FIT5047: Fundamentals of AI – Assignment 1

Due date: Sunday, 20 Sep 2020 (23:55PM Melbourne time).

Evaluation: 100 marks = 20%.

Penalty: 10 marks for every hour of late submission.

Submission: You have to submit your report (in PDF format) via Moodle.

Uploading your report in Moodle: exact instructions sent in week 5 via Moodle.

Report: You should submit a file called "FIT5047_StudentId_2020S2_Ass1.pdf" to the relevant place on Moodle. Please, note that StudentID refers to your Student ID number. Then, as an example, if your StudentID is 12345678, then you should submit the PDF file FIT5047_12345678_2020S2_Ass1.pdf

Note 1: Please follow the University policies and regulations regarding Academic Integrity. Details can be found online from the following hyperlink: click!.

Note 2: You will be required to present your work during your tutorial in week 8 individually. Please be prepared since it is a compulsory component of this assessment. The exact time of your interview will be determined by your lecturer and tutor at a later stage.

Q1: Agents - PEAS

{4+3+3=10 marks}

Consider the task of assembling a bookcase from its components.

(a) Use PEAS to specify the task environment.

- Performance measure:
- Environment:
- Actuators:
- Sensors:

(b) Specify three properties of the environment. Explain these properties in the context of the task. *(No marks will be given for an absent or incorrect explanation.)*

(c) Determine which of the following agent types you would employ: Simple reflex, Model based, Goal based or Utility based. Explain why in the context of the task, and list your assumptions. *(No marks will be given for an absent or incorrect explanation.)*

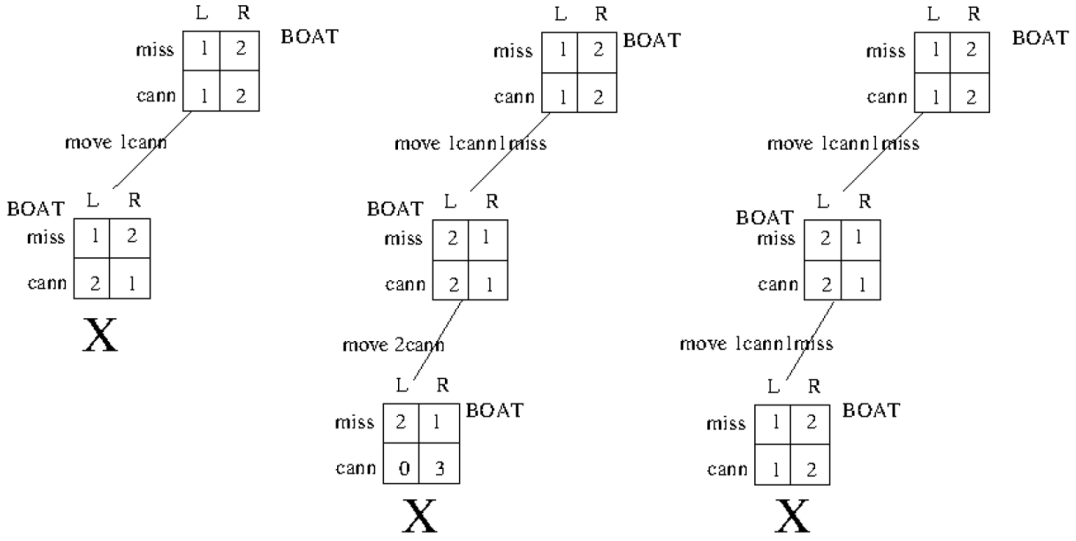
Q2: Search - Backtrack

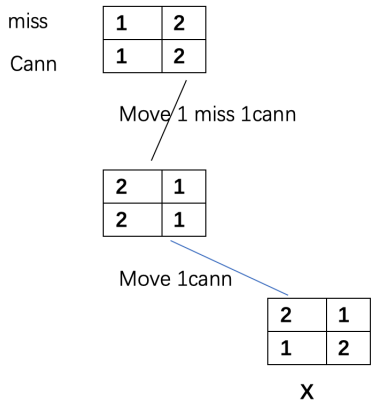
{6 marks}

Consider the missionaries and cannibals problem: Three missionaries and three cannibals come to a river. There is a boat on their side of the river that can be used either by one or two persons. How should they use this boat to cross the river in such a way that cannibals never outnumber missionaries on either side of the river?

The diagram below shows a sequence of partial solutions produced by the Backtrack algorithm, where each state marked with X is a state in which the algorithm has backtracked. In these solutions, cannibals are labeled "cann", missionaries are labeled "miss", the banks are labeled L (left) and R (right), and the position of the boat is indicated with the label BOAT. The objective is to reach side R.

Label each state marked with X with the reason for backtracking, using one or more of the following labels: DEADEND, BOUND-REACHED, PREVIOUS-STATE, NO-MORE-APPLICABLE-ACTIONS.

