CPSC625-600 Midterm Exam (10/14/2010, Thu)

Last name: ________________, First name: ________________

Time: 2:20pm–3:35pm (75 minutes + α), Total Points: 100

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• Be as succinct (i.e., brief) 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 9 pages, including this cover and the Appendix at the end. **Before starting, count the pages and see if you have all 9.**

• This is a closed book, closed note exam.

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1 Instructor: Yoonsuck Choe.
1 AI, in General

Question 1 (10 pts): Do you think human-level AI is possible in the next 50 years? Explain why or why not. [This is an open question. Any reasonable answer will be fine. Don’t write more than one paragraph. I expect a scientific answer. Unscientific answers will be given 0.]

2 Search

Question 2 (10 pts): Explain why A* is generally faster than breadth-first search, considering that both have the same time and space complexity.
Question 3 (10 pts): (1) Explain why IDA*'s space complexity is linear with respect to the maximum depth of the exploration. (2) Explain how IDA*'s space complexity can be measured (it does not keep an explicit node list).

Question 4 (10 pts): In simulated annealing (SA) there are two quantities that are important in determining whether a certain random move will be accepted or rejected when the move results in an increase in energy (note: in SA, the objective is to reduce the energy). (1) What are these and (2) under what conditions are the moves accepted?
3 Game Playing

Question 5 (10 pts): (1) Fill out the utility value in the following Min-Max tree, and (2) show the solution path.

```
3 5 5
1 4 8 2 2 0 9 5 4
7 8 3
```

Question 6 (10 pts): Can the following cuts occur? For each of the indicated locations, (1) answer yes (cut can happen) or no (cut cannot happen), and (2) if yes, give an example (e.g., when $U = 10$, $V = 5$ and ...)

- Cut 1: YES / NO
- Cut 2: YES / NO
- Cut 3: YES / NO
- Cut 4: YES / NO
Question 7 (5 pts): Explain why node ordering is important for efficient alpha-beta pruning.

Question 8 (5 pts): For games with an element of chance, why does the actual magnitude of the utility values matter and not just the rank (ordering)?
4 Logic

Use the laws of logic at the end of the test as necessary (see the last page).

**Question 9 (5 pts):** (1) Explain how a resolution theorem prover can be used to extract answers to questions like “Who is the father of X?”.

**Question 10 (10 pts):** Explain why the following equality is useful for resolution-based theorem proving: $C_1 \land C_2 \land ... \land C_n = C_1 \land C_2 \land ... \land C_n \land H$ where $H$ is a result of resolving a pair of clauses $C_i$ and $C_j$.

**Question 11 (10 pts):** Convert the following into prenex normal form, disjunctive normal form, and then skolemize: $\neg \exists x (\neg P(x) \rightarrow \neg (\exists y (Q(x,y) \lor R(y))))$.
Question 12 (5 pts): Given the premises below, show that \( A \rightarrow E \) is a logical consequence. Use resolution.

1. \( \neg B \land \neg A \)
2. \( D \lor \neg C \lor B \)
3. \( C \)
4. \( \neg D \lor E \)
No exam questions on this page.
Appendix: Laws of Logic

Note: There is no exam question on this page.

Use the laws of logic below as necessary. You may detach the last page from the test.

• \( P \lor Q = Q \lor P, \)
  \( P \land Q = Q \land P \) (commutative)

• \( (P \lor Q) \lor H = P \lor (Q \lor H), \)
  \( (P \land Q) \land H = P \land (Q \land H) \) (associative)

• \( P \lor (Q \land H) = (P \lor Q) \land (P \lor H), \)
  \( P \land (Q \lor H) = (P \land Q) \lor (P \land H) \) (distributive)

• \( P \lor \text{False} = P, P \land \text{False} = \text{False} \)

• \( P \lor \text{True} = \text{True} \)
  \( P \land \text{True} = P \)

• \( P \lor \neg P = \text{True} \)
  \( P \land \neg P = \text{False} \)

• \( \neg(P \lor Q) = \neg P \land \neg Q, \)
  \( \neg(P \land Q) = \neg P \lor \neg Q \) (DeMorgan’s law)

• \( P \rightarrow Q = \neg Q \rightarrow \neg P \) (contrapositive)

• \( P \rightarrow Q = \neg P \lor Q \)

• \( (Qx, F(x)) \lor G = Qx, (F(x) \lor G) \)
  \( (Qx, F(x)) \land G = Qx, (F(x) \land G) \)

• \( \neg(\forall x, F(x)) = \exists x, (\neg F(x)) \)
  \( \neg(\exists x, F(x)) = \forall x, (\neg F(x)) \)

• \( (\forall x, F(x)) \land (\forall x, G(x)) = \forall x, (F(x) \land G(x)) \)
  \( (\exists x, F(x)) \lor (\exists x, G(x)) = \exists x, (F(x) \lor G(x)) \)

• \( (Q_1x, F(x)) \lor (Q_2x, H(x)) = Q_1x, Q_2z, (F(x) \lor H(z)) \)
  \( (Q_1x, F(x)) \land (Q_2x, H(x)) = Q_1x, Q_2z, (F(x) \land H(z)) \)

These are the common inference rules:

• Modus Ponens:

\[
\begin{align*}
F \rightarrow G, F \\
\hline
G
\end{align*}
\]

• Unit Resolution:

\[
\begin{align*}
F \lor G, \neg G \\
\hline
F
\end{align*}
\]

• Resolution:

\[
\begin{align*}
F \lor G, \neg G \lor H \\
\hline
F \lor H \quad \text{or equivalently} \quad \neg F \rightarrow G, G \rightarrow H
\end{align*}
\]