CPSC420-500 Midterm Exam (10/12/2006, Thu)

Last name: __________________, First name: ________________

Time: **12:45pm–2:00pm (75 minutes + α)**, Total Points: **100**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI General</td>
<td>/10</td>
</tr>
<tr>
<td>Search</td>
<td>/35</td>
</tr>
<tr>
<td>Game Playing</td>
<td>/24</td>
</tr>
<tr>
<td>Propositional Logic</td>
<td>/31</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>/100</td>
</tr>
</tbody>
</table>

- You may use the back of the sheet, but please **prominently mark** on the front in such a case.
- 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 10 pages, including this cover and the Appendix at the end. **Before starting, count the pages and see if you have all 10.**
- 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):** Pick one of the academic disciplines related to AI and explain how it is related. [Don’t spend too much time on this question! No more than one paragraph please.]

**Question 2 (5 pts):** Do you think AI is possible? Explain why or why not. [This is an open question. Any reasonable answer will be fine. Don’t write more than one paragraph.]
2 Search

Question 3 (4 pts): Why does queuing order (and/or sorting) affect the behavior of different search algorithms? Explain in terms of the operations performed on the node list.

Question 4 (5 pts): Explain why Iterative Deepening Depth-First Search (IDS) can be better than Breadth-First Search and also Depth-First Search? Explain in terms of one or more of the four evaluation criteria.

Question 5 (7 pts): Why is A’ superior to Greedy search? Explain in terms of one or more of the four evaluation criteria.
**Question 6 (5 pts):** Iterative Deepening A* (IDA*) is superior to A* in one crucial way, but it can be disadvantageous in another. Identify what are these two, in terms of one or more of the four evaluation criteria, and explain why.

**Question 7 (4 pts):** Why does relaxing the constraint on legal moves usually result in an admissible heuristic? Explain in terms of the 8-puzzle.
Question 8 (4 pts):  What is the main drawback of hill-climbing or gradient-based iterative improvement algorithms?

Question 9 (6 pts):  In Simulated Annealing, the goal is to move from one state to another by applying an operator so that the energy $E$ associated with the state is minimized. Given a state, an operator is allowed to be applied (rather than being rejected) only in two cases depending on the $\Delta E$ value (the change in energy $E$ in the two states): (1) Explain what are these two cases, and (2) explain why this can help solve the problem of local search methods such as hill-climbing. Assume the temperature $T$ is fixed.
3 Game Playing

Question 10 (6 pts): Using the following figure, explain how $\alpha - \beta$ pruning works. (1) Show each stage of the search and $\alpha/\beta$ value updates. (2) Show the cut(s). (3) Show which values should be compared to determine whether or not to cut (i.e., choose a pair from $v$, $\alpha$, and $\beta$), and which comparison should be used ($\leq$ or $\geq$). For example $v \leq \alpha$. Note that $v$ is the returned utility value for each child.

![Game tree with $\alpha$ and $\beta$ values]

Question 11 (6 pts): For the following tree, repeat the same subquestions in Question 10 above.

![Game tree with $\alpha$ and $\beta$ values]
Question 12 (4 pts): What assumption is necessary for the results of \( \alpha - \beta \) pruning to be the same as minmax search? Explain in terms of the MIN and MAX players’ general characteristics.

Question 13 (4 pts): Why is node ordering important in \( \alpha - \beta \) pruning?

Question 14 (4 pts): Is the MIN-MAX algorithm similar to BFS or to DFS? Explain why.
4 Propositional Logic

Use the laws of propositional logic at the end of the test as necessary (see the last page). You may detach the last page from the test.

Question 15 (6 pts): Convert $\neg [(P \lor Q) \rightarrow \neg (S \rightarrow (R \land \neg P))]$ to conjunctive normal form. Show every step of the derivation.

Question 16 (6 pts): Given axioms $F_1, F_2, ..., F_n$ and a conclusion $G$, why is deriving False in resolution equivalent to showing that $(F_1 \land F_2 \land ... \land F_n) \rightarrow G$ is valid?
Question 17 (8 pts): Using resolution, show that:

\((P \lor S)\) is a logical consequence of

1. \(X \lor Q\)
2. \(Q \rightarrow (R \lor S)\)
3. \(\neg R \lor P\)
4. \(\neg X \lor R\).

First, convert the problem into a form suitable for resolution. Then, show every step of the derivation.

Question 18 (6 pts): Choose one: Resolution is domain (1) independent or (2) dependent. Explain why that particular property is both an advantage and a disadvantage.

Question 19 (5 pts): What is the limitation of propositional logic, in terms of its representational power?
Appendix: Laws of Propositional Logic

Note: There is no exam question on this page.
Use the laws of propositional 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)

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

These are the common inference rules:

- Modus Ponens:
  \[
  F \rightarrow G, \quad F \\
  \hline
  G
  \]

- Unit Resolution:
  \[
  F \lor G, \quad \neg G \\
  \hline
  F
  \]

- Resolution:
  \[
  F \lor G, \quad \neg G \lor H \quad \text{or equivalently} \quad \neg F \rightarrow G, \quad G \rightarrow H \\
  \hline
  F \lor H \quad \neg F \rightarrow H
  \]