

**May 2018**

**Examination Paper Solutions**

***School of Science and Technology***

**MIDDLESEX UNIVERSITY**

**EXAMINATION PAPER**

**Academic Year 2017/2018 (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) Go is an adversarial game where players alternate putting down a stone. You can play on a 9x9 board. How big is the search space?

(8 marks)

Marking scheme:

2 for something involving 81.

3 for an exponent or factorial

3 for correct

**Sample answer:**

**The size is 81!. Order matters. The first person can put his stone down on any of the 81 spots. The second can put his on any of the remaining 80 and so forth.**

(b) If there was a good evaluation function for evaluating boards in the middle of a game, what would be a good algorithm for a machine to use to play go? Name the algorithm if you can, but explain it.

(7 marks)

Marking scheme:

2 for minimax (name or description)

2 for plys (levels to look ahead)

3 for alternating minimizing and maximizing levels

**Sample answer:**

**Minimax is a good algorithm. The algorithm takes the current board, and expands it to all of the next person’s moves, then the responding moves, down to as large a depth as possible. The evaluation algorithm is used on the leaves, and the values are passed up with one player being the maximising player, and the other the minimizing player. In minimax, the algorithm assumes the minimizing player picks the option that leads to the smallest valued board (by the evaluation function). It assumes, the maximising player will pick the maximum value option. The tree will thus alternate between maximising and minimizing levels.**

(c) What additional standard techniques could be used to improve the program?

(5 marks)

Marking scheme:

2 iterative deepening.

3 for alpha beta pruning

Other good answers (like cached games) will be awarded points.

**Sample answer:**

**Two commonly used techniques are iterative deepening, and alpha beta pruning. Iterative deepening moves forward in plys and retains the relevant portion of the old tree. It continues to search while the opponent is making his move. So, if the system has a tree of depth 10, and then makes a move, his tree is now of depth 9. He can continue his search from there, and may already have expanded it to a depth of 10 by the time the opponent makes his move. Alpha beta pruning is a technique for pruning search branches. If it is an optimising level and the best branch to date has returned a value of X, the next level is a minimizing level; if future branches have values < X, they do not need to be explored any further, as the result will be X and this branch will not be pursued; it can be pruned. The reverse is true for minimizing levels.**

(d) Expert go players play on a 19x19 board. Until recently, it was assumed that go would be difficult for machines to play well. What was this assumption based on?

(5 marks)

Marking scheme:

5 The search space is huge.

Some points for other reasonable answers like the theory is not well defined, but probably many fewer points.

**Sample answer:**

**The size of this space is (19x19)!; that’s 361!, which is enormous. Even in the middle of a game, looking ahead 10 moves would be impossible. What has enabled AlphaGo to succeed is an excellent, quick, evaluation function, that has been developed using deep nets derived from a vast number of games.**

2. Knowledge Representation

(a) Write a semantic net for the topics in CSD3939. This should include at least 12 nodes, and 5 types of arcs, including the most important types of arcs. In this case, the topics are also important.

(10 marks)

Marking scheme:

2 points for IsA

2 points for instance

2 points for other reasonable arcs (mine are not exhaustive)

2 points for 12 nodes

2 points for good topics

**Sample answer:**

IsA

IsA

IsA

IsA

Instance

Uses

Instance

Instance

Instance

Instance

Similar

Uses

Instance

(b) Write rules for a three step traffic light (green->yellow->red->green)

(8 marks)

Marking scheme:

2 points for rules

2 points for alternating facts

2 points for some timing mechanism (mine is just one)

2 points for correct

**Sample answer:**

**If (timer On) and (light green) -> (light yellow) (timer Off)**

**If (timer On) and (light yellow) -> (light red) (timer Off)**

**If (timer On) and (light red) -> (light green) (timer Off)**

(c) A conversational agent is being designed to answer questions about mobile phones. Why would it be or would it not be wise to develop an ontology to support the agent?

(7 marks)

Marking scheme:

2 points for depends on size or sophistication of the agent.

