



Knowledge Engineering

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Answer the following questions identifying the key aspects and try not to exceed the 1 page limit per question.

- Use only the sheets provided by the teacher
- **Write Part I and Part II on separate sheets of paper**
- Write your name and Student ID on each sheet you turn in
- English is the official language, however Italian is allowed
- Both pen and pencil are allowed, no other support is allowed

In case you have special needs (e.g., being graded within a given time) please **tell it to the teacher!**

PART I

Question 1.1: Perceptron Learning [8/30 Points]

Consider the classical Perceptron model but use 5 Input and 1 Output in this exercise:

- Draw it and write its analytical output characteristic
- Describe the training algorithm for the Perceptron
- What are the possible issues with the training algorithm of the Perceptron?
- Perform an epoch of training for the XOR function (the output is 1 if and only if only 1 input is 1).
- Can this modified Perceptron solve the XOR problem as previously defined? Why?

Question 1.3: Genetic Algorithms [8/30 Points]

We want to use a genetic algorithm to solve a boolean Constraint Satisfaction Problem (CSP). Binary CSP looks for the assignment of a set of boolean variables to satisfy as many as possible out of K given logical constraints among those variables (e.g., X1 and X2 or not X3, X1 or X3, X2 and X5, and not X22, etc.)

- Write the general schema of a genetic algorithm
- Describe a possible coding and genetic operators for the problem
- Write a possible fitness function for the problem
- Describe the possible selection schema for the algorithm
- The SUDOKU game can be described as a constraint satisfaction problem with integers. Can you provide a variation of the previous coding, genetic operators, and fitness function for SUDOKU?

Question 2.1: Knowledge Representation [6/30 Points]

Write the conceptual model (represented by ``units") that can be extracted from these sentences:

- A cow is a mammal
- The typical sound for a cow is "Muuu"
- A cow produces milk
- Blanche is the only cow of aunt Ginny

Please, structure knowledge and, eventually, add knowledge elements enabling to write at least one rule to detect that aunt Ginny can have milk ever day. General solutions are more appreciated.

Question 2.2: Expert systems [2/30 Points]

Please, briefly describe the different applications that can be implemented with forward and backward rules.

Question 2.3: Fuzzy Systems [8/30 Points]

We would like to implement a fuzzy system to control the level of water in a basin. Given a reference level, set by the user, the basin has to reach that level in the shortest time, and to keep it. The output from the basin can be controlled by a valve. The input comes from external sources and cannot be controlled. A red lamp should be turned on when the level reaches a critical threshold.

Please, select and model input and output variables of the system, define the corresponding fuzzy sets, select how to implement operators, write at least three of the rules implementing the fuzzy controller. Please, remember to **motivate** all your choices, including shape and position of the membership functions.