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To support multidisciplinary communication in VR-based virtual prototyping of mechatronic systems

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Abstract

A typical mechatronic product includes mechanical parts, software techniques, electrical and electronic components. This interdisciplinary character significantly increases the complexity of mechatronic products. Therefore, inefficient communication between the engineers, who come from different domains, becomes one of the main challenges in the development of mechatronic systems. Although, innovations in the field of virtual prototyping can help the engineers to handle a complex system and then accelerate the development processes, the technique itself does not offer a solution to the problem of multidisciplinary communications. In this paper, we present a practical solution of supporting knowledge sharing and communication within a multidisciplinary developing group, whose members need to work cooperatively for doing virtual prototyping of mechatronic systems in VR environment.

Keywords: Knowledge sharing; Multidisciplinary design; Mechatronics; Virtual prototyping; CSCW

1. Introduction

Modern mechanical engineering systems are based on close cooperation between elements from the areas of mechanics, electronics, control engineering and software engineering. Unfortunately, along with the development of innovative mechatronic products, the complexity of their prototype design manifests in many different ways that slows down the development speed. Typically, the complexity is caused by the increasing number of components to be integrated. The intricate relationships among these elements, especially concerning information processing, might easily exceed the engineer's imagination. Additionally, the individual parts also incorporate more functions in an increasingly high-integrated package.

Since mechatronic components are related to many different engineering disciplines, cooperation of multidisciplinary design teams is necessary right from the beginning of the design. This brings difficulties to share the knowledge and to communicate within the group.

On the other hand, because the scope of the resulting behavior of the mechatronic system usually cannot be anticipated by the developers, suitable processes and tools are required for rational exploration [1]. These tools are also required for supporting the communication between developers and for presenting the system, which allow the active mechanisms to be visualized and made comprehensible.

In an attempt to cope with the problems of the complexity in the development of mechatronic systems, virtual prototyping is widely used to help the design. It derives from integrated CAD-systems and is enriched with new interaction and visualization technologies, which can help the engineering team to understand the whole design in a more intuitive way. Therefore it is considered as a potential supporting technique for engineering design. However, the technology – virtual prototyping itself does not specified for supporting multidisciplinary communication among the designers, especially for their cooperative work in the development of mechatronic systems.

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Our aim is to develop and test new interaction, representation and analysis techniques for composing and verifying mechatronic systems in virtual prototyping environment, especially to support designers to exchange their ideas and knowledge as well as to help them in analyzing the behavioral models of the mechatronic system being developed. The virtual prototyping environment means here an immensive VR environment for doing virtual prototyping, which allows the designer to work more intuitively and interactively than those conventional platforms.

In Section 2, the existing research works, which are focused on supporting knowledge sharing in design or education, are briefly introduced and reviewed. As following, we continue the discussion with the framework of our solution, and explain how a virtual prototype of a mechatronic system can be created from a composition of solution elements. Further, Sections 4 and 5 will explicate the supporting techniques and system configuration used in the realization of the multidisciplinary communication, as well as the working flows arranged to fit the communication within the designers in the virtual prototyping environment. Finally, a experimental prototype of our solution is evaluated and illustrated with a practical example in Section 6.

2. Related works

The problems of multiple users sharing resources, such as information, material, and knowledge, are already known from the field of computer supported collaborative work (CSCW) [2–4]. The research work of CSCW reveals the major challenges in supporting nowadays cooperative activities, which include the distribution of resources, the delegation of rights, and the representation of group structures.

The research works introduced in [5–8] show that a great interest has aroused on the social-communication aspects of CSCW over recent years. Those projects and research works are going to realize the knowledge sharing for the cooperative work in design.

In addition, many other works have been done to resolve the challenges of CSCW located in virtual environments and virtual society. For examples, the authors of [3,9,10] introduced several different CSCW approaches for establishing distributed CAVE systems and VR systems.

However, those literature reviews show that most previous approaches are mostly focused on resolving the problems in sharing the data or general knowledge resources within the users. On the other side, to share the multidisciplinary knowledge between the engineers in their cooperation work was seldom taken into account.

Unfortunately, the multidisciplinary communications are widely existed in the design of mechatronic systems. Additionally, our previous research work [11] shows that a more intensive exchange of information is also required by the cooperative activities among the designers in the virtual prototyping of mechatronic systems. The research work presented in this paper is going to explore the approaches to support that multidisciplinary communications in VR-based virtual prototyping of mechatronic systems.

3. Overview of the approach

A conventional communication for design problem resolving goes through the sequence of "to request, be understood, be answered, to understand and to execute". Although it is the natural communicating way, it is inefficient. Based on our experience, it is hard or even impossible to let the engineers, who come from different domains, understand each other. The alternative communicating way suggested by our approach is to separate the communicators to "questioner" and "responser", which is defined towards to the communication rather than people. The questioner only needs to care what he wants, and the responser only needs to concentrate on how to fulfill the demands. And the connection between the questioner and responser is realized by certain tools.

Therefore, the basic idea of our approach is to let the multidisciplinary engineers concentrate themselves on the work, which they are more familiar with or responsible to, and let them communicate with each other via specified user interfaces and a common communicating platform. Fig. 1 illustrates the conceptual frame work of this idea.

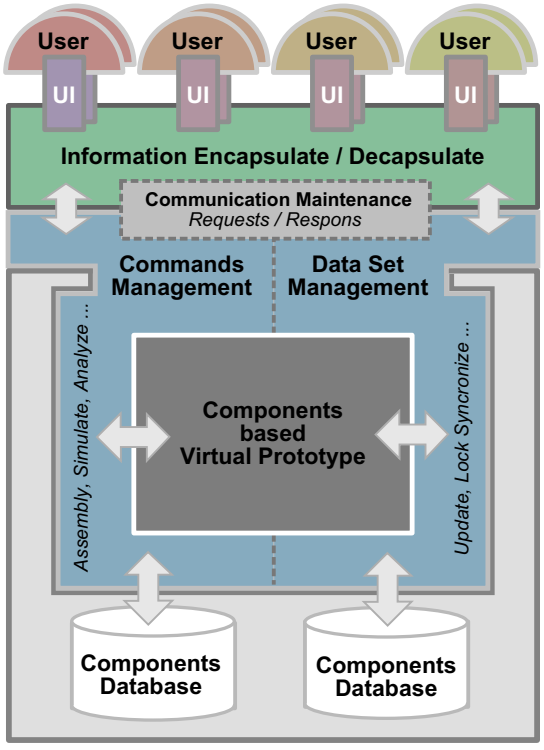

Fig. 1. The multidisciplinary communications among the users are realized by providing them specified user interfaces and a common communicating platform.