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Fuzzy logic

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Abstract: This paper described the overview of Fuzzy Logic. Many type of critical questions are answered in the paper. This paper also represent the steps necessary to develop a fuzzy expert system (FES) from the initial model design through to final system evaluation will be presented. The current state-of-the-art of fuzzy modeling can be summed up informally as anything goes. What this actually means is that the developer of the fuzzy model is faced with many steps in the process, and each with many options from which selections must be made.

In general, there is no specific or prescriptive method that can be used to make these choices, there are simply heuristics which may be employed to help guide the process. Each of the steps will be described in detail. Fuzzy logic is a mathematical formalism based on the theory of fuzzy sets, provides tools that are of potential interest here.

The fuzzy logic is the basis of fuzzy control which is used in an increasing number of applications characterized by large uncertainty. Whether, fuzzy logic offers a wide range of aggregation operators that can be used to trade off different goals. The computation suggests its use as a formalism to integrate the numeric control and symbolic planning. While many applications of fuzzy logic control have appeared in the autonomous robotics literature. This thesis explores the possible uses of fuzzy logic for autonomous robot navigation.

1. INTRODUCTION

Fuzzy logic can be defined as a superset of conventional (Boolean) logic that has been extended to handled the concept of partial- true values between "completely true" and "completely false".

Fuzzy Logic (FL) is a multi value logic, that allows intermediate values to be defined between conventional evaluations like true/false, yes/no, high/low, etc. Notions like rather tall or very fast can be formulated mathematically and processed by Computers, In order to apply a more human-like way of thinking in the programming of computers. Fuzzy systems is an alternative to traditional notions of set membership and logic that has its origins in ancient Greek philosophy. Whether, The precision of mathematics owes its success in large part to the efforts of Aristotle and the philosophers who preceded him. Fuzzy Logic has emerged as profitable tool for the controlling and steering of systems and complex industrial processes, as well as for household and entertainment electronics, as well as for other expert systems and applications like the classification of SAR data.

2. FUZZY LOGIC

Fuzzy logic can be defined as a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth - truth values between "completely true" and "completely false"

How it work:

- Basics of Fuzzy Logic (Rules)
  - Operates similar to humans
- Humans base their decisions on conditions
  - Operates on a bunch of IF-THEN statements
  - An example is A then B, if C then D where B and D are all set of A and C.

Steps by Step Approach

- Step One
  - Define the control objectives and criteria.
- Consider question like
  - What is trying to be controlled?
  - What has been done to control the system?
  - What kind of response has been needed?
  - What are the possible (probable) system failures modes?
- Step Two
  - Determine input and output relationships
  - Determine the least number of variables for inputs to the fuzzy logic system
- Step Three
  - Break down the control problem into a series of IF X AND Y, THEN Z rules based on the fuzzy logic rules.

- These IF X AND Y, THEN Z rules should define the desired system output response for the given systems input conditions.

- Step Four
  - Create a fuzzy logic membership function that defines the meaning or values of the input and output terms used in the rules
- Step Five
  - After the membership functions are created, program everything then into the fuzzy logic system
- Step Six
  - Finally, test the system, evaluate results and make the necessary adjustments until a desired result is obtain
- The above steps are summarized into three main stages
  - Fuzzification
- Membership functions used to graphically describe a situation
  - Evaluation of Rules
- Application of the fuzzy logic rules
  - Diffuzification
- Obtaining the crisp results

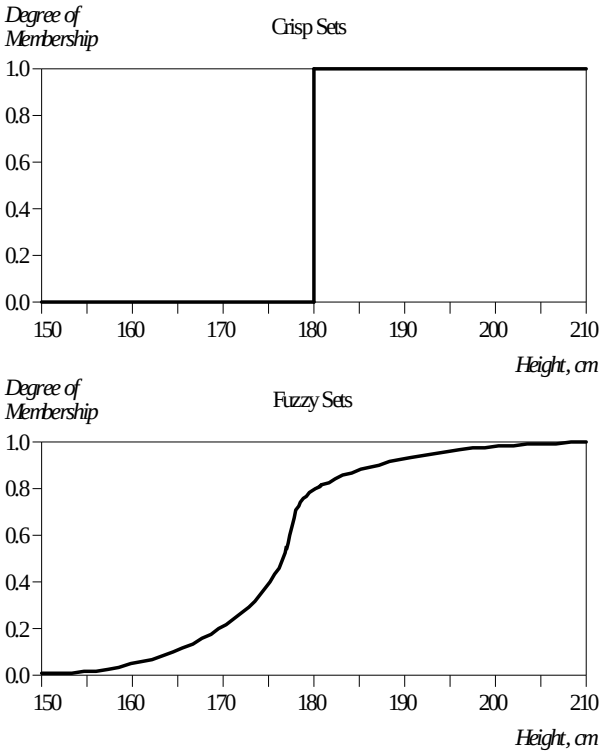
3. DIFFERENCE BETWEEN FUZZY LOGIC AND BOOLEAN LOGIC?

