CPSC 625-600 Midterm Exam (10/13/2005, Thu)[1]

Last name: _______________, First name: _______________

Time: **11:15am–12:25am (75 minutes)**, Total Points: **100**

Subject	Score
AI General	/5
Search	/35
Game Playing	/20
Logic and Theorem Proving	/40
Total	/100

- You may use the back of the sheet, but please **prominently mark** on the front in such a case.
- Be as **succinct** as possible.
- Read the questions carefully to see what kind of answer is expected (*explain blah* **in terms of ...** *blah*).
- Solve all problems.
- Total of 8 pages, including this cover and the Appendix at the end. **Before starting, count the pages and see if you have all 8.**
- This is a closed-book, closed-note exam.
- You may rip off the last page (Appendix) to view it while solving the logic problems.

[1] Instructor: Yoonsuck Choe.

1 AI, in General

Question 1 (5 pts): What do you think is the major conceptual roadblock in AI? (This is an open question.) **No more than 5 lines please.**

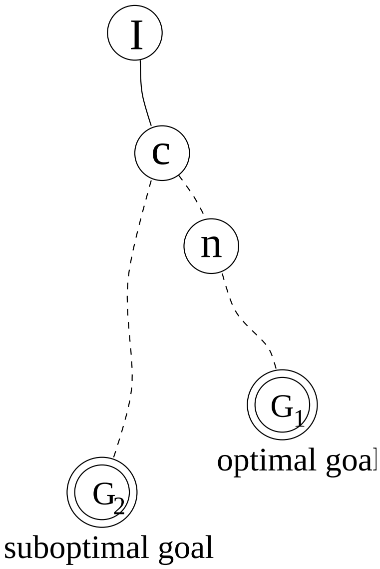
2 Search

Question 2 (5 pts): Explain how Iterative Deepening Search combines the merits of both Breadth-First Search and Depth-First Search. Explain in terms of the evaluation criteria.

Question 3 (10 pts): In Simulated Annealing, (1) explain when a move (or operation) is accepted, and (2) explain how the probability of accepting changes as the temperature parameter T and the change in energy ΔE varies. (3) Explain why Simulated Annealing helps overcome problems in hill-climbing or gradient-based methods.

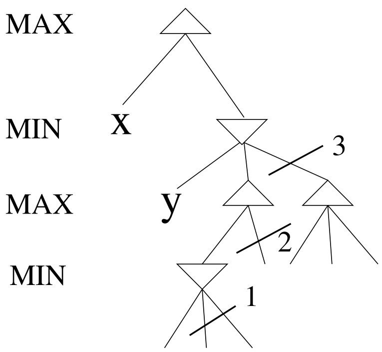
Question 4 (10 pts): Given two heuristics $h_1(n)$ and $h_2(n)$ where $\forall n h_1(n) > h_2(n)$, explain why A* using $h_1(n)$ stores less nodes in its node list than that using $h_2(n)$. Explain with reference to the f-contour radius $f^* = f(G)$ at the goal node G, and $f_1(n) = g(n) + h_1(n)$ and $f_2(n) = g(n) + h_2(n)$ at the node n where $g(n) < f^*$.

Question 5 (10 pts): Prove that A* is optimal when the heuristic $h(n)$ is admissible. Refer to the figure below to develop your argument: Assume that you are currently at node (c), and $g(G_2) > g(G_1)$. Explain in terms of the relationship between $f(n)$, $f(G_1)$, and $f(G_2)$.

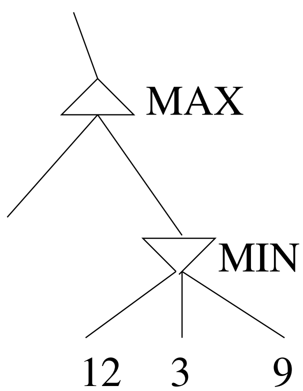


3 Game Playing

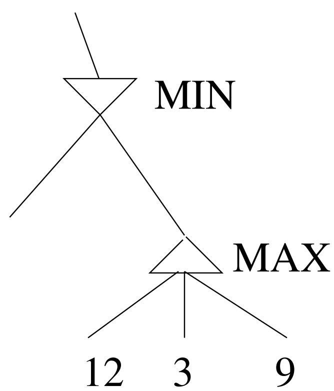
Question 6 (10 pts): In the following MIN-MAX tree, (1) is it possible for the values x and/or y to affect the decision to make the cut labeled 1 (both, x, y, or neither)? Explain why or why not. (2) How about the cut labeled 2? Explain. (3) How about the cut labeled 3? Explain.



Question 7 (10 pts): In the following MIN-MAX trees, how should the three nodes be ordered in each tree for optimal pruning? Provide answers for the two trees separately, and explain why.



