A Classical ODE-based Approach to ARGESIM Comparison C 11 'SCARA Robot' using DESIRE

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Simulator: DESIRE stands for *Direct Executing SImulation in REal time*. It is specially designed for solving differential equations very fast.
DESIRE is text-based with graphical output. The programming language is similar to BASIC, and line numbering is obligatory. Differential equations, either linear or nonlinear, can be entered in natural mathematical notation, and mixed with matrix/vector equations. DESIRE allows solving up to 40.000 ODEs using fixed- and variable-step *Runge-Kutta* routines, or up to 600 differential equations with variable-step/variable-order *Adams* and *Gear* integration rules.

A - Task: Description of mechanical model. The system of differential equations has to be made explicit prior to solving it with DESIRE, as it has no abilities to handle implicit differential equations. Furthermore, the differential equations of second order have to be reduced to a system of first order.
In DESIRE's first program section, the program parameters, like time step, simulation time, etc., are set.
After that all the constants are defined, followed by the command `drun`, which executes all commands in the DYNAMIC block. In the following, some self-explaining parts of the model:

```
264  u1 = 130 | u2 = 100 | u3 = 1047
311  m3 = m3A + m3L
321  Theta1 = (m1/3 + m2 + m3)*L1*L1
333  if op=0 then U3max=1 | else proceed
435  xtip = L1*cos(q1) + L2*cos(q1+q2)
531  d/dt I1 = (U1-kT1*u1*qdot1 - ...
612  ma12 = Theta2*cos(q2) + Theta3
621  denom = ma11*ma22 - ma12*ma21
632  mainv12 = -ma12/denom
```

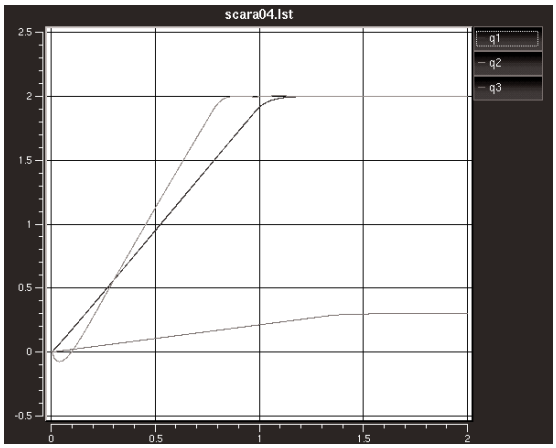

Figure 1: Joint position over time with PD control.

```
811  d/dt q1 = qdot1
812  d/dt qdot1=mainv11*b1+mainv12*b2
851  term q1-2 (target condition)
```

B - Task: Servo motor and PD control. Control is implented by simple equations and by the `term` statement. The limits for the current are defined by saturation limiters:

```
531 I1 = ... * I1max * sat(I1 / I1max))
```

Results for the joint positions are shown in Figure 1.

C - Task: Collision avoidance. DESIRE does not support state events directly. A proper way around to is to make use of the simple switch function. Here, the operation mode is determined by applying this switch function in the conjunction of height and distance to obstacle:

```
1-switch(height))*(1-switch(dist))
```

In case of emergency, the current positions are defined as new target values for the joints, so that the PD control stops as fast as possible. All three motors have the maximal voltage at their disposal for that purpose. It can be seen in Figure 2, that the position of the robot arm stays nearly constant until the tool tip has cleared the obstacle height, and then continues to move to the desired position.

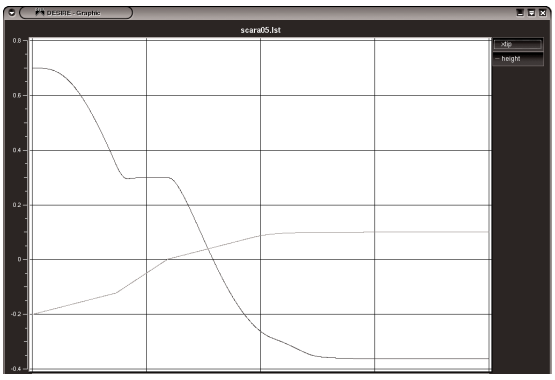

Figure 2: Tip positions in case of obstacle.

Classification: Explicit model approach
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