# A Very Brief Introduction to Fuzzy Control

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# Fuzzy Sets

- The most basic notion underlying fuzzy systems is the Fuzzy set

- Fuzzy sets are sets whose elements have degrees of membership which range continuously from 0 (false) to 1(true)

- Fuzzy sets were introduced by Lotfi A. Zadeh in 1965 as an extension of the classical notion of set (which are sometimes called “crisp” sets to distinguish them from fuzzy sets)

# Fuzzy Logic

- Zadeh went on to define new versions of the AND, OR and NOT operators which are defined to operate on these continuous values
- this enables logical inferences to be made
- this effectively created a *fuzzy logic inference* system

# Linguistic Variables

- The basic concept underlying FL is that of a linguistic variable
  - a variable whose values are ***words*** rather than numbers

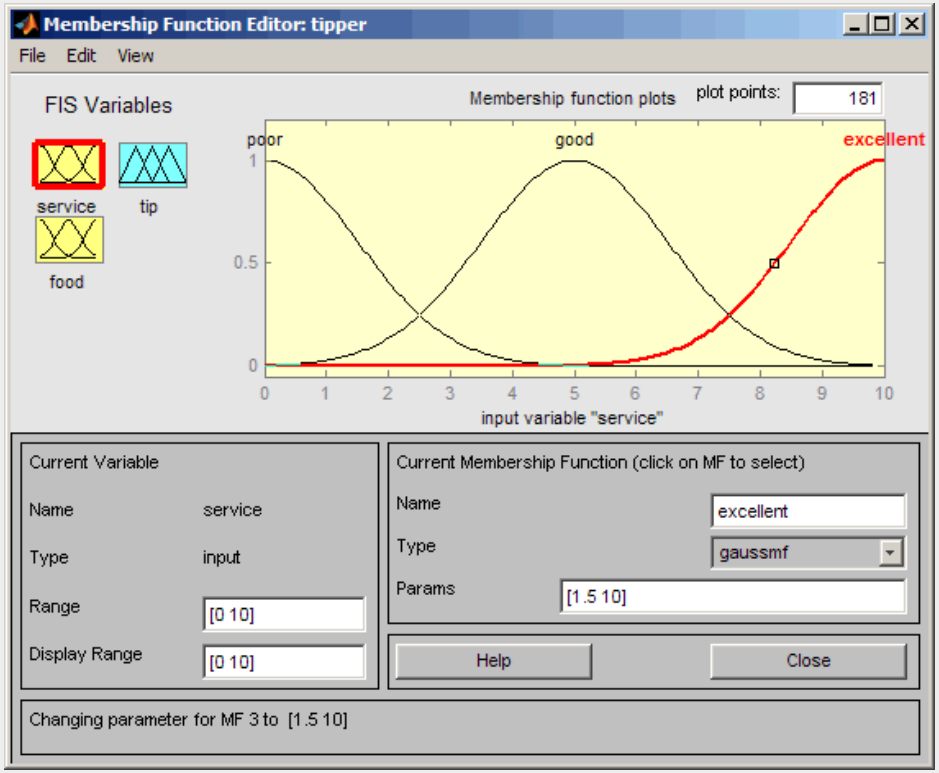
- In effect, much of FL may be viewed as a methodology for computing with words rather than numbers

- Although words are inherently less precise than numbers, their use is closer to human intuition

- Furthermore, computing with words exploits the tolerance for imprecision and thereby lowers the cost of solution

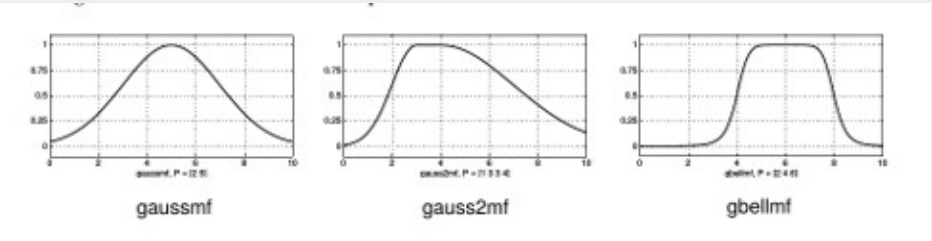
# Membership Functions

- Linguistic variables are defined using Membership Functions
- A membership function (MF) is a curve that defines how each point in the input space is mapped to a membership value (or degree of membership) between 0 and 1
- The input space is sometimes referred to as the *universe of discourse*, a fancy name for a simple concept



