

# Intelligent Systems: Reasoning and Recognition

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ENSIMAG 2 / MoSIG M1

Final Exam - May 2015

Conditions: You have the right to use any notes or written material. You may answer questions in English or in French. When appropriate, illustrate your answer with mathematics. Your written answers must be clear and legible. Illegible text will not be graded. Duration: 3 hours.

1) (4 points) Define knowledge. Identify several forms of knowledge and explain how each form can be represented. For each form of knowledge, describe tasks for which the form may be used, explain how the knowledge can be acquired, and discuss limitations.

2) (8 points) The goal of this exercise is to program a system for temporal reasoning using rules written in CLIPS 6. Your system should use the following templates for RELATIONS and TEMPORARY. The table of transitivity is defined by the deffacts named TABLE-OF-TRANSITIVITY listed below. You will use the functions UNION and INTERSECTION listed below.

In the list of temporal relations, the symbols ">", "<", and "=" correspond to CLIPS keywords. These must be replaced with "b" (before), "bi" (before-inverse) and "e" (equals).

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(deftemplate RELATIONS (slot INT1) (slot INT2) (multislot RELATIONS))
(deftemplate TEMPORARY (slot NAME) (slot INT1) (slot INT2)
  (multislot RELATIONS))
(deftemplate TABLE (slot R1) (slot R2) (multislot RELATIONS) )

(deffacts TABLE-OF-TRANSITIVITY
  (TABLE (R1 b) (R2 b) (RELATIONS b))
  (TABLE (R1 b) (R2 bi) (RELATIONS b bi d di o oi m mi s si f fi e))
  (TABLE (R1 b) (R2 d) (RELATIONS b o m d s))
  (TABLE (R1 b) (R2 di) (RELATIONS b))
  .....
  (TABLE (R1 fi) (R2 fi) (RELATIONS fi))
)

(defun UNION (?R1 ?R2)
  (progn$ (?e ?R1)
    (if (not (member ?e ?R2)) then (bind ?R2 (insert$ ?R2 1 ?e))))
  (return ?R2)
)

(defun INTERSECTION (?R1 ?R2)
  (bind ?r3 (create$))
  (progn$ (?e ?R1)
    (if (member ?e ?R2) then (bind ?r3 (insert$ ?r3 1 ?e)) ))
  (return ?r3)
)
```

Suppose that you have three intervals, ?A, ?B, and ?C as well as a list of possible RELATIONS ?RAB from ?A to ?B, and a list of possible RELATIONS ?RBC from ?B to ?C. The generation of the list of RELATIONS from ?A to ?C will be performed by three rules named R1, R2, R3 and R4.

a) For each pair of RELATIONS (?rab, ?rbc) such that ?rab  $\in$  ?RAB and ?rbc  $\in$  ?RBC, the rule R1 will generate a fact of type TEMPORARY using the table of transitivity. Write the rule R1.

b) Whenever there exists two facts of type TEMPORARY with the same value for INTERVAL1 and INTERVAL2, but with different names, the lists of RELATIONS given by these facts must be combined using the function UNION. Write the rule R2 that deletes the two facts and creates a new fact of type TEMPORARY, in which the list of possible RELATIONS is the UNION of the lists from the two facts.

c) When all of the facts of type TEMPORARY have been combined, the resulting list should be used to create a fact of type RELATIONS. Write the rule R3 that creates this new fact. This same rule should delete the fact of type TEMPORARY. Be careful that all of the TEMPORARY lists have been fused before this rule fires.

d) Write the rule R4 that detects when two lists of RELATIONS have been generated for the same pair of intervals. This rule should delete the two facts of type RELATIONS and create a new fact with the intersection of the possible set of temporal RELATIONS.

3) (2 points) Provide a definition and an explanation for an ROC curve? How is it calculated? How is it be used?

4) (6 points) You are responsible for an International Masters program. Over the last 5 years, your program has accepted 200 students from three Universities. You wish to use the academic results of these students in two of your courses in order to provide guidelines for admissions for future students. For each student, you have the name of his university, his ranking in the last year of studies at his home university, and the grades that he has obtained in the two reference classes in your program, noted as numeric grade from 0 to 20.

a) Explain how to use a ratio of histograms to estimate the origin of a student from his grades in your reference classes. Present the formula and explain its terms. How large are the histograms? How many students from each University are necessary in order for a ratio of histograms to give a reasonable result? How can you estimate the probability of error?

b) Bad Luck! There are not enough students to use a ratio of Histograms. Explain how to use a normal (Gaussian) probability density functions to estimate the probability that a student is from one of the three Universities given his notes in your two reference classes. Explain how to estimate the parameters for the normal density functions. Can you determine a probability of error for the origin of the students? If yes, how is it determined?

c) You have really bad luck! Your secretary has erased the information about the origin of your students. All you have are their notes in your two reference classes. Explain how to use the EM algorithm to estimate the probability that each student belongs to each of the three universities. Explain how to initialize the parameters for the algorithm.