Boolean logic has sharped distinctions. It forces to draw lines between members of a class and non-members. For instances, Tom is tall because his height is 181 cm. If we draw a line at 180 cm, we would find that David, who is 179 cm, is small. Is David a small man or we have just drawn an arbitrary line in the sand? Fuzzy logic reflects that how people think. It attempts to model is our sense of words, our decision making and our common sense. As a result, it is leading to new, more human, intelligent systems

4. FUZZY SETS AND CRISP SETS

The concept of a set is fundamental to mathematics.
Our own language is also the supreme expression of sets. For example, car indicated the set of cars. When we say a car, we mean that one out of the set of cars. Crisp set theory is the governed by a logic that uses one of only two values: true or false. This logic cannot represent vague concepts, and therefore fails to give the answers on the paradoxes. The basic idea of the fuzzy set theory is that an element belongs to a fuzzy set with the certain degree of membership.This degree usually taken as a real number in the interval [0, 1].
The classical example of fuzzy logic in fuzzy sets is tall men. The elements of the fuzzy set "tall men" are all men, but their degrees of the membership depend on their height.

Name	Height, cm	Degree of Membership	
		Crisp	*Fuzzy*
Chris	208	1	1.00
Mark	205	1	1.00
John	198	1	0.98
Tom	181	1	0.82
David	179	0	0.78
Mike	172	0	0.24
Bob	167	0	0.15
Steven	158	0	0.06
Bill	155	0	0.01
Peter	152	0	0.00



The *y*-axis represents the membership value of the fuzzy set. In our case, the fuzzy set of "*tall men*" maps that height values into corresponding membership values. Let X be the universe of discourse and its elements be denoted as x. In the classical set theory, crisp set A of X is defined as function $f_A(x)$ called the characteristic function of A

$f_A(x)$: $X \rightarrow \{0, 1\}$, where

This set maps universe X to a set of two elements. For any element like x of universe X, characteristic function $f_A(x)$ is equal to 1 if x is an element of set A, and is equal to 0 if x is not an element of A.
In the fuzzy logic theory, fuzzy set A of universe X is defined by function $\mu_A(x)$ called the *membership function* of set A

$\mu_A(x)$: $X \rightarrow [0, 1]$, where $\mu_A(x) = 1$ if x is totally in A;$\mu_A(x) = 0$ if x is not in A

$0 < \mu_A(x) < 1$ if x is partly in A.

This set allows a continuos of possible choices. For any element x of the universe X, membership function $\mu_A(x)$ equals

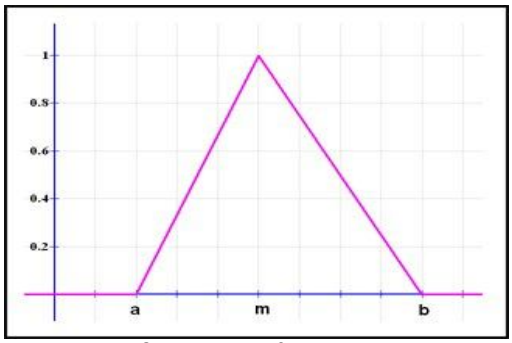
the degree to which *x* is the element of set *A*. This degree described a value between 0 and 1.

5. MEMBERSHIP FUNCTIONS

a membership function for a fuzzy set A on the universe of discourse X is defined as μ_A:X → [0,1], where each element of X is mapped to a value between 0 and 1. This value is called membership value or degree of membership, quantifies the grade of membership of the element in X to the fuzzy set A.

