

## Case Study

# Real-time Simulation of Industrial Robots with Dymola

## The Challenge

Real-time simulation of industrial robots for hardware-in-the-loop testing of robot control hardware and software.

## The Project

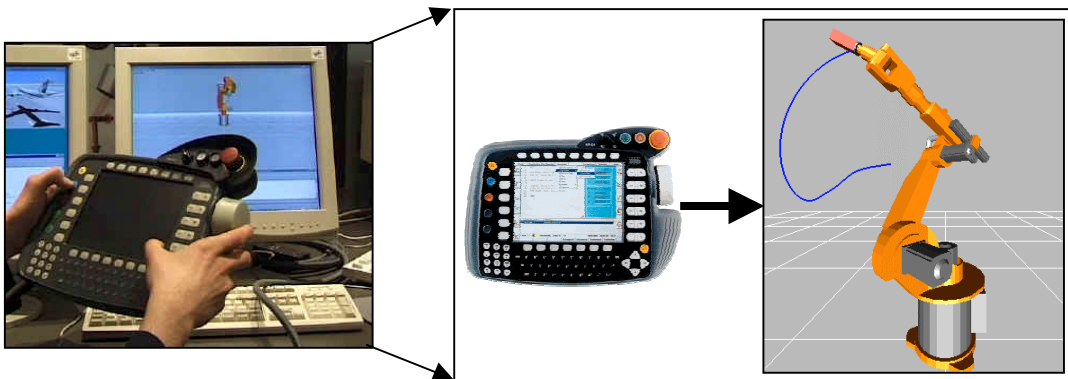
One main objective of the European project REALSIM - Real-time Simulation for Design of Multi-physics Systems - is to enhance tools for efficient real-time simulation, where the multi-domain modeling language Modelica is used as a basis. The results are evaluated in an industrial application: A detailed model of an industrial robot is simulated in real-time and driven by the actual robot control hardware. The robot model includes the mechanical structure, gearbox effects such as elasticity and Coulomb friction, electrical motors and the axes controllers.

## The Solution

The systems under consideration contain components with varying model structure, such as Coulomb friction, and systems with slow and fast dynamics, such as the elasticity of gearboxes or controllers (fast dynamics) and 3-dim. mechanics (slow dynamics). In order to obtain real-time capability special symbolic and numerical model processing and simulation code generation methods have been developed for Dymola. For example, slow components are discretized with the explicit Euler method, fast components with the implicit Euler method, and the model equations are symbolically processed together with the discretization formulas (= mixed mode inline integration).

## The Result

The developed methods give a speed-up of 15 for the detailed robot model, compared to the standard offline simulation of Dymola, and allows for the first time to run this model in real-time. This result has been demonstrated at the Hannover fair 2001: A virtual KUKA industrial robot has been driven in real-time by a standard KUKA control panel and animated with Dymola including special visualisation of the tool center point vibrations which are due to gearbox vibrations.



Hannover fair demonstration of robot real-time simulation controlled by KUKA control panel.

**Partners:**

- Dynasim AB, Lund, Sweden is the leading company for complex modeling and high performance simulation. Dynasim has developed the Dymola software for multi-engineering simulation that enables design engineers to simulate the physical behavior and complex interactions between mechanical, electrical, thermodynamic, hydraulic, control and other systems.
- DLR, Germany, is the German national organisation for aerospace research and development. The main research areas are aeronautics, space flight, energy and transport technology and robotics.
- KUKA, Augsburg, Germany is Germany's No. 1 robot manufacturer, the second largest in Europe and the third on a world-wide basis.

The REALSIM project is carried out in the IST program of the Commission for the European Community (CEC), contract Number IST-1999-11979. More information is available under: <http://www.ida.liu.se/labs/pelab/realsim/>.