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Configuration of mechatronic systems using feature models

Farisoroosh Abrishamchian*, Ansgar Trächtler

Heinz Nixdorf Institute, University of Paderborn, Fürstenallee 11, 33102 Paderborn, Germany

Abstract

To analyze and describe the behavior and the interaction pattern of the product's subsystems and their components, multiple simulation models have to be developed in each engineering domain. In this paper, a Software Product Line (SPL) approach is adopted to demonstrate the dependencies and associations between models of subsystems. SPL approach provides a structured method for handling variability by using feature models. The particular focus of this paper is on the mapping between components in different tools with more than one modeling depth, the level of detail respectively, through deployment of feature modeling.

Keywords: Feature modeling; mechatronic systems; modeling depth; multidisciplinary systems; Software Product Line; variability management

1. Introduction

In the field of mechatronics, products are described by multiple models belonging to different engineering domains such as mechanical, electrical, and electromechanical. These models are often complex and interact with one another in a heterogeneous way. Therefore, to model the entire system, many domain specific tools will be required. Furthermore, because of the highly coupled nature of mechatronic products, change in one of the product's subsystem typically results in change in the other subsystems in other domains. To simulate such interconnected systems, one integrated and comprehensive simulation system is needed that encompasses multiple domains.

* Corresponding author. Tel.: +49-5251-60-6286; Fax: +49-5251-60-6297.
E-mail address: farisoroosh.abrishamchian@hni.uni-paderborn.de

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In a simulated model, the interfaces between the defined system components with input and output variables for actuators and sensors must be matched together. This paper proposes a conceptual design for a model configurator for integrated simulation of multidisciplinary mechatronics products. The proposed model ensures a complete coverage of the entire system without overlaps between the subsystems. In addition, the proposed model supports modeling variables with varying depths. Here, as observed by Just et al. [1], a large modelling depth means a very detailed model. Similarly, a simple model with many assumptions and simplifications is said to be simulated using a low modeling depth. Consistency is another requirement for creating valid interfaces that is addressed by the proposed model. In other words, how is following changes of model issues would be discussed in this paper.

To match the submodels together, there are two main issues which need to be addressed:

- matching the interfaces of a component
- the variant of modeling depth and modeling tools within different domains

To handle this variability, Feature Modeling Approach is used to configure the subsystem models. Feature modeling is developed for the description of the product variants in the field of Software Product Line [2]. Here, the variants of modeling depth and variants of modeling tool create a variant model for a component. What differentiate these models of a component from each other are the properties of modeling. The properties of a component are classified in three categories of inputs, outputs and parameters as shown in Table 1. Inputs and outputs are variables, while the parameters are constants of a component. For example, a pneumatic cylinder requires pneumatic pressure as input to give the displacement of piston as an output. The parameters are total mass, piston mass, piston length etc. They are represented as features of feature diagram. The model configurator is based on the concept of feature modeling.

Table 1. Variability within a component

	Component		
	Input	**Output**	**Parameter**
Interface	Minimal interface		
Modeling Depth		Variant of depths	
Modeling Tool		Variant of domains	

The outline of remaining paper is as follows. The related works are reviewed in the next section. The fundamentals of feature models are discussed in the third section. Then uses of feature modeling in mechatronic systems and the structure of model configurator described next in Section 4 and 5. The last section provides the concluding remarks and the future works.

2. Related Works

In multiple research and industrial projects such as "Design Methodology for Intelligent Mechatronic Systems" (ENTIME), several methodologies are proposed for model-based design of mechatronic systems. In particular, for automotive applications, several sophisticated methods and models have been developed [3], [4]. In ENTIME ontologies are developed to connect the abstracted simulation models for solution patterns of the early design stage to the detailed physical simulation models of elements of the solution [5], [6].

Berg et al. propose a solution for managing variations at different levels of abstraction for the software product line [7]. This approach can be used in multidisciplinary mechatronic systems. Using these ideas, a conceptual variability model is created in a third dimension to capture the variability of information. This allows a One-to-One mapping between the problem space and the solution space [7].

Herzig et al. have analyzed and discussed the consistancy of sytems [8]. The authors have detected inconsistent points of the system which are not detected normally. Their work categorizes the inconsistencies to manage specific types of consistency issues. Qamar and Paredis have studied the practical approaches for consistency management