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Virtual Reality & Augmented Reality in Industry



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虚拟现实与增强现实技术及其工业应用(英文版)

The 2nd Sino-German Workshop

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Preface

Virtual reality and augmented reality (VR/AR) are key technologies for virtual engineering. They are the basis for functional virtual prototyping, which enables engineers to analyse the shape, form and functional behavior of future products in an immersive and interactive virtual environment. Applying these technologies greatly improves the communication in product design and production development: It helps to identify and avoid design errors in early stages of the development process, it reduces the number of physical prototypes and saves time and cost for enterprises. VR/AR are considered as valuable tools for improving and accelerating product and process development in many industrial applications. However, there are still many requirements unaddressed leaving considerable potential for further developing and improving VR/AR-based tools and methods.

This workshop intends to establish an open forum, dedicated to present and discuss innovative applications from industry and research from China and Germany, as well as to exchange experiences. It provides the opportunity to learn about state-of-the-art VR/AR applications in industry, and to directly experience new development and future trends of VR/AR technology.

This workshop is supported by the Department of High and New Technology Development and Industrialization of MOST (Ministry of Science and Technology of China), Deutsches Generalkonsulat Shanghai and Shanghai Science & Technology Committee. The purpose is to promote industrial application of VR/AR tools and methods in China, and to promote the science & technology exchange and cooperation between China and Germany. The publication of these proceedings is also supported by Shanghai JiaoTong University Press and Springer SBM.

We acknowledge all workshop sponsors, organizers and co-sponsors: Shanghai Jiao Tong University, Heinz Nixdorf Institute, University of Paderborn, Shanghai Automotive Industry Science and Technology Development Foundation, Manufacture Information Engineering of China Magazine, Shanghai Academy of Science & Technology, National Engineering Laboratory for Digital Shipbuilding (China), Shanghai Electric Group Co., Ltd. Central Academy, State Key Lab of CAD&CG, State Key Lab of Mechanical System and Vibration (China), Virtual Reality Professional

Committee (China Society of Image and Graphics), Shanghai Science & Technology Museum.

These proceedings can be used as reference for researchers and students in the fields of virtual reality and augmented reality and its application.

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Design and VR/AR-based Testing of Advanced Mechatronic Systems

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Abstract

Advanced mechatronic systems with inherent partial intelligence, so-called self-optimizing systems, react autonomously and flexibly on changing environmental conditions. Such systems are capable of learning and optimizing their behavior during operation. Their principle solution represents a significant milestone because it is the result of the conceptual design as well as the basis for the concretization of the system itself, which involves experts from several domains, such as mechanics, electrical engineering/electronics, control engineering and software engineering. Today, there is no established design methodology for the design of advanced mechatronic systems. This contribution presents a new specification technique for the conceptual design of advanced mechatronic systems along with a new approach to manage the development process of such systems. We use railway technology as a complex example to demonstrate, how to use this specification technique and to what extent it facilitates the development of future mechanical engineering systems. Based on selected virtual prototypes and test beds of the RailCab we demonstrate, how VR- and AR-based approaches for a visual analysis facilitate a targeted testing of the prototypes.

Keywords

Mechatronics, Self-Optimization, Design Methodology, Principle Solution, Targeted Testing, Virtual Prototype, Visual Analysis, Virtual / Augmented Reality

1 Virtual Prototyping in the Product Innovation Process

Products and manufacturing systems of mechanical engineering and its related industrial sectors like automotive engineering are getting more and more complex. Time-to-

market is decreasing simultaneously. Under these circumstances the product innovation process is facing extraordinary challenges. Before we point out how to overcome these challenges, let us spend a brief look on the product innovation process.

The product innovation process starts from the idea of a product or business and leads to the successful product launch. It incorporates the areas of product planning, R&D and manufacturing process planning. The general work flow is shown in the figure. In practice, the product innovation process is iterative and comprises a number of cycles (see Fig. 1).

