COMPUTATIONAL INTELLIGENCE AND "FUZZY LOGIC"

During the last decades some areas besides classical mathematics have been developed, which use analogies to behaviours observed in nature, to model problems and find their solutions better than it is possible by methods of classical mathematics.
Three of the best known areas, which all appeared in the 60's, is the "Theory of Fuzzy Sets" (generally known as "Fuzzy Logic"), the "Theory of Artificial Neural Nets", and the area of "Genetic Algorithms or Evolutionary Programming". Aims and procedures in these areas differ from each other: Fuzzy Logic tries to better model human communication and inference than is possible with dual logic (true-false) or with classical set theory (an element belongs to a set or not). Artificial Neural Nets are (very simple) models of human (or other) brains and the served at the beginning primarily pattern recognition in big messes of data. Genetic or evolutionary algorithms model evolutionary processes of genetics. And primarily serve optimisation.
At the beginning of the 90's one observed increasingly, that these areas were complementary to each other and numerous "hybrid" methods and theories were developed. These are methods, which combined basic ideas of several of theses areas. 1994 international conferences were organised in Aachen, San Diego and Yokohama in which researchers of all three areas participated. All three conferences had the title "Computational Intelligence". Since then "Computational Intelligence" is used as name for all three areas of "biologically inspired mathematics". It is estimated that by now there exist at least 50 000 to 60 000 publications in this area.

What is "Fuzzy Logic"?

"Fuzzy Logic" has in the 80's become the popular name for Fuzzy Set Theory. Actually Fuzzy Logic is a special part of the theory of fuzzy sets. The basic idea of this theory is, that in real life often structures or phenomena can be found, which are not two valued (black-white, on-out, bad-good, true-false, etc) and, thus, cannot easily be processed by our digital computers. The theory extends, therefore, classical two valued (dichotomous) logic and set theory to continuous modelling. Elements can therefore not only belong to a set or not, rather they can belong to sets to various degrees. That means, that borders of sets can become "fuzzy". In logic statements cannot only be (absolutely) true or (absolutely) false, but they can also be "generally true", "mostly true" or "sometimes true" (similar to multi valued logic). This means two things: First of all, human statements (which are often not meant not two valued) can be better modelled and, second, classical methods of inference, as they are used in classical expert systems, have to be further developed, since they cannot be restricted to the existence of

Contact:
INFORM GmbH,
Pascalstrasse 23, 52076 Aachen, Germany
info@inform-ac.com, www.inform-ac.com

INFORM

only two values.
Fuzzy Set Theory has been successfully applied in many areas of our life during the last decades. This happened primarily in knowledge based systems and by relaxing classical methods for modelling and finding solutions to these models.

Knowledge based systems:
In the 70's of last century so-called expert systems were designed for cases in which closed mathematical models could not be developed by acquiring the knowledge of experts and using it in formal inference schemes. The most common method was that of collecting the knowledge as if-then-rules and then applying formal inference methods of logic (modus ponens etc.) in order to arrive at solutions. High expectations in expert systems were most often not met. One of the main reasons was probably, that expert systems did not really process knowledge but only the truth values (true and false) of statements. Here fuzzy set theory enters: The fuzziness that existed in the statements of the experts was modelled by using “linguistic variables” which are context dependent and which are modelled by so-called membership functions. If an expert makes, for instance, the statement: “High age reduces the productivity” the term “high age” means very different things if it applied to mayflies, humans or turtles. Also the meaning of “an old man” can be very different, depending on who uses it. The word “big” has very different meanings, depending on whether it refers to diamantes, rocks or mountains. The context (to which the statement refers) and the fuzziness of the boundaries is now modelled by the membership function. After one has expressed the fuzziness of the expert's knowledge, the statements also has to be combined with other (fuzzy) statements appropriately in order to arrive at a result which resembles the result that a human expert would have found. For this inference process fuzzy set theory has also suggested numerous ways.
There successful application was shown in the 80's of last century particularly in the area of Fuzzy Control. These were fuzzy control systems by which washing machines, video cameras, subways, cranes, and many other technical systems were successfully controlled, even though the design of classical control models was very difficult or even impossible due to nonlinearities and other complications. In more recent times the application of knowledge based systems as Fuzzy Expert Systems has gained more acceptance in the area of management (so-called business intelligence). They are used for portfolio analysis, strategic planning, fraud detection and prevention, the determination of credit worthiness etc. Hence, they are useful wherever formal mathematical methods are inferior to the knowledge of experts. Increasingly fuzzy modules are also combined with classical decision making tools.

Contact:
INFORM GmbH,
Pascalstrasse 23, 52076 Aachen, Germany
info@inform-ac.com, www.inform-ac.com

INFORM

Relaxation

Classical models of problems (of pattern recognition, optimisation etc.) are usually “crisp” since mathematical methods for their solution require this. This even though problems, as they are observed by people, do often not have the “either-or structure” but are more of the “more-or-less” type. A crisp model often pretends a higher accuracy than it has in reality. Fuzzy set theory provides means to model problems such that the fuzziness of the problem is maintained. The solution of such a model can then be determined either by fuzzy methods or even by efficient crisp methods.

In the area of optimisation this leads, for instance, from crisp classical linear programming to fuzzy mathematical programming, here Objective functions as well as constraints can be either fuzzy or crisp. Similar possibilities exist for multi criteria decision models, certain problems in critical path methods, heuristic methods etc..

For ever increasing masses of data methods for data mining and pattern recognition become more and more important. This area is the focus of fuzzy data analysis. Here also the character of the structure of models changes: Let us consider cluster analysis: It serves to find in a large number of elements (people, observations etc.) a smaller number of clusters (classes), which are homogeneous in themselves. In classical cluster analysis one assumes, that each element belongs exactly to (at most) one class. Now consider a number of project that shall be classified into classes of “risky projects”, “attractive projects”, “future-oriented projects”. One can easily see that a classical distribution of projects to these classes is not possible or does not make sense. The same is true if, for instance, for customer segmentation, if different class criteria have to be used. Fuzzy cluster methods are, therefore, often more adequate because they do not require that each element belongs exactly (and fully) to one class or not. They rather determine a degree to which elements belong (possibly to several) to classes.

What are the aims of FuzzyTech?

One could possibly assume, that the application of “fuzzy logic” is only possible, if a specialist is well familiar with fuzzy set theory and also with the problem that has to be solved. FuzzyTech is a software (tool or shell) which makes it possible to model problems by use of fuzzy set theory even though one is not a specialist in fuzzy set theory. It is possible to use FuzzyTech to describe a problem graphically or linguistically. FuzzyTech then compiles this description and solves the model on a normal digital computer. FuzzyTech, for instance, offers a number of membership functions for the modelling of linguistic expressions (words or sentences). It also offers different “operators” which are used to join different parts of knowledge in if-then-rules, and it offers inference methods to finally arrive at a solution.

Contact:
INFORM GmbH,
Pascalstrasse 23, 52076 Aachen, Germany
info@inform-ac.com, www.inform-ac.com

INFORM