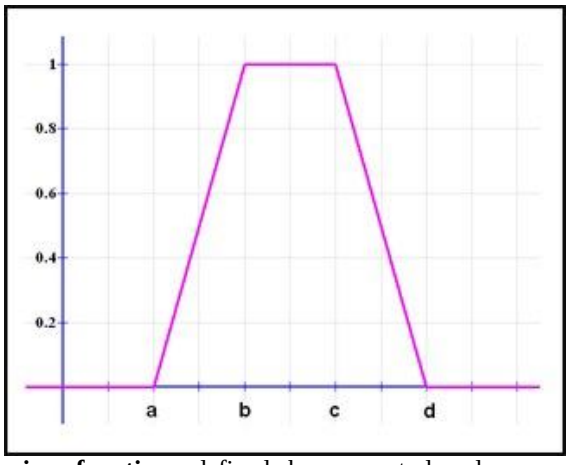
Triangular function: defined by a lower limit **a**, an upper limit **b**, and a value **m**, where **a < m < b**.

$$\mu_A(x) = \begin{cases} 0, & x \le a \\ \frac{x-a}{m-a}, & a<x\le m \\ \frac{b-x}{b-m}, & m<x<b \\ 0, & x\ge b \end{cases}$$



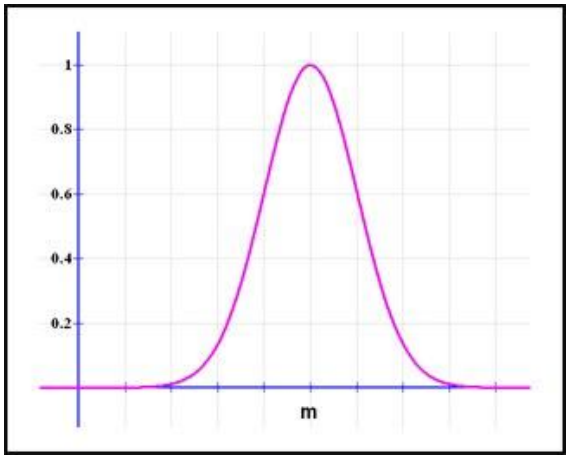
Trapezoidal function: defined by a lower limit **a**, an upper limit **d**, a lower support limit **b**, and an upper support limit **c**, where **a < b < c < d**.

$$\mu_A(x) = \begin{cases} 0, & (x < a) \text{ or } (x>d) \\ \frac{x-a}{b-a}, & a\le x\le b \\ 1, & b\le x\le c \\ \frac{d-x}{d-c}, & c\le x\le d \end{cases}$$



Gaussian function: defined by a central value **m** and a standard deviation **k > 0**. The smaller k is, the narrower the "bell" is.

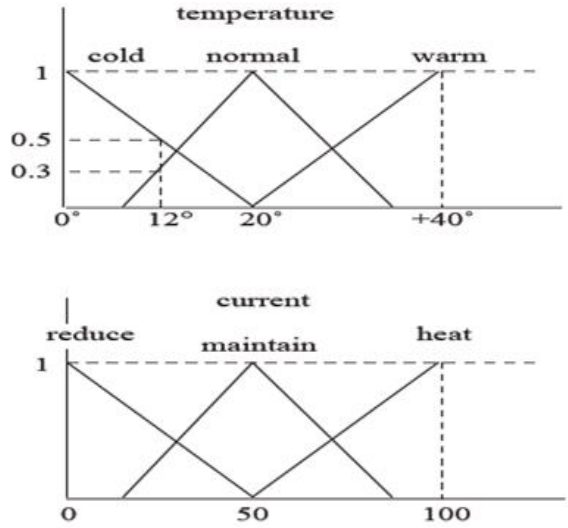
$$\mu_A(x) = e^{-\frac{(x-m)^2}{2k^2}}$$



6. FUZZY CONTROLLERS

In fuzzy logic, fuzzy code designed to control many things, usually mechanical. They can be in software and hardware and can be used in anything from small circuits to large mainframes.

The example with the electrical heater will be completed in this section. We must determine the domain of definition of the variables used in the problem Figure 11.14 shows the membership functions for the temperature categories "cold", "normal", and "warm" and the control categories "reduce", "maintain", and "heat".