The first cycle characterizes the steps from finding the success potentials of the future to creating the promising product design, what we call the principle solution. There are four major tasks in this cycle:

- foresight
- product discovering
- business planning
- conceptual design

The aim of **foresight** is to recognize the potentials for future success, as well as the relevant business options. We use methods such as the scenario technique, Delphi studies and trend analysis.

The objective of **product discovering** is to find new product ideas. We apply in this phase creativity techniques such as the Lateral Thinking of de Bono or the well-known TRIZ.

Business planning is the final task in the cycle of strategic product planning. It initially deals with the business strategy, i.e. answering the question as to which market segments should be covered, when and how. The product strategy is then elaborated on this basis. This contains information:

- on setting out the product program
- on cost-effectively handling the large number of variants required by the market
- on the technologies used and
- on updating the program throughout the product lifecycle

Additionally, a business plan must be worked out to make sure an attractive return on investment can be achieved.

This first cycle is also concerned with the **conceptual design**, although this area of activity is actually assigned to product development in the strict sense. The result of the conceptual design is the principle solution. It is, for example, required to determine the manufacturing costs needed in the business plan. That is the reason why there is a close interaction between strategic product planning and product design linked by conceptual design. Conceptual design is the starting point for the next cycle.

This second cycle corresponds to the established understanding of product development. The essential point here is the refinement of the cross-domain principle solution by the domain experts involved, such as mechanical engineering, control technology, electronics and software engineering. The results elaborated by the domains in this cycle must be integrated into an encompassing product specification. This specification has to be verified in the light of the requirements given by the first cycle.

