Stolen can be either Yes or No.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Example No. | Color | Type | Origin | Stolen? |
| 1 | Red | Sports | Domestic | Yes |
| 2 | Red | Sports | Domestic | No |
| 3 | Red | Sports | Domestic | Yes |
| 4 | Yellow | Sports | Domestic | No |
| 5 | Yellow | Sports | Imported | Yes |
| 6 | Yellow | SUV | Imported | No |
| 7 | Yellow | SUV | Imported | Yes |
| 8 | Yellow | SUV | Domestic | No |
| 9 | Red | SUV | Imported | No |
| 10 | Red | Sports | Imported | Yes |

You need to decide whether a Red Domestic SUV would be stolen.

1. (2 marks) Compute *P*(*Yes*) and *P*(*No*).
2. (3 marks) Do you think the car would be stolen? Justify your answer, using Bayes classifier.