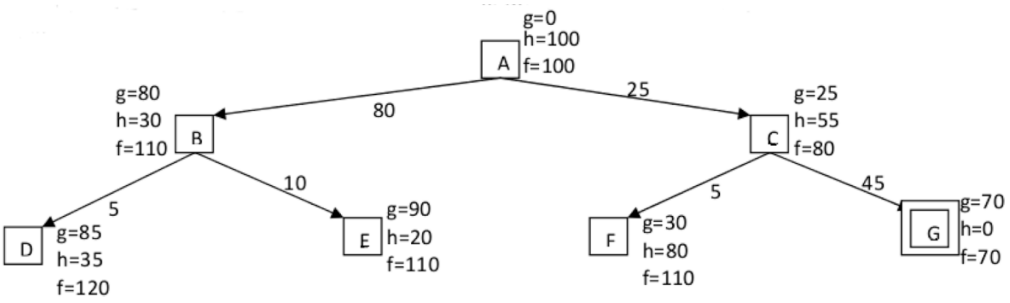




Q3: Search - Tentative control strategies

{3+7=10 marks}

Use the following (fully expanded) search tree to indicate the order in which nodes are expanded for different types of search algorithms. Assume that `A` is the start node and `G` (double boxed) the only goal node. How many nodes are there in the resultant search tree?



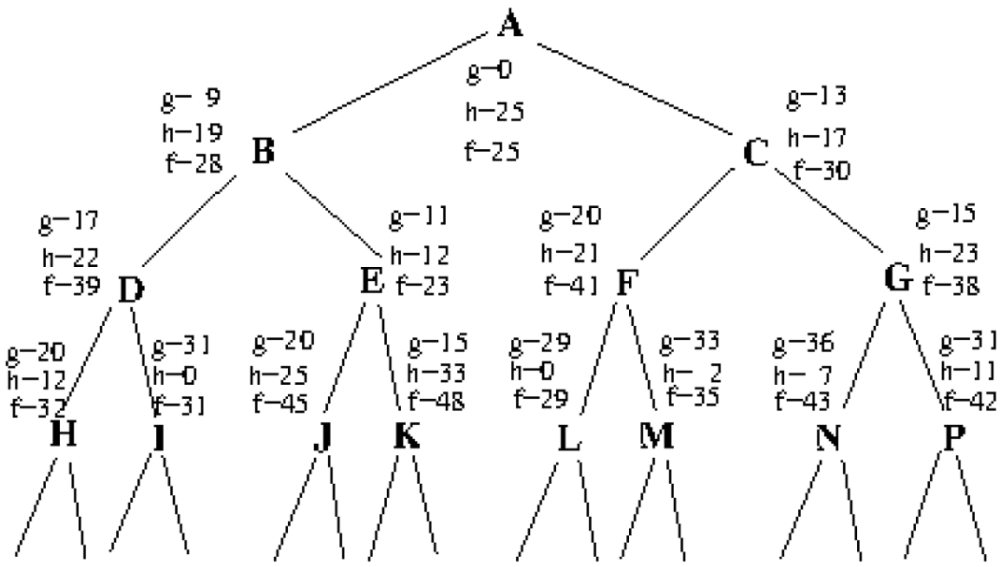
(a) Depth-first search.
List the nodes according to their order of expansion. List the nodes in the final search tree (without the nodes deleted by the algorithm).

(b) Best-first Greedy search. List the nodes according to their order of expansion. For each expansion, list OPEN (with the nodes in the correct order) and CLOSED. List the nodes in the final search tree.

Q4: Search - A/A*

{13+2=15 marks}

The following (fully expanded) search tree indicates the cost of reaching each node (g), the estimated cost of reaching a goal node from each node (h), and their sum (f). For example, the cost of reaching node `C` is 13, and the estimated cost of reaching the goal node from node `C` is 17. Node `A` is the start node, and nodes with 0 cost estimates (h) are goal nodes.



(a) Draw the search tree that would be generated by Algorithm A, using Roman numerals to indicate the order in which nodes are expanded. Upon completion, mark the goal node. After each expansion, provide the following information:

- the node that was expanded, and
- the nodes in the horizon (OPEN) in order of merit, that is, in the order in which they will be expanded, together with their f value. If several nodes have the same merit, order them from left to right.

(b) Did algorithm A find the optimal answer, and is the h function admissible? Why or why not? Illustrate your answer with an example from the provided search tree. *(No marks will be given for an absent or incorrect explanation.)*

Q5: Search - Irrevocable control strategies

{4+1.5+1.5=7 marks}

The following exercises are about Simulated Annealing and Genetic Algorithms.

(a) In Simulated Annealing, if T2 > T1, is the probability of adopting a new worse state higher in T2 or in T1? Why? *(No marks will be given for absent or incorrect explanations.)*

(b) Does the Simulated Annealing algorithm given in class always terminate? Why or why not? *(No marks will be given for absent or incorrect explanations.)*

(c) A Genetic Algorithm is used to evolve a binary string of length n to one where the sum (from left to right) of the last four genes is equal to 1. The initial population is a randomly generated set of binary strings of length n, such as those shown here:

00110001

01011101

11101111

Give a suitable fitness function for this problem.

