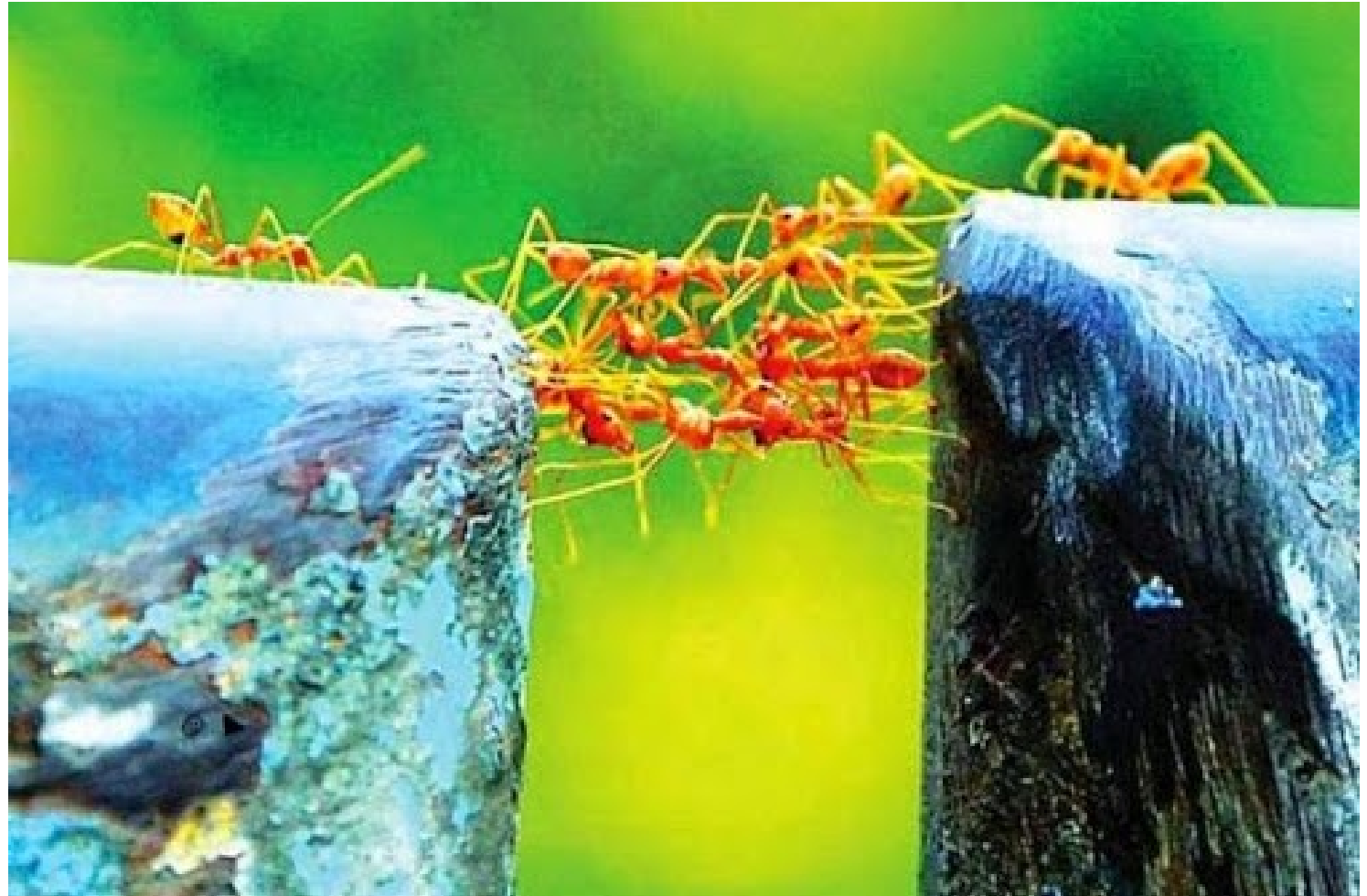
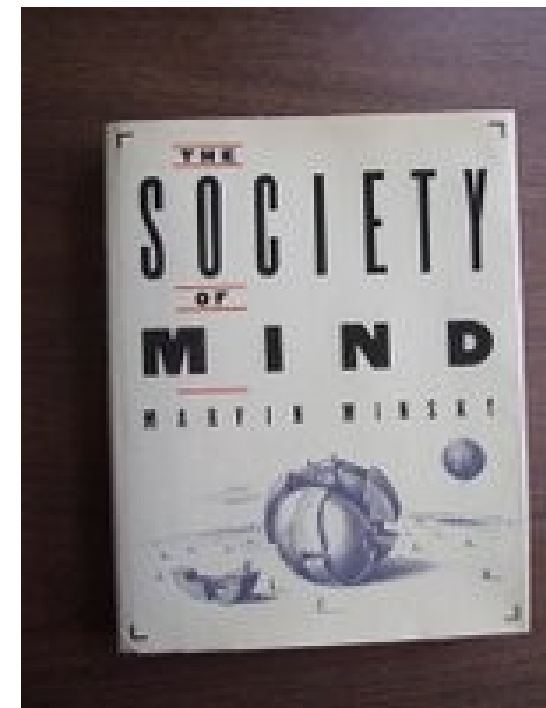


