Abstract

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The subject of this thesis is the development of computer–based support for conceptual design of technical–physical systems, specifically controlled electro–mechanical systems.

Two new design approaches have been proposed recently in response to increasing demands on products to be designed, namely “concurrent engineering” and “mechatronics”. Both these approaches advocate a systems point of view in design, and stimulate integrated problem solving within designing. Two types of problems oppose the usage of an integrated problem solving approach during (conceptual) design:

– cooperation and coordination among members of the design team is difficult due to a lack of shared meaning of communicated messages.
– reduction of the initial lack of understanding of the design problem is hard, and the required learning takes too much time.

A formal description of the design process reveals that the use of models and abstractions plays a crucial role in communication and learning. Solution of the above problems demands improved modeling capabilities of design support systems.

One required improvement is to enable simultaneous formulations of one model in multiple languages, in such a way that the model can be manipulated in either of the formulations. This concept is called “multiple model formulations”. A system setup that enables multiple model formulations and yet keeps different formulations of a model consistent and tractable is devised. The setup incorporates automatic conversions between different formulations of one model. Bond graphs and iconic diagrams are taken as an example set of formulations for demonstrating the feasibility of the setup.

Furthermore, designers require more flexible model descriptions than contemporary modeling systems provide. The lack of flexibility is due to the way in which classification of subsystems is realized in these systems. An improvement of this is obtained by modularizing a subsystem description into a type and a specification, and by subtyping, i.e. by expressing a type as a specialization of a more general type. The combination of modularization and subtyping, named “polymorphic modeling”, leads to hierarchical subsystem libraries and gives modeling systems the possibility to conform to the evolutionary nature of model building.

A model building environment for mechatronic systems is presented: the MAX system. MAX supports the user in creating models and evaluating them by means of network–based analyses. Multiple model formulations (i.e. bond graphs and iconic diagrams) and polymorphic modeling are incorporated in the system. Conversions between
model formulations and polymorphic model refinements enable to learn about the design problem. Due to the availability of an extendible, well organized model library, the use of explicitly described models is made easy, which enhances communication about the design problem. These features make MAX into a powerful model building environment that is well adapted to usage by designers.