2 points for ontologies supporting moderate to large domains

2 points for supporting understanding

1 point for maintenance

Other points are available up to 7

**Sample answer:**

**If the agent is going to have any degree of sophistication, it probably should be knowledge driven. In this case, an ontology would be wise. (If it’s a very simple system, then the ontology is probably unnecessary.) The ontology would support a more solid understanding of user input, support the planning (or reasoning) needed to derive answers, and support producing the text to answer. An ontology would also support the ongoing development and maintenance of the system.**

3. Machine Learning

(a) Show a multi-layer perceptron that categorises inputs into two categories that are not linearly separable. There are five floating point input values. Describe the transfer function on the output layer.

(9 marks)

Marking scheme:

2 points for five inputs

3 points for 3 or 4 feed-forward layers

2 points for one on the output layer (though more will work if the transfer function is different)

2 for a step function for the transfer function. (1 for winner take all output or something workable)

**Sample answer:**

**The transfer function should be a step function. If it’s below a value the answer is category one, equal or above the answer is the other category. You could do it with winner take all output, but that would be odd.**

(b) If a line can separate two different sets of 2D data items, there are usually an infinite number of lines that can. The Support Vector Machine framework suggests that a particular line is the best. Describe that line.

(7 marks)

Marking scheme:

2 point for support vectors

3 points for the maximum margin of separation; I don’t need the term but the idea.

2 point for a solid description.

**Sample answer:**

**The SVM terminology suggests that the line that provides the maximum margin of separation is the best line. This is based on the support vectors of the two classes. Each category has a support vector which passes through the point nearest to the other category, and another close point. The vector needs to separate the categories. The maximum margin of separation is a line that splits angle between these support vectors; if they’re parallel, then it’s the line that’s equidistant.**

(c) AlphaGo, a computer program, recently beat the world go champion, and is thus the best player in the world. AlphaGo used deep nets to learn about go. What do you think it learned? What did it learn from?

(8 marks)

Marking scheme:

3 points it learned the evaluation function

3 point it learned from games

3 points it learned from games it generated

**Sample answer:**

**It learned the evaluation function for a board. They still took advantage of standard game playing techniques, like minimax. They used a deep net with a lot of free parameters to store the evaluation function. They got a lot of data from human players, but then increased the amount of data by having the system play itself. One of the benefits of this type of system is that after the net is set and learning turned off, the evaluation function can be calculated quite quickly.**

4. Applications

(a) There are an increasing number of flying drones. These are often controlled remotely by a person, but the person may lose contact, so the drone must fly on its own. What kind of sensors can the drone use to return to where it was launched?

(9 marks)

Marking scheme:

3 points GPS

3 points vision

3 points other reasonable sensors

**Sample answer:**

**The drone is going to need to fly back to where it was launched. A simple sensor that it can use is GPS. This should lead it back to the right area; with any luck, radio contact can be re-established. It will similarly benefit from a sensor that tells its elevation. If the terrain is level, this should work most of the times, but if it is mountainous or there are large buildings, the system will need to avoid these things. A camera with vision processing should help here. It might also be able to take advantage of radar; lidar is probably too big.**

(b) The 3 queens problem is a constraint satisfaction problem with no solutions. Place three queens on a 3x3 board so that no queen can take another. (One queen can take another if it is on the same horizontal, vertical or diagonal line as another.) Show that there is no solution.

(8 marks)

Marking scheme:

2 points for placing queens

2 points some sort of search (including a tree)

4 points for correct answer (note there are other ways of doing it than mine)

**Sample answer:**

**There can only be one queen per column, so we will do a search starting from the first column. First place a Queen in the first row of the first column. The only place a queen could go in the second column is the third (last) row. No queen could go in the third column as the first row is prevented by the first queen and the last two rows by the second queen. By symmetry, the starting in the bottom row of column 1 doesn’t work; 1,3; 2,1; no 3,x works. If you start with the queen in the second row of the first column, you can’t place a queen in the second column. Since it won’t work with a queen in any location in the first column, it won’t work.**

(c) When is a rule based system good, and when is a case based reasoning system good?

(8 marks)

Marking scheme:

2 points for experts are available

3 points theory for RBSs

3 points no theory for CBRs

**Sample answer:**

**RBSs and CBRs are the standard expert system types, dating from the 70s. ESs are good when there are experts that can be used to generate information for the systems. The theory is that RBSs are good when the domain has a strong theory. CBRs are good when there is no theory, but there are a lot of examples.**