

Integration of Modelica models with CasADi

Björn Lennernäs

17 juni 2013

Why pay to build expensive physical prototypes if you can build virtual ones faster and cheaper?

In industry today there is a trend to move the product development cycle to virtual product development, i.e. using software tools and computer models. This reduces cost by reducing the time it takes to make new products and by reducing the cost to create physical prototypes. This trend also offers some unique advantages like optimization, utilizing the power of computers and the software that represents the computer models.

Virtual product development needs to rely on a robust mathematical formalism. The computer models are essentially mathematical models, and the tools that handle them are based on mathematical methods that can for example simulate and solve, in the case of optimization, such models.

This thesis has implemented an extension to a tool called JModelica.org, which handles models expressed using the Modelica modeling language. JModelica.org has been connected to the tool called CasADi, to utilize some desirable advantages.

Modelica

Modelica is a modeling language, i.e. it provides the framework that a modeler uses to create the computer models. It has been around since the late 90s, and is used to model very diverse systems, e.g. power plants, cars, electrical systems and robotics. Examples of companies that use it are Audi, Ford, Siemens and ABB.

Modelica has gained some popularity in recent years, and a large part of the reason is that it allows the modeler to express models on a high level. This compares to traditional modeling approaches, where the modeler was often forced to do a lot of work to obtain correct models. This higher level, and subsequent ease of modeling, is enabled by the fact the mathematical foundation of Modelica is more general and allowing than that of traditional tools. This comes at a price though. The tools that handle the models are often required to interpret and manipulate the models to some extent before they can be simulated.

JModelica.org and CasADi

JModelica.org is software tool that can handle Modelica models. It can perform all the manipulations required to simulate the models, and it is connected to software that can simulate them. JModelica.org also defines an extension to Modelica called Optimica, which allows for the formulation of optimization problems. It is developed by Modelon AB in collaboration with Lund University.

CasADi is an open source tool designed for the user and developer of numerical algorithms. It is a general purpose tool and many kinds of mathematical systems can be expressed by it, including Modelica and Optimica. It is designed in such a way that many useful properties are automatically and efficiently calculated for the mathematical system expressed in it, most importantly derivatives. Beyond this core it offers the developer and user of it an understandable and powerful environment to work in that can be used interactively.

This thesis

The aim with this thesis was to lay a foundation for a new way for JModelica.org to handle models, by using CasADi. Today models are handled in a rigid manor, and once a model has been processed it can be modified only to a small extent. By moving to CasADi the models can be worked with interactively and efficiently. So the goal was to use the parts of JModelica.org that interpreted and manipulated the models, and then transfer and represent this information in CasADi.

The problems that this thesis therefore had to solve were.

- Connect JModelica.org and CasADi. JModelica.org is written in the programming language Java, and CasADi in C++. Therefore an infrastructure that allowed these languages and tools to communicate were developed.
- Construct a representation of Modelica and Optimica models in C++ in a way that was integrated with CasADi.
- Achieve the above points in an efficient, understandable and extendable manner. The purpose is that this software becomes an integral part of JModelica.org, why extra care must be taken to lay a good foundation. To concretize, it is not unusual that models with 100.000 or more equations and variables are used.

The work was successful and models were transferred from JModelica.org to CasADi, using the constructed model representation there. These transferred models were tested using constructed mathematical algorithms that mirrored those found in JModelica.org, and it was found that almost identical results were obtained.

Naturally this thesis was limited in scope, and only subsets of Modelica and Optimica can be handled by the implemented software. As mentioned however, Modelon aims to develop the system further to support more of Modelica and Optimica.