**May 2019**

**Examination Paper Solutions**

***School of Science and Technology***

**MIDDLESEX UNIVERSITY**

**EXAMINATION PAPER**

**Academic Year 2018/2019 (May)**

**CSD3939**

###### Developing Artificial Intelligence

**Prof C. Huyck**

Time allowed: 3 Hours

Total number of questions: 4 Questions

Instructions to candidates: Answer all questions. Each question carries 25 marks.

Materials provided: Equipment permitted: None

 Total number of pages: 3

**EXAM PAPER CAN BE REMOVED FROM THE EXAM ROOM**

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| **No books, paper or electronic devices are permitted to be brought into the examination room other than those specified above.****Candidates are warned that credit cannot be given for work that is illegible** |

1. State Spaces

(a) A case based reasoning system has five input features. Four are integers between 0 and 99, and the fifth is an enumerated type of 8 colours. How many different possible cases are there? What is the size of the search space?

(9 marks)

Marking scheme:

2 for features are independent

3 on the order of a million.

2 for correct

1 for the size of the search space is the number of cases

**Sample answer:**

**Each of the first four features has 100 values, and they’re all independent so 100^4 or 100,000,000. The fifth has 8 so there are 800 thousand possible different cases. The size of the search space is 800,000,000.**

(b) Give an example similarity metric for this system.

(8 marks)

Marking scheme:

3 for a metric that includes all 5 features.

3 for a reasonable metric

2 for a sound metric. Note, you can do something else than Euclidean distance; city block distance works.

**Sample answer: A good metric is Euclidean distance for the first four features and then a simple metric for the colours. As Euclidean distance is on the order of 100 for the first four, the last needs to have similar values (assuming it is of equal importance). So, you could make a table where equal values are 0, and similar colours (e.g. red and orange) are 20, while distant colours (red, blue) are 50.**

(c) Describe in terms of state spaces what makes a good similarity metric on this case base.

(8 marks)

Marking scheme:

4 for correct answers

4 for closeness in similarity space.

**Sample answer: A good similarity metric will give the correct answers. A good way to test this is with the existing cases. The question doesn’t say what the case base system is for, or even what it’s outputs are, but let’s assume they’re binary. If a known answer is removed from the case base, and then queried as a novel case, it should give the correct answer. Indeed, you can test this with all of the cases, and see how well the similarity metric does. So, in terms of state space, the similarity metric needs to make cases that have the same result or output close in the similarity space.**

2. Knowledge Representation

a) When campaigning, Donald Trump said “I will build a great great wall on our southern border and I’ll have Mexico pay for that wall.". Write a logic formula for this statement. Include variables and how they link to the statement.

(6 marks)

Marking scheme:

2 for an equation

2 for variables

2 for correct

**Sample answer: W is I will build a great great wall on our southern border. P is I’ll have Mexico pay for that wall. The formula is merely**

**W&P**

(b) Draw a truth table for the formula from part a.

(5 marks)

Marking scheme:

2 for a table with filled in values

2 for a correct table for the equation

1 for a correct table equation combination

**Sample answer:**

 **W not(W)**

**P T F**

**not(P) F F**

**where T is true and F is false.**

(c) At present, is the statement true? You can state your understanding of the current situation. (That is you don’t have to know if there is a wall built, just say what you think.) Draw an arrow to the cell in the truth table (from part b) that represents your understanding of the statement.

(6 marks)

Marking scheme:

2 for correct value of statement (based on the student’s assumptions)

2 for stating assumptions (1 if they just give the answer correctly from the world).

2 for correct location in table.

**Sample answer: Donald Trump has not built a wall (not(W)), and as it hasn’t been built, the Mexicans haven’t paid for it (not(P)). This is the bottom right cell of the table. The statement is False.**

 (d) Inheritance conflicts are a problem for semantic nets (and class based languages). Describe an example of an inheritance conflict. (You may use a picture.) How might a knowledge representation system resolve inheritance conflicts?

