Abstract

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Mechatronic design requires that a mechanical system and its control system be designed as an integrated system. This contribution covers the background and tools for modelling and simulation of physical systems and their controllers, with parameters that are directly related to the real-world system. The theory will be illustrated with examples of typical mechatronic systems such as servo systems and a mobile robot. Hands-on experience is realised by means of exercises with the 20-sim software package (a demo version is freely available on the Internet).

In mechatronics, where a controlled system has to be designed as a whole, it is advantageous that model structure and parameters are directly related to physical components. In addition, it is desired that (sub-)models be reusable. Common block-diagram- or equation-based simulation packages hardly support these features. The energy-based approach towards modelling of physical systems allows the construction of reusable and easily extendible models. This contribution starts with an overview of mechatronic design problems and the various ways to solve such problems. A few examples will be discussed that show the use of such a tool in various stages of the design. The examples include a typical mechatronic system with a flexible transmission and a mobile robot. The energy-based approach towards modelling is treated in some detail. This will give the reader sufficient insight in order to exercise it with the aid of modelling and simulation software (20-sim). Such a tool allows high level input of models in the form of iconic diagrams, equations, block diagrams or bond graphs and supports efficient symbolic and numerical analysis as well as simulation and visualisation. Components in various physical domains (e.g. mechanical or electrical) can easily be selected from a library and combined into a process that can be controlled by block-diagram-based (digital) controllers.
This contribution is based on object-oriented modelling: each object is determined by constitutive relations at the one hand and its interface, the power and signal ports to and from the outside world, at the other hand. Other realizations of an object may contain different or more detailed descriptions, but as long as the interface (number and type of ports) is identical, they can be exchanged in a straightforward manner. This allows top–down modelling as well as bottom–up modelling. Straightforward interconnection of (empty) submodels supports the actual decision process of modelling, not just model input and output manipulation. Empty submodel types may be filled with specific descriptions with various degrees of complexity (models can be polymorphic) to support evolutionary and iterative modelling and design approaches. Additionally, submodels may be constructed from other submodels in hierarchical structures.

An introduction to the design of controllers based on these models is also given. Modelling and controller design as well as the use of 20-sim may be exercised in hands-on experience assignments, available at the Internet (http://www.ce.utwente.nl/IFACBrief/). A demonstration copy of 20-sim that allows the reader to use the ideas presented in this contribution may be downloaded from the Internet (http://www.20sim.com).

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