
Accelerating development with Model-Based Design

David Bergström and Robert Göransson

Department of Automatic Control, Lund University

As development of new technology is happening faster than ever before manufacturers are always looking for new ways to make the development more efficient.

An easy way of designing systems

Model-Based Design (MBD) is an increasingly popular method of visually designing systems and creating embedded software. It can be used to solve problems involving control systems, signal processing, communications systems etc. It is used in fields such as the industrial automation, aerospace and automotive industry. It gives developers the ability to create mathematical models of different components and simulate them together. By creating a plant model that represents the physical behavior of the hardware system one can create and test controllers without having to use any real hardware. This is done by simulating the plant model and controller together. This means that errors in the control algorithm can be discovered before any code is written and without having to build a hardware prototype. Since it is easier and cheaper to fix errors early in the development process this is big advantage. A tool that is often used for this type of development is Simulink. In this software users can build models of a system using building blocks that represents different parts of the system. The models can then be simulated and analyzed.

3D simulation

When a new machine is developed manufacturers usually create CAD models of the hardware. This gives developers the ability to get an idea of how the machine will look. For software developers, however, it might be difficult to picture how the embedded software will work on the hardware. They have to write the code and implement it on a prototype to test it. This is a problem that the German company Machineering GmbH & Co. KG is trying to fix. Their software *IndustrialPhysics* is a tool for 3D simulation of mechatronic systems. Users can import CAD models, set physical parameters and run the model in real time. It is also possible to control the models by sending and receiving data from a Programmable Logical Controller (PLC). This means code on a PLC can be tested together with the 3D model and its behavior can be observed. While CAD software only has the ability to show the model in 3D. *IndustrialPhysics* is used to see how different parts of a CAD model can move and how different parts interact with each other. This means developers can see how the machine actually will work when it has been built.

A problem is that the code for the PLC has to be written to test the model. A way to solve this problem is to create an interface between Simulink and *IndustrialPhysics*. When data can be exchanged between these two programs one can develop the control model in Simulink and directly see how the

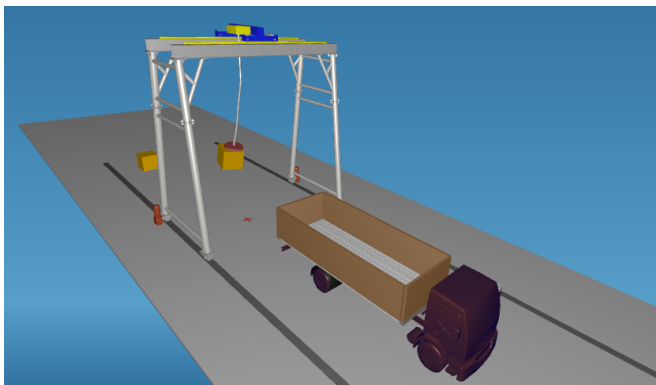
3D model is behaving. Fixes to the model can now be made and the changes can be seen without writing any code.

Automatic code generation

One of the great advantages of using MBD is the automatic code generation. It means that code is automatically generated from the control model instead of having programmers interpret the model and manually write code. A lot of errors from this development stage now disappears since the human error factor is removed. This is quite a big deal since machines comes with more and more embedded software. It is estimated that even the best programmers makes 10 to 20 mistakes per 1000 lines of written code. Since a modern car usually has millions of lines of code these errors quickly add up. Software bugs can sometimes mean manufacturers have to recall millions of cars so it is of great importance to reduce the number of errors.

Demonstrating the advantages

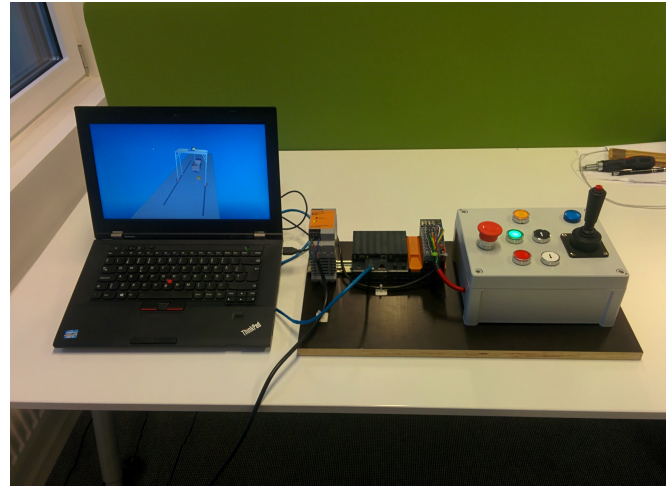
One company that promotes the use of MBD a lot is the Swedish company *Comine Control Systems AB*. Their office in Lund wanted to have a way of showing the advantages of using MBD when visiting technical fairs. To do this they let thesis students develop a model of a crane in *IndustrialPhysics* and a control model made in *Simulink*.



The model of a crane in IndustrialPhysics.

Code was generated from *Simulink* and transferred to a PLC. The PLC is connected to a set of buttons on a control panel. During the demonstration the model in *IndustrialPhysics* is running on a computer with a monitor. This gives users the ability to control the 3D model of the crane with the control panel and directly see the changes on the screen. The whole

demonstration setup will be a so called Model-in-the-Loop (MiL) test. MiL tests are often a part of MBD and lets developers try out the embedded software on the hardware without using the real hardware of the machine that is going to be controlled.



The PLC and control panel used for user interaction with the crane model running on the computer.

The future

The future looks bright for the Model-Based Design method since companies are constantly trying to reduce development cost and time and competition is tougher than ever. To be able to try different thousands of solutions without building prototypes is something that would take years to do in some cases. MBD greatly improves the development phase and gives possibilities that did not exist before. It is possible that the use of MBD in embedded software design can improve development in a similar way that the introduction of CAD software improved hardware design.