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: Feedforward [8/30 Points]

Consider the classical feed forward neural network architecture with I input neurons, J hidden neurons and one output neuron:

- Draw it and write its output characteristic
- Define the general formula for the weights update according to backpropagation
- What are the main limits of backpropagation being it a basic gradient descent technique? How to face those limits?
- Derive the error function to be used in case of classification (i.e., the error model is a Bernulli distribution with the neural neural output being the Bernulli parameter)
- What should be the activation functions of the network in case of classification? What if we have more than 2 classes?
- Describe the issue of overfitting and list the standard techniques used to face it in neural networks?

Question 1.3: Genetic Algorithms [8/30 Points]

We want to find a symbolic boolean expression to represent a given boolean function (i.e., a table of 0s and 1s for a given set of input variable). We can have a large number of variables (e.g., A, B, C, D, …) and a predefined set of operators (e.g., and, or, not, xor, nand). The goal is to find the expression which satisfies the given table and the fastest execution when evaluated by a parallel computer.

- 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

PART II

Question 2.1: Knowledge Representation [6/30 Points]

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

- A car is a motorized vehicle
- A motorized vehicle has a motor
- A motor needs fuel to work
- Gord is Johnny's car

Please, structure knowledge and, eventually, add knowledge elements enabling to write at least one rule to detect that the fact that Gord is not moving due to lack of fuel. General solutions will be more appreciated.

Question 2.2: Expert systems [2/30 Points]

Please, briefly describe what are the main roles of people in a Knowledge Based System development team.

Question 2.3: Fuzzy Systems [8/30 Points]

We would like to implement a fuzzy system to control the temperature of a room by air conditioning. Given a reference temperature, set by the user, the room should reach that temperature in the shortest time. Cold and hot air are available, and the system can control both how they mix (by moving an actuated paddle that partially closes one or the other pipe) and the speed of the fan.

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.