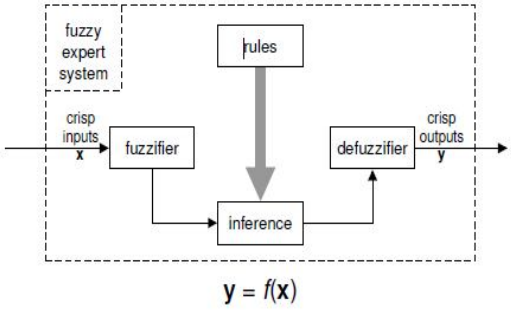
Membership functions for temperature and electric current categories The temperature of 12 degrees corresponds to the fuzzy number T = cold/0.5+normal/0.3+warm/0.0. These values lead to the previously computed Inference action=heat/0.5+maintain/0.3+reduce/0.0.The controller must transform the result of this fuzzy inference into a definite value. The surfaces of the membership triangles below the inferred degree of membership are calculated. The light shaded surface in Figure 11.15 corresponds to the action "heat", which is valid to 50%. The darker region corresponds to the action "maintain" that is valid to 30%. The centroid of the two shaded regions lies at about 70.

Why Should We Use Fuzzy Controllers?

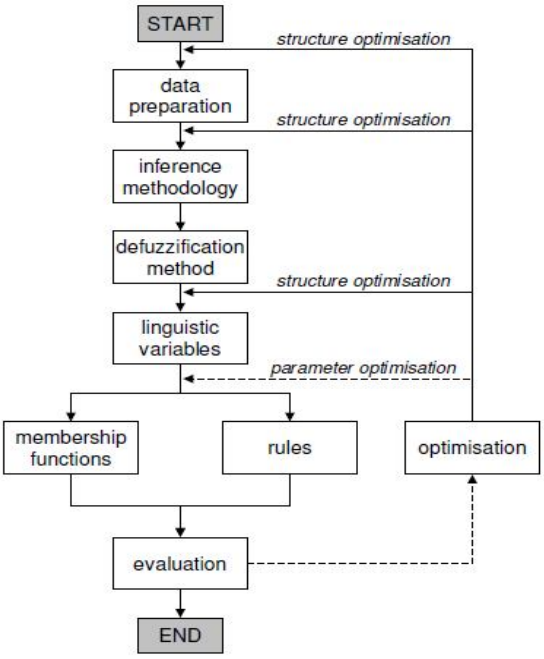
• Very robust
• Can be easily modified
• Can use multiple inputs and outputs
Sources.
• Much simpler than its predecessors
• Very quick and cheaper to implement

7. FUZZY EXPERT SYSTEM

The generic architecture of a fuzzy expert system showing the flow of data through the system is shown in Fig. Whether, The general process of constructing such like a fuzzy expert system from initial model design to system evaluation is shown in Fig. This illustrates the typical process flow as distinct stages for clarity but in reality the process was not usually composed of such kind of separate discrete steps and many of the stages, although present, are blurred into each other.



However, Generic architecture of a fuzzy expert system. Once the problem has been clearly specified the process of constructing the fuzzy expert system begin. Invariably some degree of data.



Typical process flow in constructing a fuzzy expert system The essential difference in these two methodologies is that the result of Mamdani inference is one or more fuzzy sets which must (almost always) then be defuzzified into one or more real numbers, whereas the result of TSK inference is one or more real functions which may be evaluated directly. Thus the choice of inference methodology is linked to the choice of defuzzification method. Once the inference methodology and defuzzification method have been chosen, the process of enumerating the linguistic variables necessary can commence. The next stage of deciding the necessary terms with their defining membership functions and determining the rules to be used is far from trivial however. Indeed, this stage is usually the most difficult and time consuming of the whole process. After a set of fuzzy membership functions and rules has been establish the system may be evaluated and usually by

comparison of the obtained output against some desired or known output using some form of the error or distance function. However, it is very rare that the first system constructed will perform at an acceptable level. Usually some form of optimisation or performance tuning of the system will need to be undertaken. There are a multitude of options that a designer may consider for model optimisation.

8. CONCLUSION

In this paper we discussed the fuzzy logic and what is different between Boolean and fuzzy logic.
this paper also represent how we can use fuzzy set and member Function and Also represent how we can use fuzzy logic in Expert System.

9. ACKNOWLEDGMENT

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