(a) Tree 1



(b) Tree 2

4 Logic and Theorem Proving

Use the axioms and inference rules of logic at the end as necessary (see the last page). You may detach the last page from the test. For all of the problems in this section, the following convention will be used: u, v, w, x, y, z are variables, A, B, C are constants, $P(\cdot), Q(\cdot), R(\cdot), S(\cdot), T(\cdot)$ are predicates, and $f(\cdot), g(\cdot)$ are functions.

Question 8 (10 pts): In resolution theorem proving, the theorem $(F_1 \wedge F_2 \wedge ... \wedge F_n) \rightarrow G$ is considered proved (i.e., valid) as soon as **False** is derived by resolving two clauses from the set of clauses. Why is this the case? Explain in terms of the axiom clauses F_1, F_2, ..., F_n, the negated conclusion clause G, and a newly generated clause H.

Question 9 (10 pts): Using **resolution**, show that:

$(P \vee S)$ is a logical consequence of $(P \vee Q) \wedge (Q \rightarrow (R \vee S)) \wedge (R \rightarrow P)$.

Show every step.

Question 10 (10 pts): Suppose you want to prove a theorem based on the following axiom clauses:

1. P
2. $\neg P \vee Q$
3. $P \vee Q \vee R$
4. $\neg Q$

What might be a potential problem with the given axioms? Why is applying the resolution algorithm unsuitable in this case (regardless of the conclusion you want to prove)?

Question 11 (10 pts): When skolemizing, why do we have to use a skolem function instead of a constant, if the existential quantifier appears after a universal quantifier? Use this expression as an example: Why can we not replace y with a constant?

$$\forall x \exists y [Geek(x) \wedge Loves(x, y)]$$

Appendix: Logic

Note: There is no exam question on this page.

Use the axioms and rules of logic below as necessary. You may detach the last page from the test.

Propositional logic:

- $P \vee Q = Q \vee P$,
  $P \wedge Q = Q \wedge P$ (commutative)
- $(P \vee Q) \vee H = P \vee (Q \vee H)$,
  $(P \wedge Q) \wedge H = P \wedge (Q \wedge H)$,(associative)
- $P \vee (Q \wedge H) = (P \vee Q) \wedge (P \vee H)$,
  $P \wedge (Q \vee H) = (P \wedge Q) \vee (P \wedge H)$ (distributive)
- $P \vee \textbf{False} = P, P \wedge \textbf{False} = \textbf{False}$
- $P \vee \textbf{True} = \textbf{True}$
  $P \wedge \textbf{True} = P$
- $P \vee \neg P = \textbf{True}$
  $P \wedge \neg P = \textbf{False}$
- $\neg(P \vee Q) = \neg P \wedge \neg Q$,
  $\neg(P \wedge Q) = \neg P \vee \neg Q$ (DeMorgan's law)
- $P \rightarrow Q = \neg Q \rightarrow \neg P$ (contrapositive)
- $P \rightarrow Q = \neg P \vee Q$

First-order logic:

- $\forall x\, \forall y = \forall y\, \forall x$
- $\exists x\, \exists y = \exists y\, \exists x$
- $\forall x\, \exists y \neq \exists y\, \forall x$
  $\exists x\, \forall y\, Loves(x, y)$ vs.
  $\forall y\, \exists x\, Loves(x, y)$
- quantifiers can be translated using each other:
  $\forall x\, Likes(x, Coffee)$ = $\neg \exists x\, \neg Likes(x, Coffee)$
  $\exists x\, Likes(x, Broccoli)$ = $\neg \forall x\, \neg Likes(x, Broccoli)$

Equivalence formulas ($Q = \forall$ or $\exists$):

- $(Qx\, F(x)) \vee G = Qx\, (F(x) \vee G)$
  $(Qx\, F(x)) \wedge G = Qx\, (F(x) \wedge G)$
- $\neg(\forall x\, F(x)) = \exists x\, (\neg F(x))$
  $\neg(\exists x\, F(x)) = \forall x\, (\neg F(x))$
- $(\forall x\, F(x)) \wedge (\forall x\, G(x)) = \forall x\, (F(x) \wedge G(x))$
  $(\exists x\, F(x)) \vee (\exists x\, G(x)) = \exists x\, (F(x) \vee G(x))$
- $(Q_1 x\, F(x)) \vee (Q_2 x\, H(x)) = Q_1 x\, Q_2 z\, (F(x) \vee H(z))$
  $(Q_1 x\, F(x)) \wedge (Q_2 x\, H(x)) = Q_1 x\, Q_2 z\, (F(x) \wedge H(z))$

These are the common inference rules:

- Modus Ponens:

$$\frac{F \rightarrow G, F}{G}$$

- Unit Resolution:

$$\frac{F \vee G, \neg G}{F}$$

- Resolution:

$$\frac{F \vee G, \neg G \vee H}{F \vee H} \quad or\ equivalently \quad \frac{\neg F \rightarrow G, G \rightarrow H}{\neg F \rightarrow H}$$