# MATLAB MFs

- The MATLAB toolbox includes 11 built-in membership function types. These 11 functions are, in turn, built from several basic functions:
  - piece-wise linear functions (trimf, trapmf)
  - Gaussian distribution functions (gaussmf, gauss2mf)
  - generalised bell functions (gbellmf)
  - sigmoid curves (sigmf, dsigmf, psigmf)
  - quadratic and cubic polynomial curves (zmf, pimf, smf)



# MFs continued

- membership functions in the Fuzzy Toolbox have the letters mf at the end of their names
- The simplest membership functions are formed using straight lines
- the simplest is the triangular membership function trimf
  - This function is nothing more than a collection of three points forming a triangle
- The trapezoidal membership function, trapmf, has a flat top and really is just a truncated triangle curve
- These straight line membership functions have the advantage of simplicity and very often perform as well as the more complicated curves

# What is Fuzzy Control?

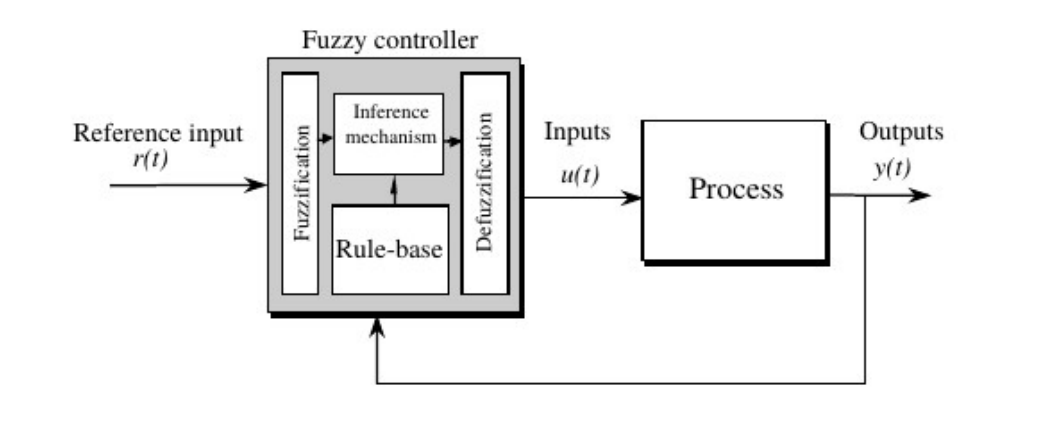
- Fuzzy control is a methodology to represent and implement a (smart) human's knowledge about how to control a system.
- The fuzzy controller has several components:
  - The rule-base is a set of rules about how to control a system
  - Fuzzification is the process of transforming the numeric inputs into a form that can be used by the inference mechanism.
  - The inference mechanism uses information about the current inputs (formed by fuzzification), decides which rules apply in the current situation, and forms conclusions about what the plant input should be.
  - Defuzzification converts the conclusions reached by the inference mechanism into a numeric input for the plant.

# Fuzzy Rules

- Another basic concept in FL, which plays a central role in most of its applications, is that of a *fuzzy if-then* rule or, simply, fuzzy rule

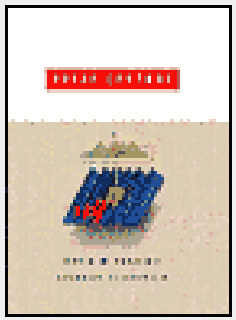
- Although rule-based systems have a long history of use in Artificial Intelligence, what is missing in such systems is a mechanism for dealing with fuzzy consequents and fuzzy antecedents

# Fuzzy Control System




- This block diagram shows a very simple control loop incorporating a Fuzzy Controller
- We will look at an example in the practical session

# Some Further Reading



Passino & Yurkovich, 1997, Fuzzy Control

download from
http://www2.ece.ohio-state.edu/~passino/FCbook.pdf

# To be continued ...

- Now do the **Fuzzy Control System Tutorial**