Fuzzy Logic

Real Life Examples.....

Where did Fuzzy Logic come from

People generally do not divide things into clean categories, yet still make solid, adaptive decisions

Dr. Zadeh felt that having controllers to accept 'noisy' data might make them easier to create, and more effective

Simple example of Fuzzy Logic

Controlling a fan:

Conventional model –

if temperature > X, run fan
else, stop fan

Fuzzy System -

if temperature = hot, run fan at full speed
if temperature = warm, run fan at moderate speed
if temperature = comfortable, maintain fan speed
if temperature = cool, slow fan
if temperature = cold, stop fan

Applications of Fuzzy Logic

Vehicle Control

A number of subway systems, particularly in Japan and Europe, are using fuzzy systems to control braking and speed. One example is the Tokyo Monorail

Applications of Fuzzy Logic

Appliance control systems

Fuzzy logic is starting to be used to help control appliances ranging from rice cookers to small-scale microchips (such as the Freescale 68HC12)

How does fuzzy logic relate to IDSS

"One of the most useful aspects of fuzzy set theory is its ability to represent mathematically a class of decision problems called multiple objective decisions (MODs). This class of problems often involves many vague and ambiguous (and thus fuzzy) goals and constraints."

MODs show up in a number of different IDSS areas – E-commerce, tutoring systems, some recommender systems, and more

“A fuzzy decision maker”

It can be difficult to distinguish between various goals and categories at times

*Is a goal in an e-commerce decision hard or soft?

*When is a restaurant crowded, or only slightly crowded?

One specific Fuzzy logic IDSS

There have been many projects in which fuzzy logic has been combined with IDSS.

One common case is in navigational and sensor systems for robotics

A specific example is:
Fuzzy Logic in Autonomous Robot Navigation

Autonomous Robotics

Autonomous robotic systems are ones which are designed to “move purposefully and without human intervention in environments which have not been specifically engineered for it”

Example of autonomous systems:
the Mars rovers Spirit and Opportunity
(the rovers use fuzzy logic in part to help with navigation, sample identification and learning)

IDSS and Autonomous Robotics

Autonomous Robot Systems require multiple components:

1) Pursue goals
2) Real Time Reaction
3) Build, Use and maintain an environment map
4) Plan formulation
5) Adaptation to the environment

Autonomous Robot Architecture

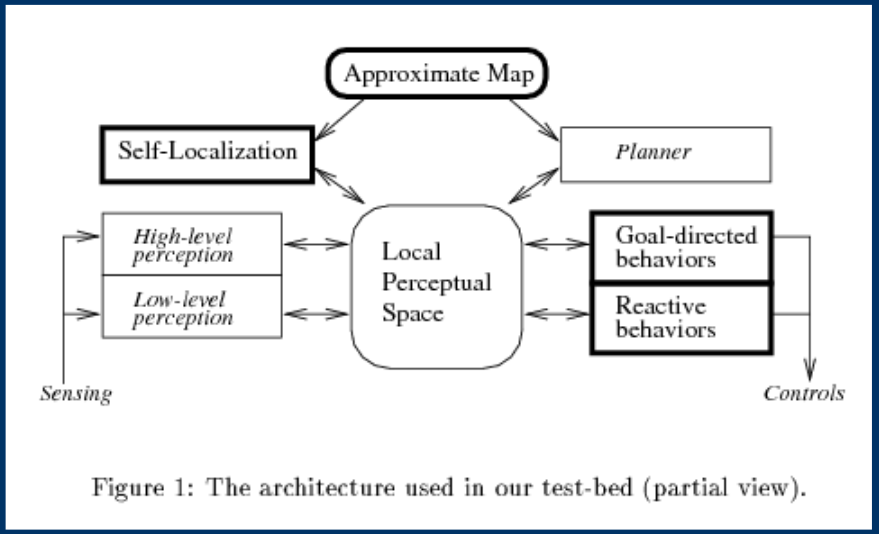

Figure 1: The architecture used in our test-bed (partial view).

Parts using Fuzzy Logic

Fuzzy techniques have been used to

1) implement basic behaviors which tolerate uncertainty

2) coordinate multiple actions to reach a goal

3) help the robot remember where it is with respect to its map

Basic Behaviors using Fuzzy Logic

Each behavior is described in terms of a desirability function, based on the current state and the various controls active:

$$Des_B : \text{State} \times \text{Control} \rightarrow [0, 1]$$

Basic Behaviors using Fuzzy Logic

IF Target-Left $\wedge$ $\neg$Out-of-Reach	THEN Turn-Left(8)
IF Target-Right $\wedge$ $\neg$Out-of-Reach	THEN Turn-Right(8)
IF Target-Left $\wedge$ Out-of-Reach	THEN Turn-Right(4)
IF Target-Right $\wedge$ Out-of-Reach	THEN Turn-Left(4)
IF Target-Ahead	THEN Go-Straight

(Out of reach means it is too close to pick up)

Behavior Coordination

IF obstacle	THEN KEEP-OFF
IF ¬obstacle ∧ at(Corr1) ∧ ¬at(Corr2)	THEN FOLLOW(Corr1)
IF ¬obstacle ∧ at(Corr2) ∧ ¬near(Door4)	THEN FOLLOW(Corr2)
IF ¬obstacle ∧ near(Door4) ∧ ¬at(Room4)	THEN CROSS(Door4)
IF at(Room4)	THEN STOP

Figure 5: A plan for reaching Room4 in the environment in Figure 9

Using Map Information

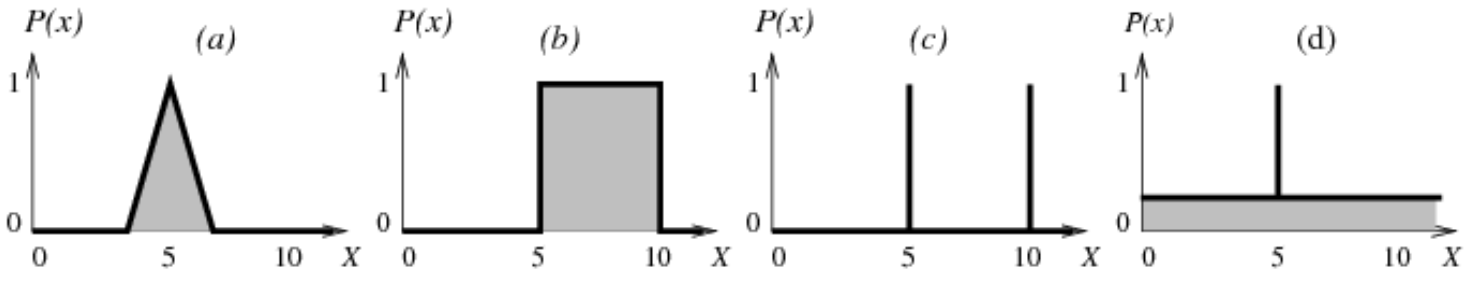

Figure 6: Representing different types of approximate locations by fuzzy sets.

Conclusions

Fuzzy Logic is a different, but still effective, type of logic and knowledge representation

Can be applied to numerous areas, especially robotics

It can also be applied effectively to IDSS and decision making