COMP 4106* Fall Term – 2008 Due: Thu, Nov 27, 2008

Assignment 3

Implement the Fuzzy Control System described below.

Good luck (and start thinking about the project ;-))

Fuzzy Nuclear Cooling Tank Controller

There is a water tank cooling the core of a nuclear power plant. To properly cool the reactor core, the water temperature must be maintained between 10 and 70 degrees. Below 10 degrees the plant will be unable to generate enough power, and it will shut down, above 70 it will undergo melt-down (as Mr. Burns would say, an "unrequested fission surplus") and destroy itself! Input to the tank is through two pipes, one for hot water (95 degrees) and one for cold water (5 degrees). The rate of incoming water varies each second, for each pipe. Output is through a drain pipe. The tank must never become less than ½ full, and it must never fill completely either. The reactor core heats the water in the tank at a rate that varies each second. Your fuzzy controller can adjust the percentage of incoming water allowed through each input pipe separately (for example: if hot water is entering at 7 l/s and your controller is stemming the flow at 50%, the input is only 3.5 l/s – your fuzzy system attains 3.5 l/s only indirectly by directly manipulating the percentage of flow). Your fuzzy controller also controls the percentage of flow on the output pipe in the same manner.

Make the following amounts vary randomly each second:
(Make the variations ***smooth*** – ie: don't just choose a uniform random value in the range at each time step)

- Incoming hot water: between 1 and 10 litres/second
- Incoming cold water: between 1 and 10 litres/second
- Reactor core heating: between 0 and N degrees/second

Your fuzzy controller takes as input:

- The current water level in the tank as a percentage (Tank volume is a parameter – see X below)
- The current rate of hot water input available (the rate you'd get with 0% flow restriction)
- The current rate of cold water input available (same)
- The current tank temperature

Your fuzzy controller constantly adjusts the following aspects of the coolant tank:

- The percentage of flow restriction on the hot water input pipe
- The percentage of flow restriction on the cold water input pipe
- The percentage of flow restriction on the drain pipe (max: 15 litres/second)

Use the following simple calculation to update tank temperature and water volume each second:

W_h: Number of litres of hot water that entered the tank in the last second.
W_c: Number of litres of cold water that entered the tank in the last second.
W_d: Number of litres of water drained in the last second.
C_i: The amount of heating from the core at time i (in degrees).
V_i: Number of litres of water in the tank at time i.
T_i: Tank temperature at time i.

$$V_{i+1} = V_i - W_d + W_c + W_h$$

$$T_{i+1} = \frac{(5 * W_c) + (95 * W_h) + (T_i * (V_i - W_d))}{V_{i+1}} + C_i$$

You may begin by starting your tank off at any volume and temperature you wish (V_0 and T_0).
Implement this fuzzy controller using *linguistic variables* and *fuzzy sets* of your own choosing and design.

The system has two parameters: X and N.

N, as indicated above, is the maximum amount of heating possible from the reactor core.

X is the maximum water volume of the coolant tank.

Determine something about the limits of your fuzzy controller's ability in the following manner:

1) For X = 500 litres, determine how high and low N can go before your controller ***typically fails***.
2) For a fixed value of N (somewhere in the range found above) determine how high and low X can go before your controller ***typically fails***.

Remember, there are 4 ways the controller can fail:

- melt-down
- shut-down
- overfilling
- underfilling

It is your responsibility to come up with a clear and meaningful definition of "***typically fails***" – a definition that lends itself to an automated test by your program (ie: "typically fails" shouldn't just mean "I ran it once and it eventually reached a melt-down"). Your definition should be precise and statistical in nature (consider the word "typically" when pondering this one).

Create a simple graphical interface to show your system in action. Indicate water temperature by colour (blue for cold, red for hot, a gradient in between).

"EXCELLENT!"