Strukturierter Entwurf selbstoptimierender mechatronischer Systeme

Kurzfassung der Dissertation von Dipl.-Ing. Oliver Oberschelp

This work was developed in the context of the Collaborative Research Centre 614 – Self-Optimizing Concepts and Structures in Mechanical Engineering. The aim of the work is to display foundations for the development of self-optimizing mechatronic systems. Main aspects are the areas of structured development, methods of optimization, reconfiguration, numerical evaluation and information processing. Several different application examples, i.e., from the project “RailCab – Neue Bahntechnik Paderborn”, demonstrate the potential inherent in self-optimization.

Self-optimization can be applied to nearly every domain of mechatronics. In addition to optimizing parameters, it is even possible to optimize the structure of a system. One approach is the reconfiguration of existing system components. The basis for modelling such systems is given by hierarchical block diagrams. As in them the construction of a hierarchical level is itself represented as a block, reconfiguration can also be performed by exchanging hierarchical configurations. This is controlled by a state-chart allocated to the reconfigurable hierarchy. These extended hierarchical elements are called hybrid.

The information processing of a self-optimizing mechatronic system has to fulfill a wide range of functions. The approach of the operator-controller module (OCM) to structure the information processing takes these requirements into account. It consists of three main components, namely cognitive operator, reflective operator, and controller.

A simulation of mechatronic systems that is suitable for real-time applications basically comprises the numerical integration of differential equations. The efficiency of the evaluation can be increased by a separate calculation of submodels using step sizes matching the individual time constants. Such procedures are also known as multi-rate procedures. The occurring disturbances can be reduced by the use of methods such as extrapolation and smoothing of the coupling data.

In a reconfigurable system the evaluation order cannot be determined during code generation, but at run-time. The goal is to generate separate parts of the system so that any coupling condition between inputs and outputs is allowed, except for algebraic loops which can be avoided only by model design. For computing the evaluation order it is sufficient to know the relations between inputs, outputs and states; equations within blocks do not have to be considered. The algorithm for the calculation of the evaluation order can be applied to hierarchical systems in a generalised form.

The basis of most optimization procedures is execution of different test runs with subsequent evaluation, followed by a targeted alteration of the system parameters. Such a form of self-optimization is particularly suitable with recurrent or comparable excitation cases. If the results of several systems are used jointly, this is called distributed optimization. This scenario will be explained in detail using the RailCab as an example.