



ARTIFICIAL INTELLIGENCE – CS 401-

Mid-Term Examination II

FALL 2010 – 13th November 2010

Instructions: This exam consists of four sections and four questions. The total marks are 67.

Section 1: Multiple Choice Questions (MCQs) [18 points]

Instructions: This section contains 18 MCQs. Mark the correct answer with a tick on the question paper. Remember that there might be more than one correct answer for a given question. Mention any assumptions you make.

- 1) Variation in a Genetic Algorithm (GA) can be obtained through:
 - a) Designing an efficient representation of the chromosome
 - b) Changing the value of one or more parts of the new chromosome
 - c) Inheriting one or more parts of the new chromosome from two parent chromosomes
 - d) Inheriting one or more parts of the new chromosome from just one parent chromosome

Answer: bc / bcd

- 2) Why are GA's able to reach better and better solutions?
 - a) Because cross-over is typically applied more than mutation
 - b) Because only the best individuals are selected for the next population
 - c) Because cross-over and mutation operators are applied to generate the next population
 - d) It's not necessary that GA's *always* end up reaching better and better solutions

Answer: bd / bcd

3) GA's:

- a) Are the most efficient technique for solving any optimization task
- b) Might not be very efficient, but they are quite effective for a majority of discrete optimization tasks
- c) Are effective solutions for programming board-game search agents
- d) Are effective solutions for evolving useful civil structures/architectures

Answer: bd

4) In a Constraint Satisfaction Problem (CSP):

- a) The state is defined by a set of variables, in which two or more variables can have the same domain
- b) The state is defined by a set of variables, where each variable should have a different domain
- c) A state is like a "black box"
- d) All of the above

Answer: a

5) A CSP:

- a) Is nothing but a simple example of a formal representation language
- b) Supports more powerful techniques as compared to standard problem-solving algorithms
- c) Should have a *complete* solution, i.e., none of the constraints should be violated
- d) Should have a *consistent* solution, i.e., all its variables should be assigned values

Answer: ab

6) Why do we typically convert a higher-order CSP into a binary CSP?

- a) Because then, it becomes easier to draw a constraint graph, and hence solve the CSP
- b) This statement is wrong; we don't always convert
- c) Even if we do not draw the constraint graph, a binary CSP is still easier to solve
- d) It facilitates getting to the solution, at the expense of minor book-keeping tasks

Answer: acd

7) In a CSP search tree:

- a) We need to consider value assignments to only *one* variable at each depth
- b) We apply depth-first search only
- c) We apply both depth-first and breadth-first search

d) We apply backtracking

Answer: abd

8) Which of the following is true concerning the CSP heuristics?

- a) Degree heuristic is useful in selecting the *first* variable for value assignment
- b) Minimum Remaining Value (MRV) selects the next variable to assign values, while the Least Constraining Value (LCV) selects both the next variable and also its value
- c) At any step, MRV next selects the variable which has the maximum possible of assignments remaining from its domain
- d) Forward Checking (FC) is very closely linked to MRV

Answer: ad

9) Basically, what makes a Multi-Agent Environment (MAE) different from a single-agent one?

- a) An MAE consists of a *set* of agents, and not just one single-agent
- b) The difference mainly occurs when agents have to compete against each other
- c) There is not much difference; if the agents are competing against each other, they are nothing but independent single agents
- d) In a MAE, each agent has to maximize its own welfare, while considering the behavior of the other agents

Answer: ad

10) Which of the following is true concerning the concept of a "game" in AI:

- a) Typically refers to a stochastic environment
- b) Typically refers to a fully-observable environment
- c) Consists of a MAE, and the actions of each agent should alternate
- d) In a two-player game, the utility values for each agent (at the end of the game) should be equal and opposite

Answer: bcd

11) Bridge and poker are examples of games:

- a) With perfect information, i.e., we can easily see what the opponent is doing
- b) With imperfect information, i.e., we don't know what cards the opponent is currently holding
- c) That are deterministic
- d) That don't involve any element of chance

Answer: b

12) Which of the following are true about the MINIMAX operation, in the context of a two-player game?

- a) One player always tries to maximize, while the other always tries to minimize
- b) One player selects actions that leads to a state of maximum utility for its opponent, while the opponent selects actions that leads to a state of minimum utility for the player
- c) Each player opposes what is best for the other one
- d) One of the players will always select the action with the highest MINIMAX value, while the other will always select the action with the lowest MINIMAX value

Answer: abcd

13) What's true about alpha-beta pruning?

- a) It doesn't affect the final result of the game
- b) Good move ordering improves the effectiveness of pruning
- c) With perfect ordering, the depth of search is doubled
- d) All of the above

Answer: d

14) What's true about evaluation functions?

