PhD Qualifying Exam — 2013

Artificial Intelligence

Code Number:

Time: 9:30AM-12:00PM
1. (20 points) Solving problems by searching is a major topic in AI, where the essence of search is following up one option now and putting the others aside for later, in case the first choice does not lead to a solution. Prove that the A* algorithm is optimal, where an optimal solution has the lowest path cost among all solutions.
2. (20 points) In knowledge representation, entailment and implication are commonly used concepts for logical reasoning. Prove the Deduction Theorem that applies the concepts of entailment, implication, and validity: $KB \models \alpha$ if and only if $(KB \Rightarrow \alpha)$ is valid.
3. (10 points) Support vectors are derived from which of the following processes? 
   (a) The primal optimization process. 
   (b) The dual optimization process. 
   (c) The formation of the kernel function. 
   (d) The formation of the nonlinear mapping. 

4. (10 points) Use the first-order logic knowledge representation language to represent the following knowledge: half sibling between two persons, which means that the two persons share one common parent. Use the “HalfSibling” and “Parent” predicates for the binary relations.
5. (10 points) Indicate whether the following statements are True or False:

_____ An agent is learning if it improves its performance on future tasks after making observations about the world.

_____ The problem of learning is to choose one function (from the given set of functions that can be implemented by a learning machine) that best approximates the supervisor’s response.

_____ VC dimension, which equals the maximum number of vectors in a vector space, is capable of indicating the capacity of a learning machine.

_____ The risk functional is defined as the expected value of the loss.

6. (10 points) Convert the following sentence into CNF:

\[ \forall x \ [ \forall y \ Animal(y) \Rightarrow Loves(x,y)] \Rightarrow [\exists y \ Loves(y, x)] \]
7. (20 points) Let $P_{i,j}$ be true if there is a pit in $[i, j]$. Let $B_{i,j}$ be true if there is a breeze in $[i, j]$. The knowledge base (KB) contains the following sentences:

$\neg P_{1,1}$
$\neg B_{1,1}$
$B_{2,1}$
$B_{1,1} \Leftrightarrow (P_{1,2} \lor P_{2,1})$
$B_{2,1} \Leftrightarrow (P_{1,1} \lor P_{2,2} \lor P_{3,1})$
$B_{1,2} \Leftrightarrow (P_{1,1} \lor P_{2,2} \lor P_{1,3})$

(i) Compute $M(KB)$.

(ii) Use model checking to prove that the knowledge base entails or does not entail each of the following sentences: \{ $B_{1,2}, P_{2,2}, P_{3,1}, P_{1,3}$ \}