A numerical Solution to ARGESIM Comparison C5 'Two State Model' with SAMT/DESIRE

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Simulator: SAMT/DESIRE is a simulator included in the GIS system SAMT. DESIRE originally was written by Granino Korn and was distributed as commercial version for Windows and as free version (OPEN DESIRE) for Linux. OPEN DESIRE was included in SAMT to perform geographical analysis of spatial data, but SAMT can be just used as a graphical user interface for DESIRE. SAMT/DESIRE comes on CD with a Knoppix Linux distribution, so also Windows users can boot Linux and SAMT/DESIRE directly from CD. DESIRE is a very fast simulator, handles also vector and matrix ODEs and neural nets.

Model. In DESIRE a complete simulation program consists of a so called experiment protocol program and (usually) one DYNAMIC segment with the ODE model. In the experiment protocol all parameters and initial values are set and the number and way of calls of the DYNAMIC segment is specified (Table 1).

DESIRE provides no state event handling. Consequently a hybrid approach is chosen:

- the simulation (started by `drun`) stops, if the `limit` is reached (`term` in DYNAMIC)
- in the experiment protocol the parameters `c2` and `c4` are changed
- the simulation is restarted (`drun`)
- this sequence is controlled in a `while` – loop

```
210 irule 4 | TMAX = 6 | DTMIN=10^(-15)
220 DT=10^(-12) | ERMAX=10^(-11) | NN=100000
290 STATE y1, y2 | y1=4.2 | y2 = 0.3
300 c1=2700000 | c3 = 3.5651205
320 c21=0.4 | c41 = 5.5 | c22= -1.25 | c42=4.33
340 c2=c21 | c4=c41 | eps1=c21-c22 | eps2=c41-c42
370 actst=1 | limit=5.8 | plm=-1
400 drun |write t, y1
440 while t<5.05
450   actst=abs(actst-1) | plm=-(actst-0.5)*2
470   c2=c22 + actst*eps1 | c4=c42+ actst*eps2
490   limit = limit + plm*(-1.7)
500   drun | write t, y1
530   end while
540 ------------------------------------------
550 DYNAMIC
560 d/dt y1 = c1 *  (y2 + c2 - y1)
580 d/dt y2 = c3 *  (c4 - y2)
590 term plm*(limit-y1)
```

Table 1: Mixed Model / Experiment description in DESIRE

Task a – Plot of State and Trace of Switching Times with Standard Accuracy. DESIRE offers ODE solvers for stiff systems, but stepsizes become too large to meet a switching point. Therefore a Runge-Kutta 4/2 with stepsize control and maximal stepsize is used. Figure 1 shows the result for $y_2(t)$ with switching times 1.10833, 2.12972, 3.05421, 4.0756, and 5.00009 for standard accuracy.

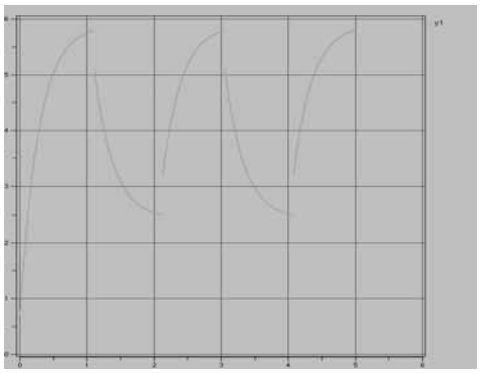

Figure 1: State plot with switching points, task a

Task b - Trace of Switching Times with Higher Accuracy. Even with very small error tolerance and further tuning of the integration parameters no better results are obtained. As a state event algorithm is missing, the integration of the ODEs is stopped, as soon as the state has exceeded the limit, and not as soon the state reaches the limit (the difference is about the stepsize.

Task c – Plot of State and Trace of Switching Times at High-Frequent Switching. Interestigly, DESIRE has no problems with high-frequent occurrence of switching points (Figure 2). No model changes are necessary; clearly, the while loop is passed much more frequently, giving switching points within accuracy of the stepsize:
1.10833, 1.12177, 1.23565, 1.24909, 1.36291….
……., 4.81337, 4.92719, 4.94063

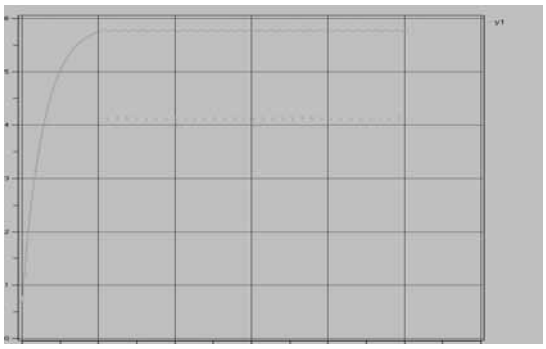

Figure 2: State plot with high-frequency switching, task c

Classification: Numerical Approach without state event handling
Version: SAMT/DESIRE 1.0