First Examination
Intelligent Systems

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Code : INFOIS Date : March 8th, 2012 Time : 08:30-10:30

This exam has 6 questions. Your answers should be given in Dutch or English. With the answers to the 6 questions you can earn 90 points. You get 10 points for free. 100 points yields a 10. This examination only contributes to your end mark if your (weighted) average benefits from it.

Question1	Question2	Question3	Question4	Question5	Question6
15pt	20pt	10pt	15pt	15pt	15pt

FOL = First Order Logic KB = Knowledge Base

1. Determine for each of the following FOL models / structures whether or not it satisfies the formula: $\forall x \exists y \exists z : P(x,y) \wedge \neg P(y,z) \wedge P(x,z) \wedge \neg P(z,y)$. Explain your answer!

   (a) Domain $= \mathbb{Z}$ (i.e., the integers),
   Relation $P = \{(m, m+1) \mid m \in \mathbb{N}\}$

   (b) Domain $= 2^{\mathbb{N}}$ (i.e., the set of subsets of the natural numbers),
   Relation $P = \{(A,B) \mid A, B \in 2^{\mathbb{N}} \text{ en } A \subseteq B\}$

   (c) Domain $= \mathbb{N}$ (i.e., the natural numbers),
   Relation $P = \{(m,n) \mid m, n \in \mathbb{N} \text{ en } m \leq n\}$

2. Translate the following sentences into FOL. If the sentences are ambiguous, also explain in words what interpretation you have chosen.

   (a) For anybody there is something that he can do better than some other person.

   (b) Women are happy if they only have daughters that love each other.

3. Which of the following pairs of predicates can be unified? Give the substitutions in case unification succeeds. In these formulas $Brother$, $Sister$ and $Mother$ are functions, and $WorksFor$, $Loves$ and Old are predicates.

   (a) $WorksFor(Brother(Jan), y)$ and $WorksFor(x, Jan)$

   (b) $Loves(Sister(Jan), Piet)$ and $Loves(x, Sister(y))$

   (c) $Old(Mother(Mother(x))$ and $Old(Mother(x))$

4. We assume that to move in the wumpus world, an agent only has the possibility to GoEast and GoNorth. Apart from that, the agent can perform the actions Grab-Gold and Shoot, both with the effect suggested by their name. The formula below represents an initial attempt to formulate a successor state axioma based on the fluent $At(Agent, x, y, s)$, where the x and the y are place coordinates (as usual for the situation calculus, all variables are implicitly universally quantified). Finish the formula by substituting a correct formula for the '...'.

$$Poss(a, s) \rightarrow [At(Agent, x, y, Result(a, s)) \Leftrightarrow (\ldots)]$$

5. During class, the lecturer explains the difference between 'completeness' and 'decidability'. A student reacts, and says:

> "Since FOL is complete, I can make an algorithm checking if a formula is derivable by systematically searching through all possible derivations that can be made with a finite axiomatization of FOL. Then, if I want to check if a formula is valid or unsatisfiable, I let the algorithm divide its time between trying to prove the formula and trying to prove its negation. Since (1) either the formula or the negation must be valid, and (2) the algorithm I use is based on a complete axiomatization, and (3) the search is systematic in that it ensures that all derivations that can be made using the axiomatization will be considered, eventually the calculation must come to an end. So, from the completeness of FOL, it follows that FOL is also decidable."

   (a) What is wrong with this student's argumentation?

6. We consider the following Prolog program:

```
parent(5,3).
parent(1,2).
parent(2,3).
parent(2,4).
ancestor(X,Y) :- parent(X,Y).
ancestor(X,Y) :- ancestor(Z,Y), parent(X,Z).
```

   What will be the output of the query '`?- ancestor(X,3).`' after repeatedly pushing the ";"?