C9 Fuzzy Control of a Two Tank System – AnyLogic

Hybrid Model / Algorithmic Fuzzy Control

Simulator: AnyLogic (www.xjtek.com) is a general-purpose simulation environment for discrete, continuous and hybrid systems. The modelling technology is entirely based on UML-RT, Java and differential-algebraic equations.

Model: The model is built up by modelling three states, conforming to UML (figure 1). "TwoTank1" and "TwoTank2" contain the system dynamics:

```
d(x1)/dt = 0.067*u-f
d(x2)/dt = f-0.0605*r*0.3*pow(x2,0.48)
```

The transitions in-between formulate the discontinuous behaviour of the turbulence parameter r. (laminar vs. turbulent). Within "FC2" the fuzzy controller is modelled. "FC2" is triggered every second.

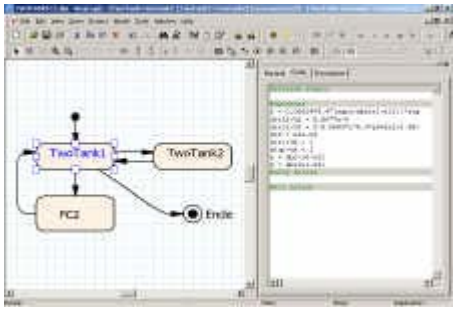

Figure 1: AnyLogic model statechart

Task a: Computation of Control Surface. The fuzzy controller is implemented by a set of membership functions. These are located in a transition from state "TwoTank1" to "FC2" ("FC1", "FC3"). The operators MAX for OR and MIN for AND are used for the rulebase, situated in state "FC2" ("FC1", "FC3").

```
if (ex2 < 0)
    {ex2mb1=1;}
 else if (ex2 >= 0 && ex2 <= 10)
    {ex2mb1=(ex2/(0-10)-10/(0-10));}
  else
    {ex2mb1=0;}
...
p1=min(ex2mb2,x1mb4)
p2=max(min(ex2mb2,x1mb3),min(ex2mb3,x1mb4))
u=(0*nl+1.25*p1+...+8.75*p7+10*p8)/
(nl+p1+p2+p3+p4+p5+p6+p7+p8)
```

For calculation of the control surface, instead of the dynamic model the parameter space is modeled by introducing a step function for x1 and a ramp function (for ex2), setting x1=0 to 70 and ex2=-70 to 70. There is no notable difference in calculation time between FC1 and FC2 (figure 2): t_{FC1} = 6 s, t_{FC2} = 6 s, ratio t_{FC1}/t_{FC2} =1 (P III, 500 MHz, 128 MB).

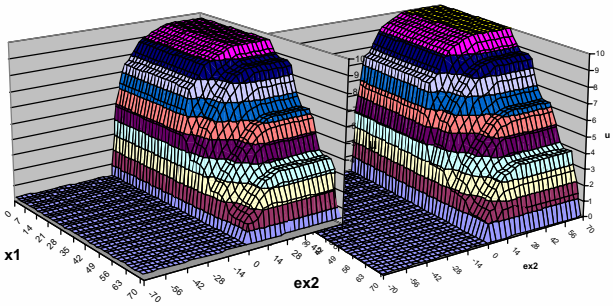

Fig. 2: Control surfaces FC1 (left), FC2 (right)

Task b: Simulation of the System. Using now the whole system for x2s = 25 cm for 1000 seconds, giving computation times t_{FC1} = 10 for FC1 and t_{FC2} = 11 (integration algorithm RK45), resulting in ratio t_{FC1}/t_{FC2} =0.9. State and control variables over time are shown in the following figures.

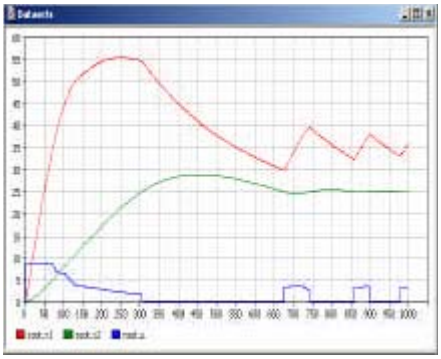

Figure 3: States and Control versus time, FC1

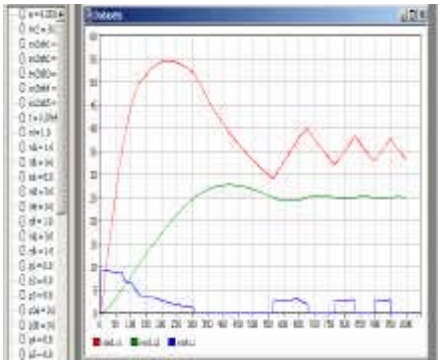

Figure 4: States and Control versus time, FC2

Task c: Weighted Fuzzy Control. FC3 is calculated, weighting simply the rulebase in the controller state. The results are very similar to those using FC2.

M. Eder, J. Fellner
Group of Waste and Materials Management
Vienna University of Technology,
m.eder@awsnt.tuwien.ac.at
j.fellner@awsnt.tuwien.ac.at