(8 marks)

Marking scheme:

2 for use of inheritance

3 for a correct example

3 for reasonable resolution

**Sample answer: The standard inheritance conflict is the Nixon Diamond. Nixon was a Quaker and a Republican. Quaker’s are pacifists (doves) and Republicans are happy to go to war (hawks). Both Quakers and Republicans are people. The conflict is whether Nixon is a hawk or a dove. A good way for a system to resolve inheritance conflicts is to warn the developer of their existence, and have the developer explicitly resolve the conflict; in this case, you could explicitly note that Nixon was a hawk.**

3. Machine Learning

(a) A self organising map (SOM) uses a distance measurement to find the distance between two data points. Find the Euclidean distance between the 3D points (5,4,7) and (-5,10,3).

(4 marks)

Marking scheme:

2 for squares and differences

2 for correct answer

**Sample answer:**

**Sqrt((5—5)^2+(4-10)^2+(7-3)^2) =**

**Sqrt(10^2+-6^2+4^2) =**

**Sqrt(100+36+16) =**

**Sqrt(152) ~ 12.3 (sqrt(152) is sufficient)**

(b) Draw a three layer multi-layer perceptron (MLP) network with three inputs, one output and 2 nodes in the hidden layer. Set each weight to be unique.

(8 marks)

Marking scheme:

2 for 3 layers

2 for correct topology

2 for weights

2 for unique weights

**Sample answer:**



(c) The nodes in the hidden layer uses a linear transfer function with a slope of 2. The output node is a step function with a threshold of 3. Show the outputs for the inputs (1,2,3) and (-2,5,2).

(6 marks)

Marking scheme:

2 for level 2 input

1 for linear transfer

1 for level 3

2 for correct

**Sample answer:**

**123 -> level 2 (-3-10+21) = 8 –transfer> = 16**

 **(4+12+24) = 40 –transfer> = 80**

**Level 3 16+160 = 170 > 3 so the output is 1**

**-2,5,2 level 2 (6-25+14) = -5 –transfer> = -10**

 **(8+30+16) = 54 –transfer> = 108**

**Level 3 108-10 > 3 so the output is also 1**

(d) Describe the common learning algorithm that is used for MLPs.

(7 marks)

Marking scheme:

3 for back prop or gradient descent

2 for errors calculated

2 for weight change to reduce the error

**Sample answer: The common algorithm is backpropagation of error. This is a form of gradient descent. What happens is the inputs are passed through, and the initial outputs are calculated. The outputs are known, thus a supervised algorithm, and the error is calculated. The weights are then adjusted so that the error will be reduced.**

4. Applications

a) What is the standard format of input to vision algorithms, and what are two common first steps for vision processing algorithms.

(9 marks)

Marking scheme:

3 for pixels

3 for line detection

3 for edge detection (1 for an alternative like segmentation)

**Sample answer: The standard format is pixels. This may be black and white, gray scale or colour scale. The common two first steps are line recognition and edge detection.**

 (b) The four queens problem is a simple constraint satisfaction problem deriving from chess. There is a 4x4 board. 4 queens need to be placed on the board so they cannot take each other. A queen can take another queen if they are in the same row or column, or if they are on the same diagonal. Show one solution.

(8 marks)

Marking scheme:

3 for four queens

5 for correct

**Sample answer:**

**Row 2 Column 1**

**Row 4 Column 2**

**Row 1 Column 3**

**Row 3 Column 4**

(c) Write pseudo code for a chatbot that responds differently to four different commands, and says I don’t understand for anything else.

(8 marks)

Marking scheme:

2 for loop

2 for if then cascade

2 for else

2 for correct

**Sample answer:**

**While (not done) {**

**If input == “hello” then ouput = “good morning”**

**Else if input == “what is your name” then output = “my name is chatbot bob”**

**Else if input == “what time is it” then output = “I don’t know the time”**

**Else if input == “stop” then {done = true; output = “bye”}**

**Else output = “sorry, I don’t understand “ + input**

**Print output**

**}**