Soft Computing

- Introduction -

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What is Soft Computing?

The term has been proposed by Lotfi Zadeh, the father of fuzzy sets, to denote programming techniques not related to "traditional" programming languages:

- **Fuzzy systems**
- **Neural Networks**
- **Stochastic systems** (**Genetic Algorithms**, **Evolutionary Algoritms**, **Reinforcement Learning Systems, Bayesian Networks** …)

Many different techniques that require different skills

Different **models** of input/output mapping

Modeling

A model is different from the modeled entity:
the map is not the land

A model is a **representation** of some entity, defined for a **specific purpose**.

A model captures only those **aspects** of the entity modeled that are **relevant for the purpose**.

Approximation, uncertainty, imprecision

Da € 70 Hotel Fieramilano
Viale Bolla 20, Milan
L'Hotel Fieramilano è situato proprio di fronte all'entrata principale della fiera di Milano, nel cuore del centro degli affari.

Da € 71 Plop Hotel Gallone
Piazza Cordusio 2, Milan
L'HOTEL GALLONE è situato in una delle piazze più belle ed importanti del centro di Milano, accanto all'uscita della stazione metropolitana (MM1 – linea rossa)

...

Approximation, uncertainty, imprecision

Approximation: the model features are similar to the real ones, but not the same, and cannot be further defined (e.g., a *green* thing)

Uncertainty: we are not sure that the features of the model are the same of the entity (e.g., "I'm not sure it's broken")

Imprecision: the model feature values (e.g.,quantities) are uncorrect, but close to the real ones (e.g., a temperature measured in integer °C)

References

Einstein (1921):

So far as laws of mathematics refer to reality, they are not certain, and so far they are certain they do not refer to reality

Russell (1923):

All traditional logic abitually assumes that precise symbols are being employed. It is therefore not applicable to this terrestrial life, but only to an imagined celestial existence

Zadeh (1973):

As the complexity of a system increases, our ability to make precise and yet significant statements about its behavior diminishes until a threshold is reached beyond which precision and significance (or relevance) become almost mutually exclusive characteristics

So, what is Soft Computing?

A set of techniques to model systems (input-output mapping) by approximating them

The main point is that the modeling process considers a relatively **small sample** of the entity to be modeled to make an **approximate model** => **generalization**

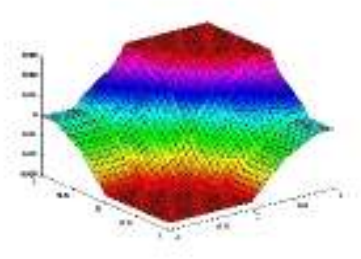
The different techniques capture different ways of modeling, according to the available information about the modeled entity

A summary of techniques (1)

Fuzzy sets:
correct model in a finite number of points, smooth transition (approximation) among them.

E.g.: **control of a power plant**.

We can define what to do at the regimen (e.g., steam temperature =120°, steam pressure 3 atm), and when in critical situations (e.g., steam temperature= 100°), and design a model that smoothly goes from one point to the other.

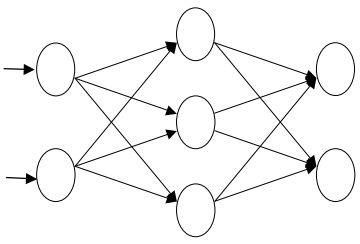


A summary of techniques (2)

Neural Networks:
Input-(output) samples, learning algorithms to define output values for unknown values.

E.g.: **classification of plants**.

We may train the network with 150 sets of plant characteristics (color of flower, number of leaves, …) and corresponding correct classifications (iris caudata, iris parviflora, …). The network is then able to classify also sets of characteristic values never received before



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A summary of techniques (3)

Genetic algorithms:

Optimal solution, obtained by evaluating populations of tentative solutions and combining their parts

E.g.: **behavior of an autonomous robot**.

In this case, the models are rules. Some rules are randomly generated and control the robot. The behavior (e.g., Go to a ball) is evaluated, the good rules kept in the population of rules, and recombined, the bad rules eliminated.

Potential applications

No limit to **imagination**:

control of washing machines, helicopters, and rice-cookers, selection of personnel, quality control, classification, design of devices, route optimization, data mining, data analysis information retrieval, security management, forecasting, resource allocation, …

… whenever a model is needed, but…

let's learn which are the correct models for which applications!

How do we proceed?

For each technique we will see:

- Theory
- Examples
- Applications

Fuzzy systems
Reinforcement Learning
Genetic Algorithms

Neural Networks
Bayesian networks

The exam...

- Written examination
- Recover is possible at any exam date
- 32 points maximum
- At least 18 is required

Participation to experiments

- positive rounding of the final vote

For people who have this course integrated with Artificial Intelligence

- the same as above, but the exam is done the same day as AI, and the marks of the two parts of the exam are averaged

Support

Course site

http://home.dei.polimi.it/bonarini/Didattica/SoftComputing/

(Reachable also from the home page of the teacher on http://www.dei.polimi.it)

Slides

On the site at last the night before the lesson

Books

On line (suggestions on the site) or in libraries

Contacts

Ask for a meeting with teachers by e-mail