Instituto Superior Técnico

Mestrado em Engenharia Informática e de Computadores
Representação de Conhecimento e Raciocínio
Knowledge Representation and Reasoning

1st test 25 March 2014 11:00h – 12:30h

Nome: _____ Número: _____

Escreva o seu número em todas as folhas do teste. O tamanho das respostas deve ser limitado ao espaço fornecido para cada questão. O teste tem 11 páginas com 7 perguntas, estando assinalada no princípio de cada pergunta, entre parêntesis, a sua cotação. Além de caneta, lápis, borracha e cartão de estudante, não são permitidos quaiquer outros objectos na sua secretária. **Boa sorte!**

Write you number on each page of your test. Your answers should be limited to the amount of space available for each question. This test has 11 pages with 7 questions, The grades are between brackets in the beginning of each question. Other than pen, pencil, rubber and your student card no other objects are allowed on your desk. **Good Luck**!

1. [4.0] Consider First-Order Logic. Complete the statements:

   a) (0.2) Every variable is a _____ .

   b) (0.6) If t1, …, tn are _____, and P is a _____ symbol of arity n then P(t1, …., tn) is a _____.

   c) (0.2) If t1 and t2 are terms, then t1 = t2 is a _____

   d) (0.4) If α and β are _____ and x is a variable then $\sim\alpha$, $\alpha \vee \beta$ $\alpha \wedge \beta$ and $\exists x.[\alpha]$ are _____.

   e) (0.4) An interpretation _____ in FOL is a pair _____, (continues in the next alinea)

   f) (1.2) where _____ is any _____ called the _____ and _____ is a _____ called the _____

   g) (0.6) Let S be a set of sentences and α any sentence. We say that α is a logical consequence of S, or that S logically entails α, which we write _____ if and only if, for every interpretation _____

   h) (0.2) We consider a reasoning process to be _____if whenever it produces α then α is guaranteed to be a logical consequence.

      (0.2) We consider a reasoning process to be _____if it is guaranteed to produce α whenever α is entailed.

2. [5.0] Consider the following sentences:

S1 Cili, Bili and Ana are children
S2 Bili is higher than Cili
S3 Ana is higher than Bili
S4 Cili and Bili are not the highest children
S5 Ana is the highest child
S6 For each child that is not the highest there is a higher child
S7 Ana is higher than Cili

a) [2.0] Represent the above sentences in FOL.

b) [1.0] Show semantically (reasoning about interpretations) that S1-S6 do not logically entail S7

c) [1.0] Write in FOL some additional **general** common sense fact(s) that most people would be expected to know, and **show**, explaining that the augmented set of sentences now entails that Ana is higher than Cili (S7).

d) [1.0] While representing facts, one can distinguish between basic, complex and terminological facts. Classify all represented facts in terms of the category to which they belong. In the case of terminological facts state their variety. Explain your assignments to each class.

3. [2.0] Use resolution to prove that ({Vx [F(x) → G(x)], ∃ x[F(x) Λ H(x)]}, ∃ x [G(x) Λ H(x)])

4. [2.0] Horn Clauses are a subset of FOL.
   a) [0.5] Explain what a Horn Clause is.

   b) [0.5] Explain what a SLD derivation is.

   c) [1.0] Explain why the problem of determining whether a set of first-order Horn clauses entails an atom remains undecidable (you can use an example to illustrate your justification).

5. [1.0] Explain the differences between the two PROLOG rules and discuss which one should be implemented in case we wanted to reason on a large Knowledge Base about families that live all over the world.

Option 1	AmericanCousinOf(*x,y*) :- American(*x*) , CousinOf(*x,y*)
Option 2	AmericanCousinOf(*x,y*) :- CousinOf(*x,y*) , American(*x*)

6. [3.0] Production systems are composed of a set of production rules and a working memory, and use forward chaining.
   a) [1.0] Describe the basic operation cycle of a production system.

b) [1.0] Suppose we want to place 3 bricks of different sizes sitting in a heap in 3 identifiable positions (position 1, 2, 3) with a robot hand. The goal is to place the bricks in those positions in order of their size with the smallest in position 1 and the largest in position 3. Assume that when we begin the working memory has the following elements:

(counter value: 1)
(brick name: A size: 10 position: heap)
(brick name: B size: 30 position: heap)
(brick name: C size: 20 position: heap)

and the following rule:

IF (brick position: hand)
(counter value: i)
THEN MODIFY 1 (position i)
MODIFY 2 (value [i + 1])

write any additional rules that would be required.

c) [1.0] Early production systems, implemented in a straightforward way, ended up spending inordinate amounts of time (as much as 90%) in rule matching. **Describe and explain** the main idea behind the RETE algorithm.

7. [3.0] MYCIN was a Knowledge Based System using rules to aid physicians in diagnosis of bacterial infections. XCON was a Knowledge Based System using rules that was used by Digital Equipment Corporation for many years to configure the VAX computer series.
   a) [1.5] Describe which kind of chaining MYCIN used to make diagnosis and which kind of reasoning it used to prescribe the most appropriate treatment. Explain how the diagnosis functionality worked.

   b) [1.5] Describe and explain how XCON implemented segmentation of a complex task.

END