Making “ants” smarter





Marvin Minsky (1927 - 2016)



(1986)

<http://aurellem.org/society-of-mind/>

You know that everything you think and do is thought and done by you. But what's a you?
What kinds of smaller entities cooperate inside your mind to do your work?
To start to see how minds are like societies, try this: pick up a cup of tea!

Your GRASPING agents want to keep hold of the cup.
Your BALANCING agents want to keep the tea from spilling out.
Your THIRST agents want you to drink the tea.
Your MOVING agents want to get the cup to your lips.

Yet none of these consume your mind as you roam about the room talking to your friends.
You scarcely think at all about Balance;
Balance has no concern with Grasp;
Grasp has no interest in Thirst;
and Thirst is not involved with your social problems. Why not?
Because they can depend on one another.
If each does its own little job, the really big job will get done by all of them together: drinking tea.

excerpt – The Society of Mind

.... and what do you think ants do ?

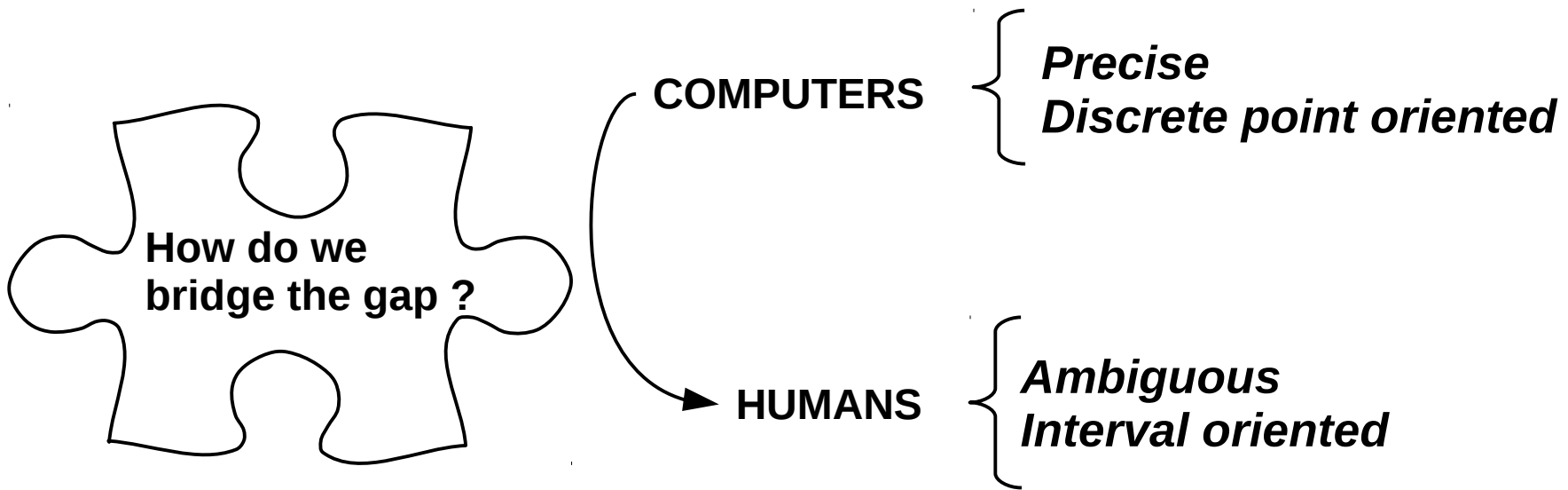
***Precise
Discrete point oriented***

IF temperature > 72 F and humidity > 30%
THEN start A/C at 10 CFM

VS

IF temperature is warm and humidity is medium
THEN set A/C at medium

***Ambiguous
Interval oriented***



Discrete point orientation MAP *Interval orientation*

Below the text "MAP" is a thick black arrow pointing to the right.

ENTER → FUZZY LOGIC

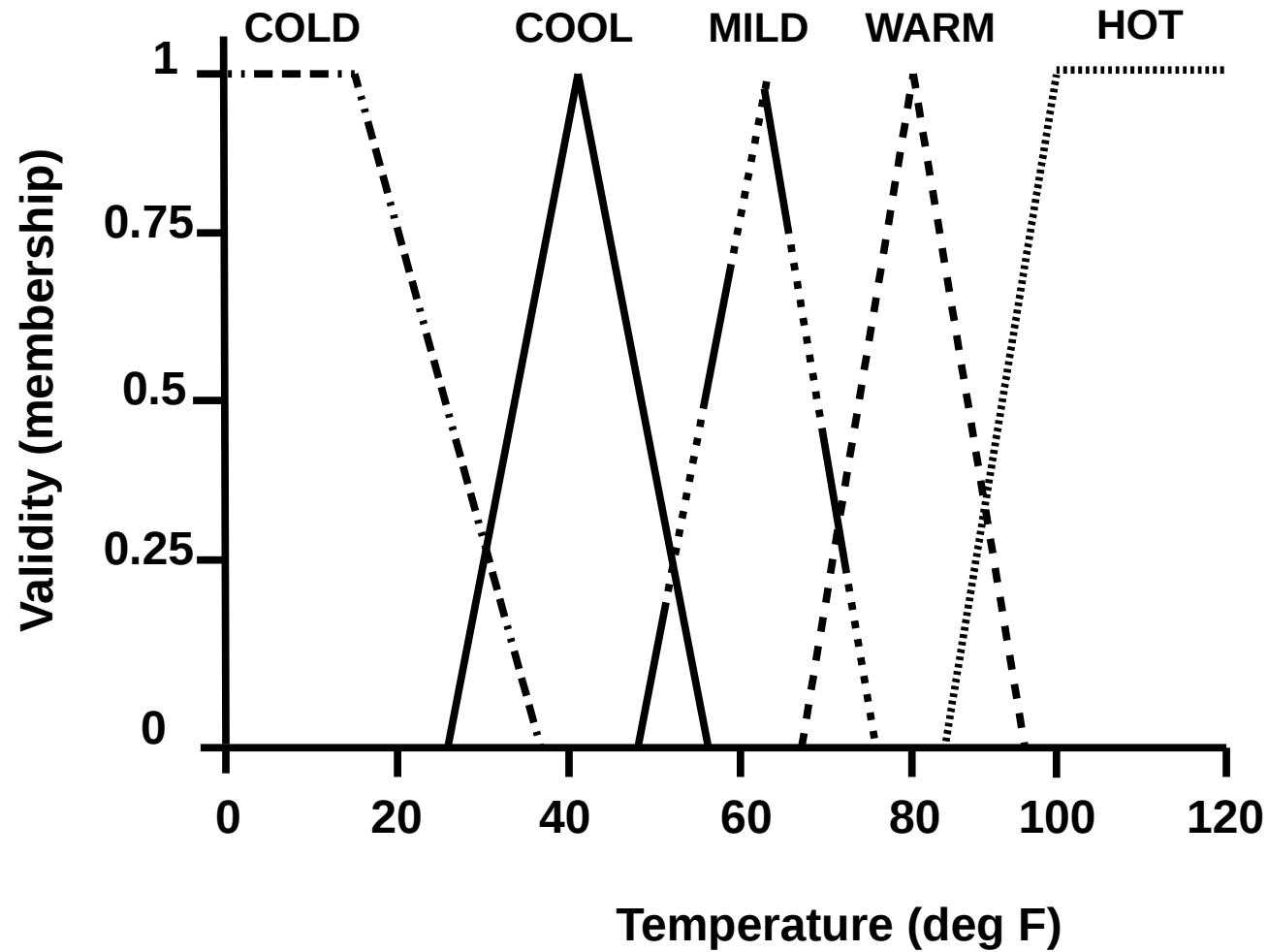
- **multi-valued logic**
- **binary logic: true, false**
- **multi-valued: degrees of truth**
- **continuous values from 0 to 1**
 - **0 = no validity**
 - **1 = full validity**
 - **> 0 and < 1 = degrees of validity**