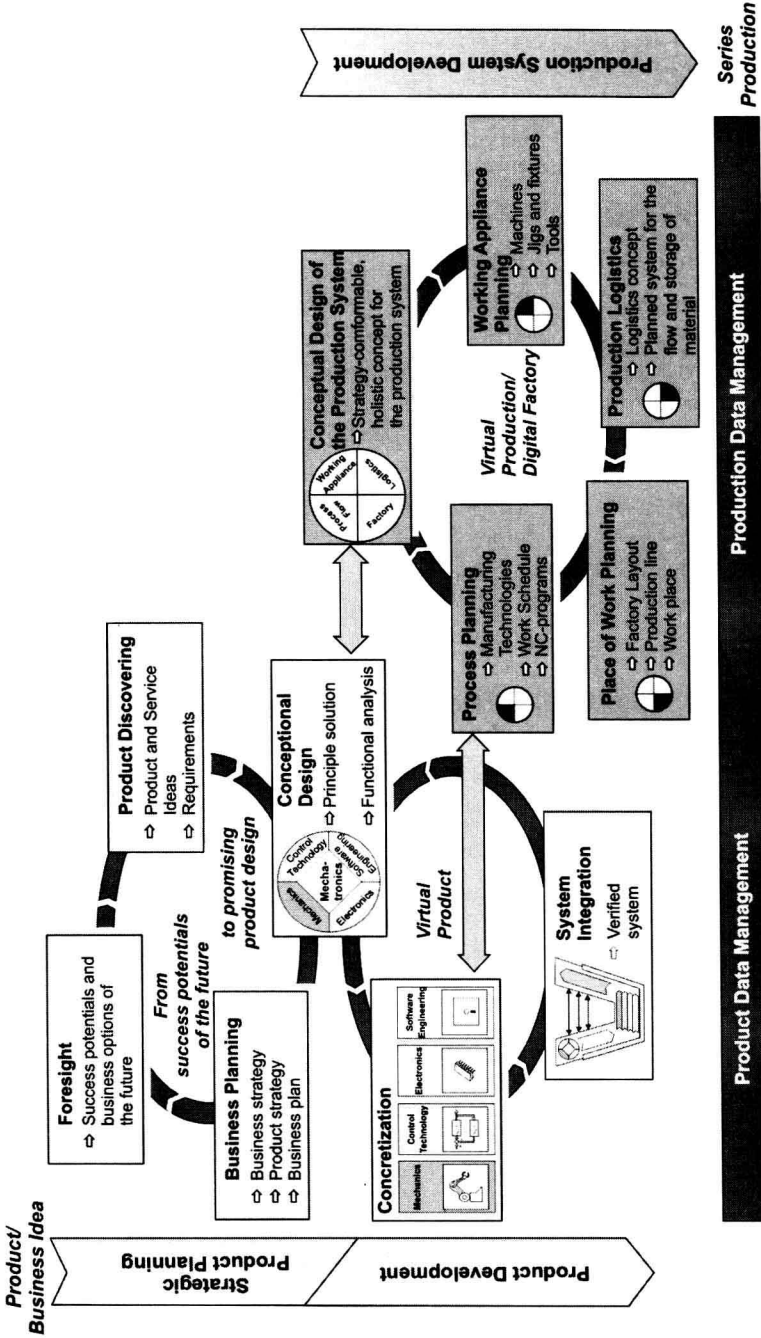


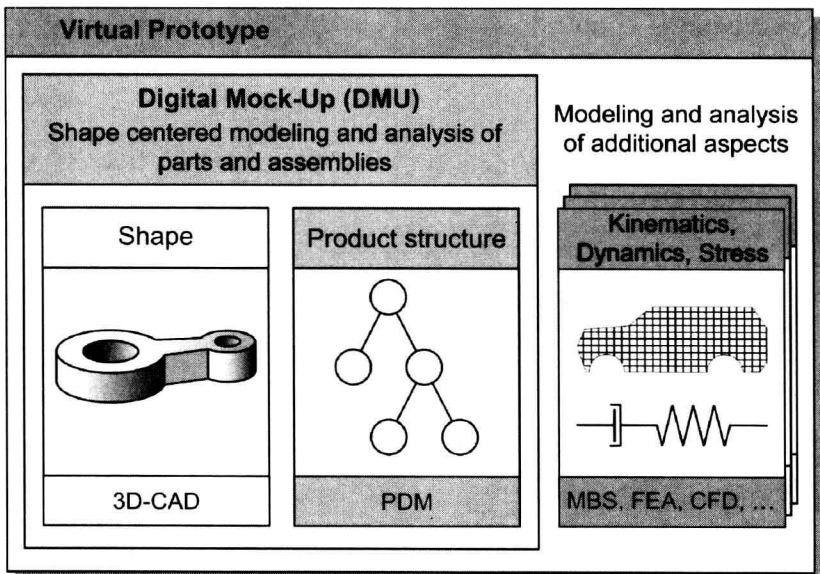
Fig. 1 The product development process as a sequence of cycles [1]

This is done in the product integration phase.

The third and last cycle focuses on manufacturing process development and the optimization of the product design with respect to manufacturing.

The second and the third cycle Product Development and Development of the corresponding manufacturing process are decisively driven by information technology. A key element is Virtual Prototyping. It means to build and analyze computer models of products and production systems being developed in order to reduce time- and cost-intensive manufacturing and testing of prototypes to a minimum. Simulation is another term for experimenting with such computer models. When we model products in the computer, we talk about the virtual product; in analogy we use the buzzwords virtual production or digital factory when we model the manufacturing system.

A perfect virtual prototype represents all aspects of a product (see Fig. 2). 3D-CAD systems are basically used to model the shape of parts. The breakdown of the product to its parts and assemblies is represented by the product structure. Therefore, it is necessary to set up a Product Data Management (PDM). The shape of individual parts in conjunction with product structure is used to develop a shape-based design of the product, what we call Digital Mock Up (DMU). It represents the spatial composition of all parts and assemblies of the product. A DMU can be used to carry out experiments such as clash detection, checking assembly and disassembly sequences. This is all based on the shape of the technical system. To analyze the behavior, we need to consider additional aspects offered by a virtual prototype.



PDM: Product Data Management
MBS: Multi Body Simulation

FEA: Finite Element Analysis
CFD: Computational Fluid Dynamics

Fig. 2 From solid modeling to virtual prototyping [2]