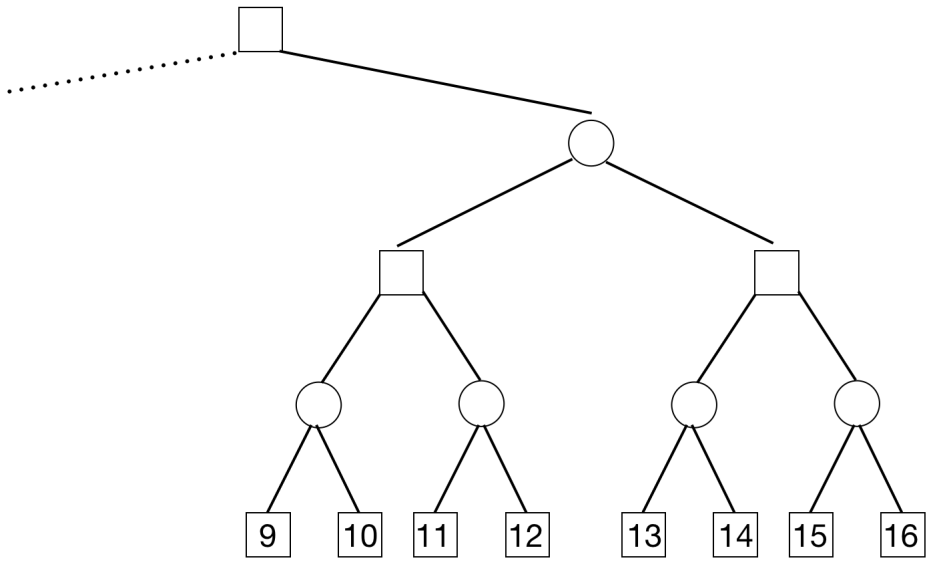
Q6: Search - Minimax

{8+1=9 marks}

Consider a game with branching factor 2. It is MAX's turn to play and he is able to evaluate his position to depth 4. The following is a list of values for the right-hand side of the game tree, should they ever need to be evaluated. The left-hand side (comprising 8 nodes) has already been evaluated and the α value of the root MAX node is 5.

node #	9	10	11	12	13	14	15	16
evaluation function	2	3	7	6	11	14	2	5

(a) In the game tree, MAX is represented by a square and MIN by a circle. Draw the right-hand side of the game tree by conducting an α–β search of the game tree, starting at the leftmost node of the right-hand side (node #9), to determine which move MAX should make. When completing the game tree, make sure that only the visited nodes appear in your diagram, that is, you should omit the nodes that are cut off. Indicate clearly the α or β value of each node (label it with α or β as appropriate), the updates performed on the backed up values, and the α and β cut-offs you have performed.



(b) What is the best move for MAX and what is its backed up value?

Q7: Knowledge Representation - Propositional Logic

{6+6=12 marks}

The following questions are about Knowledge Representation (Propositional Logic).

(a) Is the following sentences valid, satisfiable or unsatisfiable? Explain why. *(No marks will be given for absent or incorrect explanations.)*

$(B \wedge C) \vee \neg C$

$(A \rightarrow C) \vee (C \rightarrow D)$

(b) Express the following sentences in Horn form:

A child (C) who studies (S) and behaves (B) receives presents (P).

An employee (E) who works hard (W) and follows the rules (F) receives a bonus (B).

Q8: Knowledge Representation - Forward reasoning

{8+1=9 marks}

Apply forward reasoning to the following Horn clauses to prove Q. After each rule application, show the AGENDA, COUNT, and INFERRED values in the provided table, and show the search graph resulting from the application of the rules.

R1: $L \rightarrow Q$

R2: $(A \wedge B) \rightarrow L$

R3: $P \rightarrow B$

R4: $L \rightarrow A$

A

B

AGENDA	COUNT				INFERRED
	R1	R2	R3	R4	

Q9: Knowledge Representation - First-order Logic

{6+4+12=22 marks}

Consider the following statements:

1. All children have a favourite toy.
2. Whoever likes dolls for soft toys is a child.
3. Fuzzy is a soft toy: `SOFT-TOY(Fuzzy)`.
4. Ellen likes Fuzzy: `LIKES(Ellen,Fuzzy)`.

(a) Using only the following predicates `CHILD(*)`, `HAS-FAV-TOY(*,*)`, `LIKES(*,*)`, `DOLL(*)` and `SOFT-TOY(*)`, represent the two statements as predicate calculus well formed formulas. *(Notes: The asterisks indicate the number of arguments in each predicate; keep your representation consistent with the predicates in statements 3 and 4 above.)*

(b) Convert these statements into clauses.

(c) Use resolution refutation to prove that Ellen has a favourite toy. State the goal, and indicate clearly the number of the clause you are using, and any substitutions you make.

Goal 5: `HAS-FAV-TOY(Ellen)`.

Negated goal: ¬`HAS-FAV-TOY(Ellen)`.