A Study of OpenModelica in Realtime Simulation for Virtual Reality Environments

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Virtual Reality Simulation of a Concrete Spraying Machine
Software Environment

- Need for a flexible simulation environment
- Different use cases
  - Mechanical problems
  - Design of hydraulic systems
  - Controller and machine software development
  - Operator acceptance
- Reusability of (parts of) models is very important

**Modelica is the right choice**

- Simulation environment should be as flexible as modelling
- Virtual reality is no playback for simulation results
- Available desktop simulation tools are limited
Open Source Software and Standards

OpenSceneGraph (OSG)

Gimp Toolkit (GTK)

CAN bus

CAN
Organization in a Plugin Architecture

• Definition of standard interfaces
• Lightweight application
• Functionality is distributed across plugins
• Plugin composition described with XML
Simulation Model of the Concrete Spraying Arm

- **Main goals**
  - Test of operator acceptance
  - Analysis of parallel kinematics (hydraulic coupling)
Model of the Mechanics

- No support for standard multibody library in open modelica
- PyMBS with flat modelica output
- 22 Bodies
  - 28 Joints
  - 7 Internal forces and torques
  - 6 external forces and torques
  - Simplified jet head kinematics
- Events due to mechanical stops of hydraulic cylinders
- Outputs for body positions
Model of the Actuation System

- Simple model with velocity proportional controllers
  - Operator acceptance
  - Controller and software development

- Model of the hydraulic system based on a library of TU Dresden
  - Hydraulic pump
  - Proportional valves
  - Check valves and pressure protection
  - Load stabilization

- Easy exchange due to common interface
  - Multi body model
  - Inputs und outputs for interaction with virtual reality
Transfer to Sarturis

- PyMbs
- Hydraulics Library
- Modelica Model
- OpenModelica-ToSarturis
- SA-14 Module
- Input from real RC
- Simulation in SARTURIS
- Graphics

Tools:
- Python
- Modelica
- Sarturis
- Simulation
Sundials Solver

• Sarturis has an implementation of IDA and CVODE
  - Wrappers around sundials-2.4.0

• IDA
  - General DAE solver
  - OMC could create a system of DAEs

• CVODE
  - Works fine in desktop simulation
  - Step size adjustment and event handling prevent hard real time capabilities
  - Interactive simulation works with moderate models (soft real time)

• Interactive simulation better with Runge-Kutta methods
• Nice discussions about inline integration
**XML output**

- Create a more sophisticated model transformation
  - Modelica -> XML -> C++ -> Sarturis
  - Could store meta information and equations in one file
  - No parsing of generated C code
  - Could be Python based

- 1.5.0rc2 and SVN revision 4909 produce parsing errors in annotations (simulation works)

- 1.4.5 generates incorrect XML
  - Example: `<zeroCrossingElement string="vA < 0.0">`

- State of XML ambiguous
  - DAE/ODE
  - Flat model
Some sysprof results

- **Platform**
  - AMD Athlon(tm) 64 X2 Dual Core Processor 5000+
  - Fedora Core 11, Kernel 2.6.30.10-105.fc11.x86_64

- **Multithreaded application**
  - Different cpu mask for every thread

- **Waiting for real time sync is not measured**

 SVN revision 4042

 SVN revision 4909
Optimization attempts

- PyMBS modelica output
  - Write “constant Real” instead of “Real” for parameters

- SVN version 4042
  - Increase of omc compile time from 60 sec. to more than 10 min.
  - Strong increment of code size (if you are patient)
  - Poor model calculation performance

- SVN version 4909
  - No mentionable effect in omc compile time and code generation
Conclusion

- OpenModelica and Sarturis give the opportunity for real time simulations in virtual reality
- Modelica enables a flexible way of modeling, covering a lot of different scenarios in product development
- Standard use case of modelica tools (transform to C, compile, run, plot the results) can not cover interactive simulations
- Flexible output of equations will allow lots if different use cases for models
- Generated C codes of 2MB even for simple models point to a future bottleneck