- a) They cut-off the search at non-terminal states
- b) They require a cut-off point
- c) They make alpha-beta pruning more efficient
- d) They are almost always used in state-of-the-art game agents

Answer: abcd

15) A knowledge-based agent:

- a) Can be programmed to play a board game
- b) Can be programmed to implement a medical expert system
- c) Needs to remember what it infers
- d) Needs to be given an initial body of knowledge

Answer: abcd / bcd

16) Entailment:

- a) Requires the knowledge base to be initially true
- b) Is equivalent to inference
- c) Is equivalent to a semantic relationship between different sentences
- d) May not be equivalent to reasoning in the real-world

Answer: abc

17) Which of the following are true?

- a) A sound inference procedure is one that only entails knowledge which makes sense in the real world
- b) A complete inference procedure is one that is able to produce only sound inferences
- c) Suppose that P implies Q. Then: if P is false, then Q should be definitely false
- d) All of the above

Answer: a

18) What are possible inferences that could be acquired from a medical expert system:

- a) The changes in the dosage being previously given to a patient
- b) A new dosage to be given to a patient
- c) The optimum number of visits that a patient should make to the doctor
- d) The symptoms of a patient

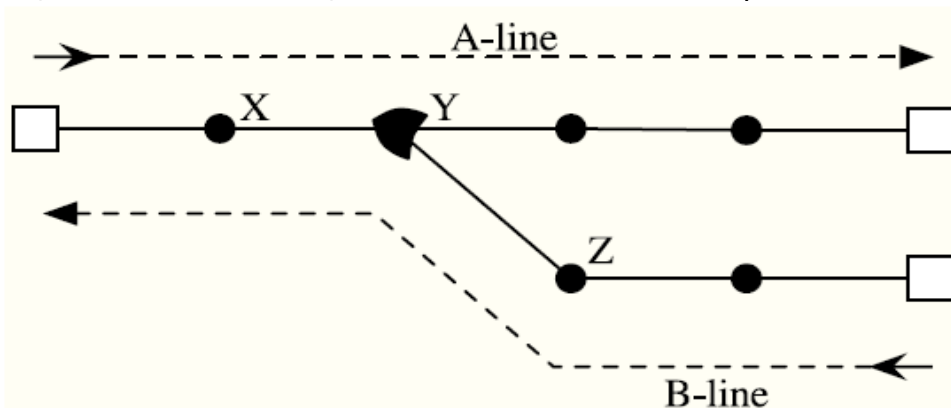
Answer: ab/abd

Section 2: Constraint Satisfaction Problem [22 points]

Q2: Two trains, the A-line and the B-line, use the simple rail network shown below. We must schedule a single daily departure for each train. Each departure will be on an hour, between 1pm and 7pm, inclusive. The trains run at identical, constant speeds, and each segment takes a train one hour to cover. We can model this problem as a CSP in which the variables represent the departure times of the trains from their source stations:

Variables: A, B Domains: {1, 2, 3, 4, 5, 6, 7}

For example, if $A = 1$ and $B = 1$, then both trains leave at 1pm.



The complication is that the trains cannot pass each other in the region of the track that they share, and will collide if improperly scheduled. The only points in the

shared region where trains can pass or touch without a collision are the terminal stations (squares) and the intersection Y.

Example 1: The A-line and B-line both depart at 4pm. At 6pm, the A-line will have reached Y, clearing the shared section of the track. The B train will have only reached Z. No collision will occur.

Example 2: The A-line leaves at 4pm and the B-line at 2pm. At 5pm, the A-line will be at node X and the B-line at the intersection Y. They will then collide around 5:30pm.

Example 3: The A-line leaves at 4pm and the B-line at 3pm. At 5pm, the A train will be at node X and the B train at node Z. At 6pm they will pass each other safely at the intersection Y with no collision.

- a) If the B-line leaves at 1pm, list the times that the A-line can safely leave without causing a collision [4 points].

Answer: A-line can leave safely at 1pm, 2pm, 6pm and 7 pm (a calculation had to be made for each possible value in the domain, and for only these 4, there was no collision)

- b) Implicitly state the binary constraint between the variables A and B for this CSP. Your statement should be precise, involving variables and inequalities, not a vague assertion that the trains should not collide [7 points].

Answer: I had solved this previously but I lost that sheet. Anyways, I think I calculated the possible values of B for all possible values of A (1 to 7). You can also do vice versa. From that, I was able to come up with 3 inequalities: $A=B$, $A < B+1$, $A > B+5$ (its possible that the $<$ and $>$ were reversed, but anyways, you should try this on your own and find out.)

- c) Imagine the A-line must leave between 4pm and 5pm, inclusive, and the B-line must leave between 1pm and 7pm, inclusive. State the variables' domains after these unary constraints have been imposed [4 points].

