PhD Qualifying Exam — 2012

Artificial Intelligence

Code Number:

Time: 2:00PM-4:30PM
There are five questions on this qualifying exam. Each question is worth 20 points.

1. (20 points) The greedy best-first search strategy applies the evaluation function $f(n)$, which is the cost from the current node $n$ to the closest goal. Please compare this evaluation function with the one used by the $A^*$ algorithm and explain the difference between the two strategies in terms of completeness and optimality.
2. (20 points) In the wumpus world game, let \( P_{i,j} \) be true if there is a bottomless pit in \([i,j]\), and let \( B_{i,j} \) be true if there is a breeze in \([i,j]\). The knowledge base contains the following sentences:

\[
\begin{align*}
\neg P_{1,1} \\
\neg B_{1,1} \\
B_{2,1} \\
B_{1,1} & \iff (P_{1,2} \lor P_{2,1}) \\
B_{2,1} & \iff (P_{1,1} \lor P_{2,2} \lor P_{3,1}) \\
B_{1,2} & \iff (P_{1,1} \lor P_{2,2} \lor P_{1,3})
\end{align*}
\]

Please use model checking to prove that the knowledge base does not entail any of the following four sentences \( \{B_{1,2}, P_{2,2}, P_{3,1}, P_{1,3}\} \)
3. (20 points) Knowledge representation in an $N \times N$ wumpus world game where $N > 2$.

(a) Use the propositional logic knowledge representation language to represent the following knowledge: square [2, 2] is breezy if and only if it is adjacent to a bottomless pit.

(b) Use the first-order logic knowledge representation language to represent the following knowledge: squares adjacent to the wumpus are smelly.
4. (20 points) In AI, some popular learning methods are based on the Structural Risk Minimization (SRM) principle and the Empirical Risk Minimization (ERM) principle, respectively. (a) Please name two learning methods that implement the ERM and the SRM, respectively, and discuss what machine learning problems are addressed by these methods, respectively. (b) Why is the SRM principle more appropriate than the ERM principle for solving some particular learning problems, such as the small-sample-size problems?
5. (20 points) Support Vector Machine (SVM), which is a popular supervised learning approach in AI, defines a maximal margin hyperplane in the feature space, which is also known as the optimal hyperplane. Please explain why a hyperplane, which in essence addresses a simple linear problem, can help solve complex learning problems that are not linear in nature.