temperature reading → 68 F

- **Binary logic**
 - **temperature > 72 F → false**
- **Fuzzy logic**
 - **temperature is warm → 0.26**
 - **temperature is mild → 0.45**

MEMBERSHIP FUNCTION



**IF temperature is warm and humidity is mild
THEN ac is low**

**IF temperature is warm and humidity is muggy
THEN ac is medium**

**IF temperature is hot
THEN ac is high**

**IF temperature is mild
THEN ac is idle**

**IF temperature is warm and room occupancy is high
THEN ac is high**

**IF room occupancy is empty
THEN ac is idle**

1. For each rule in the set,

- 1. Calculate the validity of the LHS (μ_{LHS}).**
- 2. Record the calculated validity of the LHS.**
- 3. Obtain the corresponding value of the RHS parameter and use it to calculate the centroid of its μ (v_{RHS}).**
- 4. Record the corresponding value for the RHS parameter.**

2. Perform a centroid calculation on all the recorded RHS and LHS parameter μ values to obtain the precise value of the RHS parameter

Centroid calculation:

$$\left(\sum_{i=1}^N \mu_{LHS_i} * v_{RHS_i} \right) / \left(\sum_{i=1}^N \mu_{LHS_i} \right)$$

RULE SET

**A: IF temperature is warm and humidity is mild
THEN set ac at low**

**B: IF temperature is warm and humidity is muggy
THEN set ac at medium**

CURRENT READINGS

**temperature: 75 F
humidity: 26 %**

STEP 1

**A: μ_{LHS} : $\min(0.5, 0.6) = 0.5$
 $v_{RHS} = 5$**

**B: μ_{LHS} : $\min(0.5, 0.10) = 0.1$
 $v_{RHS} = 10$**

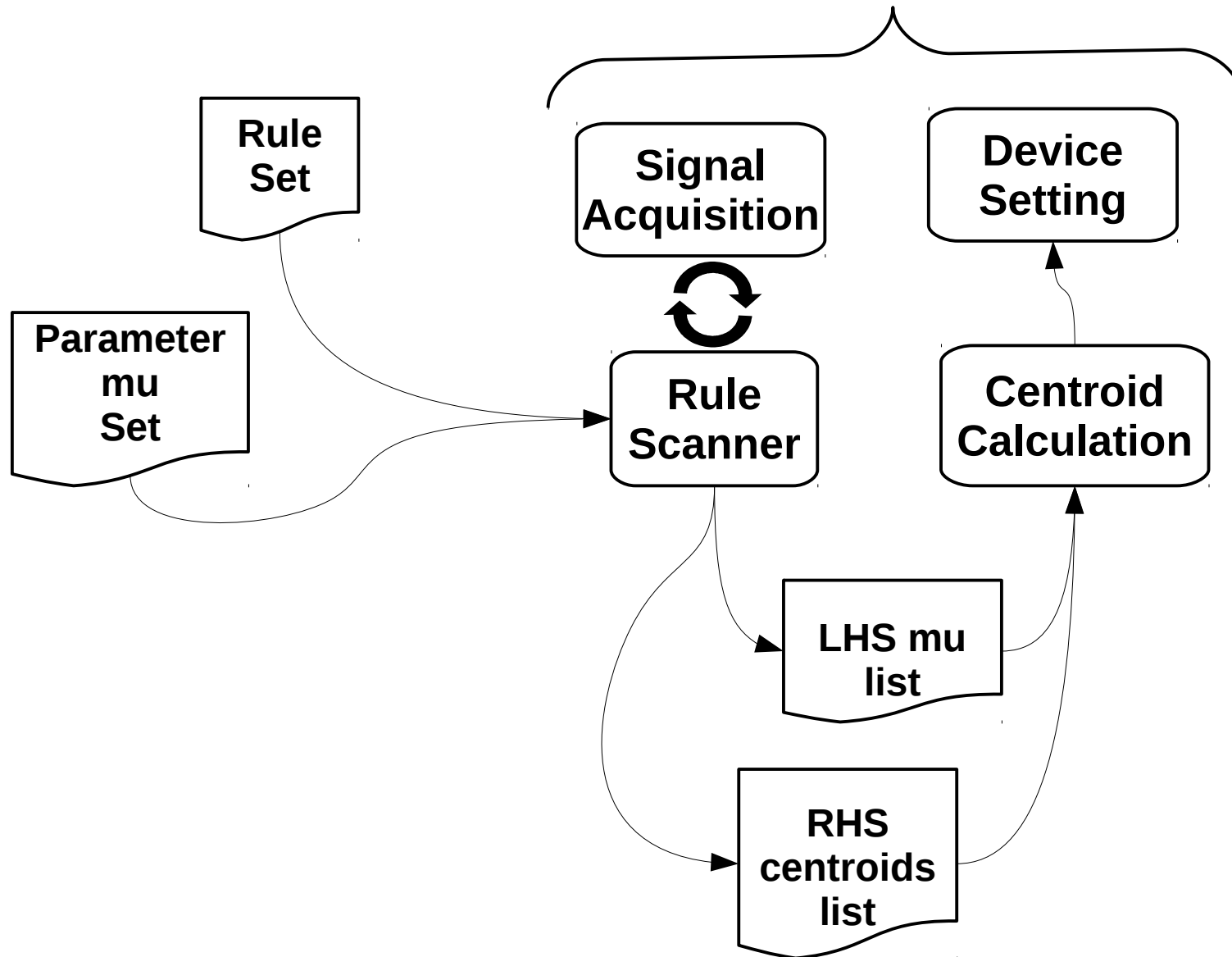
NOTE:

**ac measured as cfm
of cold air output**

STEP 2

$ac = (0.5 * 5 + 0.1 * 10) / (0.5 + 0.1) \sim \underline{5.8}$

Fuzzy Inference

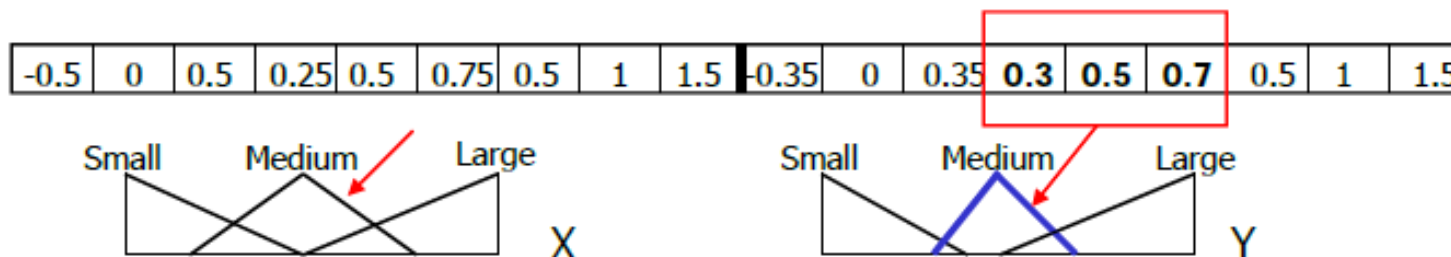
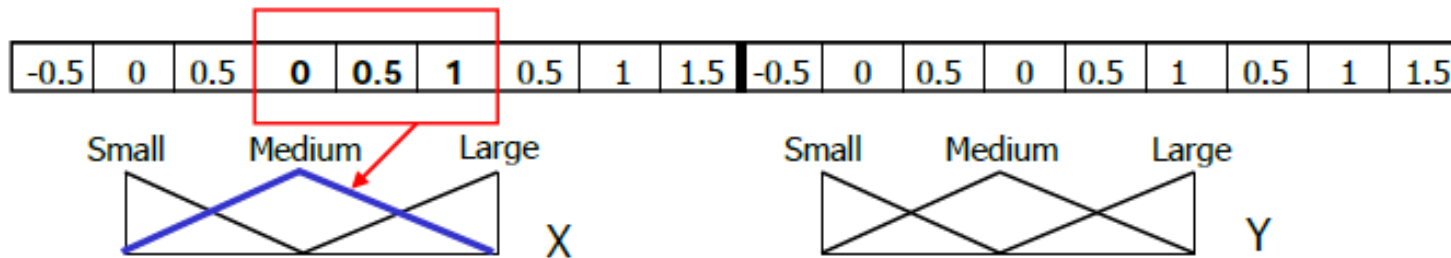


Applications of Fuzzy Logic

- **Elevators**
 - Traffic management during peak office hours
- **Industrial Automation**
 - PLC's for complex, non-linear processes
 - Multi-variable process controller
 - Sway control for overhead cranes (since 1995)
- **Transportation**
 - Running subway trains (Sendai, Japan)
 - Automotive transmission control (Japan)
- **Building systems**
 - Hospital climate control (Germany)
 - Appliance control (washing machines)
- **Autonomous aircraft**
 - ALPHA fighter 'pilot'

Learning membership functions

- Technique: Genetic Algorithms
 - Approach: modify a knowledge structure (rule, object) over time
 - Selection: fitness function
 - Selection operations: mutation, cross-over
- Example: learning membership functions
 - 2 variables * 3 ranges = 6 membership functions
 - each range defined by a (minimum) of 3 points
 - 6 membership functions * 3 points = 18 chromosomes



- ***Fuzzy Systems Theory and Its Applications*** - Terano, Asai, and Sugeno
 - Amazon.com (hardcover is ~ \$19)
 - Mathematical and deep
 - Good breadth on application areas such as:
 - Diagnosis
 - Control
 - Robotics
 - Image recognition
 - Statistical decision making
- ***Fuzzy Logic - Controls, Concepts, Theories and Applications***
 - Available at <http://www.intechopen.com/books/fuzzy-logic-controls-concepts-theories-and-applications>
 - Open Access (FREE !)
 - Collection of articles covering fuzzy logic concepts and applications such as:
 - Robotics
 - Wheelchair control
 - Power systems
 - Aluminum smelting

- **JfuzzyLogic** – Fuzzy Logic library in Java
<http://jfuzzylogic.sourceforge.net/html/index.html>
- **fuzzylite** – Fuzzy Logic library in C++, Java, Android
<http://www.fuzzylite.com/>
- **PsiberLogic 2.1.0** – Genetic Fuzzy Tree platform in Python
<https://pypi.python.org/pypi/PsiberLogic>

DEMO

TIME