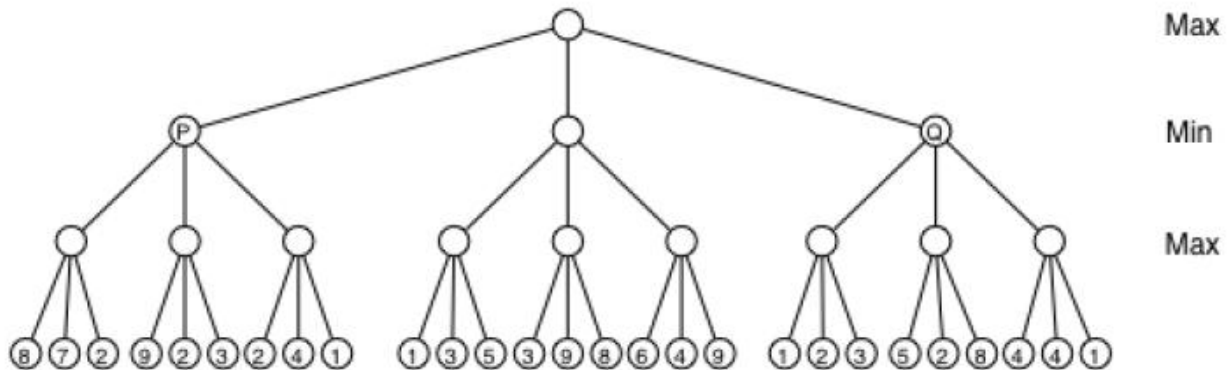
Answer: Domain of A: {4,5}, Domain of B: {1,2,3,4,5,6,7}. In this part, you only had to write the possible domain values, and not apply any algorithm

- d) Apply arc-consistency to the domains that you have specified above, and put an X through any value that is hence removed. Show all working [7 points].

Answer: When you apply AC, then the only possible values of B which are inconsistent with the domain {4,5} of A are $B=1$ and $B=2$. So, these two values should have been crossed from the answer in part(c).

Section 3: Alpha-Beta Pruning [17 points]

Q3: The figure below is the game tree of a two-player game; the first player is the maximizer and the second player is the minimizer. Use the tree to answer the following questions:



- a) What is the final value of this game? [3 points]

Answer: 5 (this means the value at the root, since evaluation always proceeds from the leaves. 5 is obtained from a simple application of the minimax algorithm)

- b) Is the final value of beta at the root node (after all the children have been visited) $+\text{INF}$? Why, or why not? [3 points]

Answer: Yes. When we start with the alpha-beta algorithm, we start off at the root, and we set $\alpha = -\text{INF}$ and $\beta = +\text{INF}$. As the root node is a maximizing node, therefore the value of beta will never change at this node. Specifically, the value of beta at P will simply become the value of alpha at the root node, but beta will not change.

- c) What is the final value of beta at the node labeled P (after all of P's children have been visited)? [3 points]

Answer: This value is 4. Let us name the 3 children nodes of P as A B and C. After evaluating A, the value of beta at P is 8. After evaluating B, the value of beta at P is still 8, and after evaluating C, the value of beta at P becomes 4 (because P is a minimizing node).

- d) Will any nodes be pruned? If yes, which one(s)? If none, why not? [5 points]

Answer: The information given here was that the value of alpha at Q is 5 and the value of beta is $+\text{INF}$. These values are passed from the root to Q, after the other two children of the root have been evaluated. We initially propagate these values to the first child of Q. Here, the value of alpha becomes 3, which makes the beta value at Q also 3. However, this is an anomaly because alpha is a lower bound,

and beta is an upper bound. So, the value of Q cannot be greater than 5 and less than 3 at the same time. So, Q will immediately return a value to its parent (the root), and the other two children of Q won't be explored. Hence, these two children will be pruned.

e) What value will Q return to its parent? [3 points]

Answer: Since beta at Q is less than alpha, Q will return its alpha value to the root, i.e., 5, which makes 5 the final value of the game.

[NB: Many students said that 3 will be returned. That's wrong because 3 creates an anomaly which simply can't be true.]

Section 4: Propositional Logic [10 points]

Q4: Ahmed, Babar, Chaudhary and Danish are making plans for spring break. They go to the travel agency, but there are only 2 tickets left. Ahmed will only go if Babar goes too. Danish will only go if Chaudhary goes too. Babar has found out that he has to work on the AI project, so he cannot go.

a) Using 4 literals, write the propositional logic formulas corresponding to this text [4 points]

Answer: The statement that there are exactly two tickets gets translated as follows:

**(A AND B AND NOT_C AND NOT_D) OR
(A AND NOT_B AND C AND NOT_D) OR
(A AND NOT_B AND NOT_C AND D) OR
(NOT_A AND B AND C AND NOT_D) OR
(NOT_A AND B AND NOT_C AND D) OR
(NOT_A AND NOT_B AND C AND D) (Eq. 0)**

Also: A -> B, which is NOT_A OR B (Eq. 1)

Also: D -> C, which is NOT_D OR C (Eq. 2)

Also: NOT_B (Eq. 3)

b) Find, through a formal proof, who will go on vacation [6 points].

Answer: By resolution between (1) and (3), we have NOT_A, so we know that NOT_A AND NOT_B. By forward search from (0), we will obtain C AND D, i.e., Chaudhary and Danish are going on vacations.

Best of Luck