A directly Programmed Solution to ARGESIM Comparison “C13 Crane and Embedded Control” with MATLAB

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Simulator. MATLAB is a widely used software tool based on numerical vector and matrix manipulation. Additionally it provides several toolboxes for various tasks.

Model: The differential equations of the mechanical model of the crane and the DC-motor are implemented directly in MATLAB. For the numerical integration a Euler-algorithm has been implemented: `[t,y]=myeuler('lindiffgl',[0 0.01],[init],steps).`

The Euler-algorithm has been chosen to provide a comparison of the performance of a simple ODE solver to more sophisticated ODE Solvers (see SNE 35/36).

To simulate the controlled system, time in general was discretised to the time base of the controller Δt=10ms. In each sample interval the Euler ODE-solver was started to integrate the system in this interval and the dedicated brake-conditions and controller reactions are evaluated.

The following code describes the implemented Euler-algorithm:

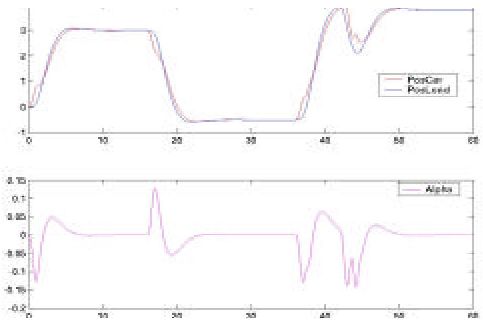
```
function [t,y] = myeuler(dglstr,range,vars,steps);

   nrsteps   = steps;
   starttime = range(1);
   endtime   = range(2);
   stepwide  = (endtime-starttime)/nrsteps;
   time = starttime;
   y=zeros(nrsteps,5); t=zeros(nrsteps,1);
   value=vars;    %Init. d. i. Int. kum.  Flaeche

for i=1:nrsteps
   time =time + stepwide;
   PosCar = value(1); PosCar_dot = value(2);
   alpha = value(3); alpha_dot = value(4);
   fc = value(5);

    fktwert = eval([dglstr,'(',num2str(time),'…
    ,[',num2str(PosCar),';',num2str(PosCar_dot)…
    ,';',num2str(alpha),';',num2str(alpha_dot)…
    ,';',num2str(fc),'])']);

   value = value + fktwert .* stepwide;
   y(i,:)=value';  t(i,1)=time;

end
```

Task a: Comparison of uncontrolled nonlinear and linear model. For this task, linear and nonlinear differential equations have been simulated at [0 600] sec with the RKF45–integration algorithm, which allows an implicit approach (DAE-systems) for the nonlinear ODE (result differences given in next table).

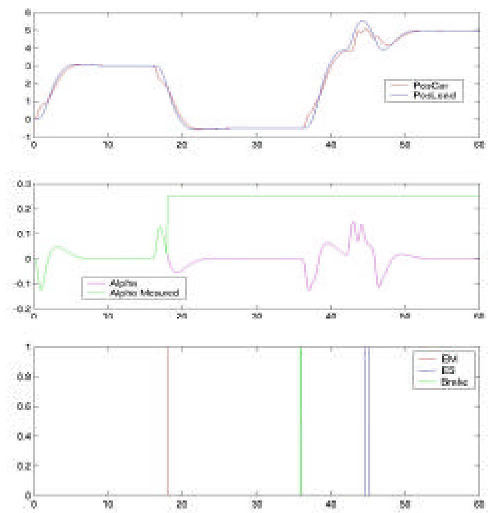
disturbance fd	-750	-800	-850
difference Δx_l	-135,7	-222,0	-311,8

Task b: Simulation of the controlled system. Controller and brake-logic were implemented in MATLAB m-functions. For the integration in task b and task c the Euler – algorithm was used.

The next figure shows the result of important variables at [0 60] sec, the times for the brake activation are: t = 15.37, 32.13 and 56.73 sec.



Task c: Simulation of controlled system with sensor diagnosis. In case of failure the controller switches to the emergency mode without a consideration of the angle alpha (time courses next figure), with time instants: emergency mode t = 18.05, brake activation t = 35.81, emergency stop at t = 44.47 sec.



Generally it turns out, that the simple Euler-algorithm (with stepsize equal to controller sampling time, Δt_E=1ms) is almost as accurate as any ODE solver of higher order: all compared results are found within the technical accuracy of the system.

C13 Classification: Hybrid / Discrete Approach

Simulator: MATLAB Rel.13