Fuzzy Systems and Genetic Algorithms

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Putting together genetic algorithms and fuzzy systems

Some possibilities:

- fuzzy representation of the fitness function (good, as well, for the reinforcement function in RL)
- genetic algorithms to learn fuzzy systems
  - Learning fuzzy sets
  - Learning fuzzy rules -> Learning Fuzzy Classifier Systems

Fuzzy fitness function

Why?

As usual, because a fuzzy representation may be easier to understand and define than a formula, more robust w.r.t. noise, etc.

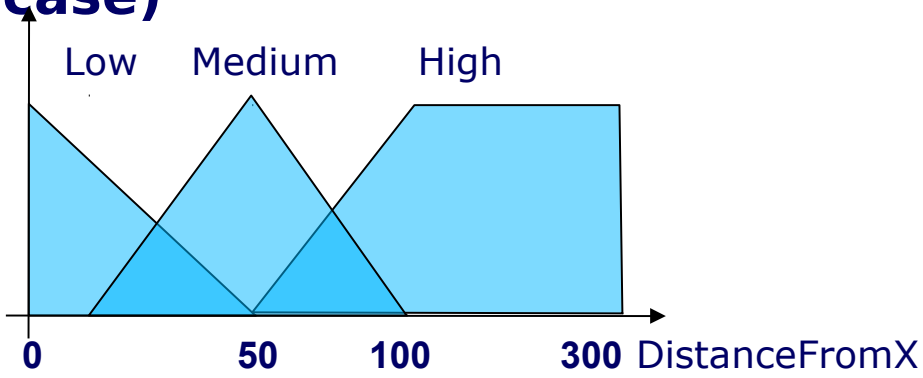
How?

The fitness function is a relationship between characteristics of (the performance of) a solution and a number.

E.g.: for a GA that has to learn the obstacle avoidance behavior for a robot, the fitness function might be

F= (DistanceFromLeft is High) and (DistanceFromRight is High) and (DisanceFromFront is High)

Let's see if it's better than a numerical one (in this case)



F_f= (DistanceFromLeft is High) and
(DistanceFromRight is High) and
(DistanceFromFront is High)

F_n= DistanceFromLeft *
DistanceFromRight *
DistanceFromFront

F_f=0

F_n=10*300*300
=90000

F_f=0.7

F_n=80*300*300
=720000

GA learning of fuzzy sets

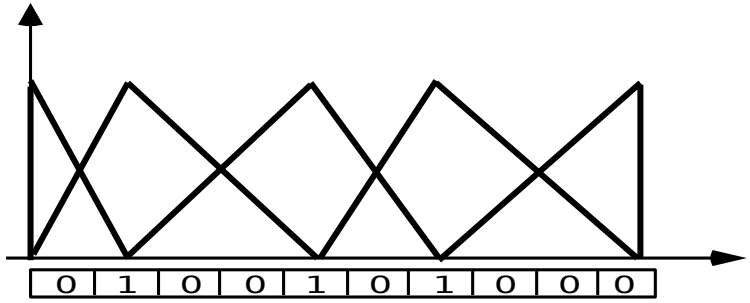
Why?

- Shape and position of fuzzy sets might be optimized
- A fitness only might be available
- The solution might have many local optima

How?

- Model for the set of fuzzy sets compatible with GA needs (e.g. string of bits),

  e.g. one bit per interval, whose value is one if the vertex of a triangular fuzzy shape is in the center of the interval, 0 if not



GA learning of fuzzy rules

Why?

- The structure of a fuzzy rule set has to be otimized
- The only available information is a fitness function
- The solution might have local optima

How?

- Models for the rules compatible with he GA needs
- Eventual models also for the fuzzy sets

What is a Fuzzy LCS?

A fuzzy LCS is a Learning Classifier System where the rules are fuzzy rules, i.e., antecedents and consequents are represented by fuzzy sets.

The main issue is that by learning a small number of parameters, we have a complete, general mapping from real numbers to real numbers.

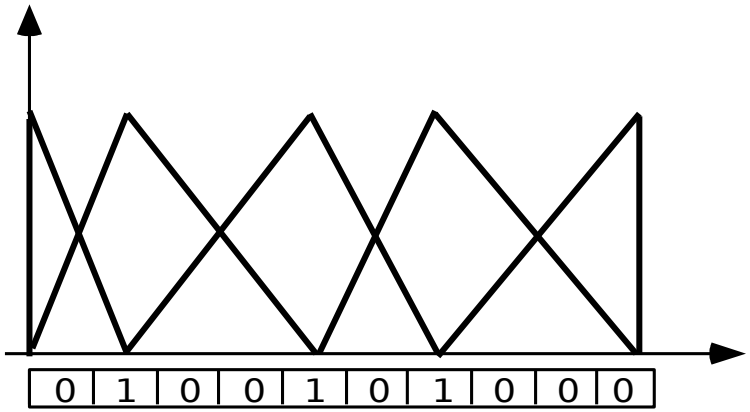
There are many approaches aimed at learning MFs and rules, or only the rule rule structure, with given MFs

Learning both rules and MFs

Nomura (1992)

Populations of bit strings corresponding to the characteristic points of the MFs

This represents number and shape of the MFs. The rulebase is complete.



Learning only the rule structure

[Valenzuela-Rendon, 1991][Thrift, 1991][Bonarini, 1991][Bonarini, 2001]

- Both with Michigan and Pitts representation (and others)
- Rules are strings of numbers corresponding to MFs

  E.g.: 132#:12