Virtual & Augmented Reality Support for Discrete Manufacturing System Simulation

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1. Introduction

The actual business situation can be characterized by an increasing dynamics of innovations and short product life cycles, whereas products become more and more complex. The keen competition forces companies to respond to market changes. High standards on the planning of manufacturing systems arise from this development. In particular it is important that either the production processes are adjusted as quick as possible to new circumstances or new manufacturing processes are planned in the way that they yield the required results straightaway (KUHN, WIENDAHL, EVERSHEIM, SCHUH 2002). In this context the discrete simulation of the manufacturing system is used. Therefore the considered system is analyzed and a computer-internal model is developed. This includes the modeling of functions, processes, behaviors/rules, which should reflect the actual interrelations of effects in a model. For various problems extensive models with a complex behavior are required. However an increasing size and complexity of the simulation model leads to more work for modeling, a higher error-rate and runtime, and to more work for interpretation. The design of the user interface has a particular part in that (ELLIS, BEGAULT, WENZEL 1997). For the usual, little intuitive WIMP-Interface (Windows, Icons, Mouse, Pointer) highly trained users are required so that the development of complex simulation models involves a lot of time. The simulation results are presented in form of tables and 2D, abstract illustrations of the manufacturing system, which is adequate for simulation experts. Thus misinterpretations might be a consequence of ambiguous statements. Therefore the development of a simulation system having more than an intuitively understandable user interface is required.

2. Fields of Application of VR/AR-Technology

The simulation of a manufacturing system is performed in several steps: Having determined the required functional range and relevant data a simulation model is developed. Based on the simulation model simulation computations giving information about the capacity of the planned production system are made. The results are evaluated and may lead to modifications.

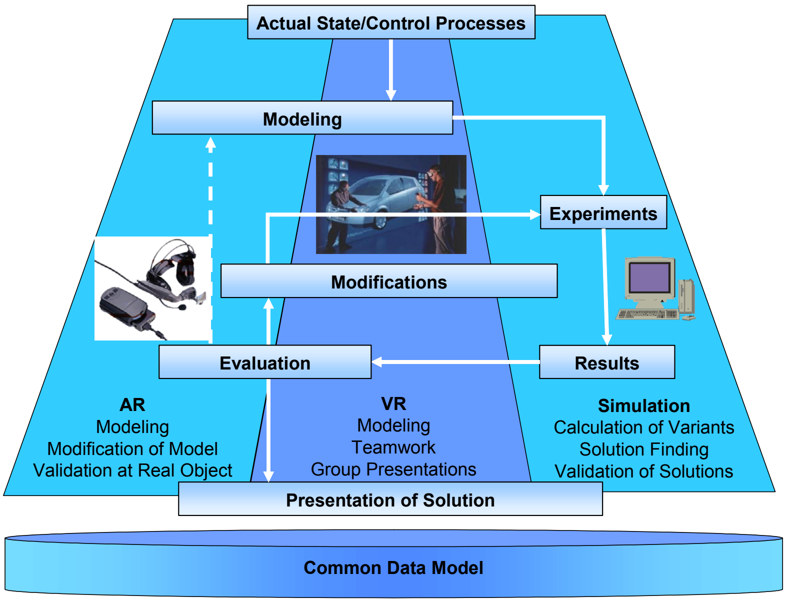

Fig. 1: Fields of application of a VR/AR-supported simulation

An iterative cycling of this process takes place until the evaluation of the simulation computation indicates that a satisfying solution for the production system is found. This solution is presented to the planning team or management giving then the final release for the realization of the manufacturing plant. The technologies Augmented Reality (AR) and Virtual Reality (VR) offer high potentials concerning the improved application of simulation techniques during the planning of manufacturing systems. Figure 1 shows in which ways the respective technologies can be applied during each stage of the simulation process.

3. Concept of a VR/AR-supported Simulation

The fields of application show that VR- and AR-based user interfaces can be used during various stages of the simulation profitably. Therefore an integrated system has been developed (figure 2).

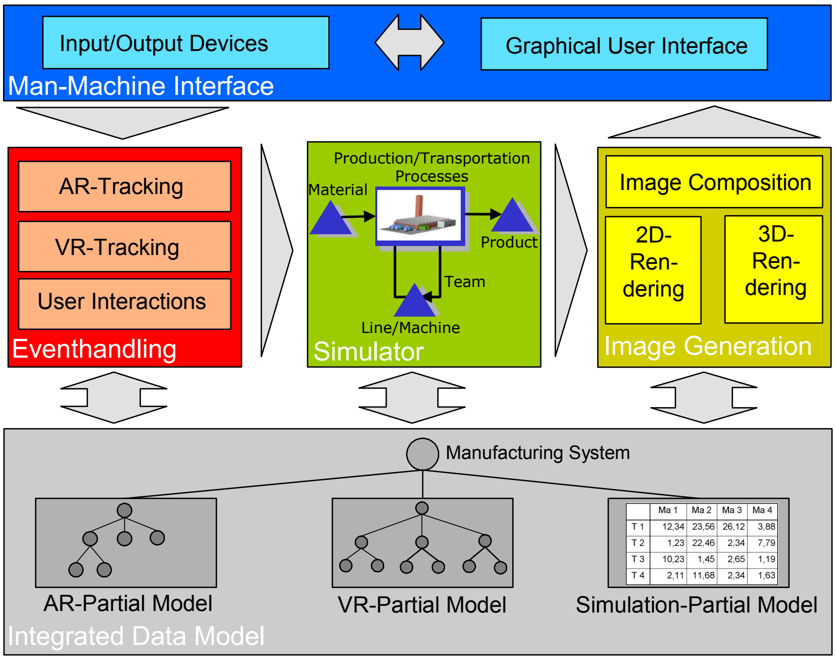

Fig. 2: Structure of the system and its elements

3.1 Simulator

The simulator must accept the user's input about the eventhandling process and adjust the simulation model accordingly. This applies to both static and dynamic data. In this way machines are produced, placed, parameterized, and linked. The simulator and the test runs are managed completely from the AR/VR-environment. Significant points of particular interest for the user are to be identified automatically or semi-automatically (targeted introduction of sensors for significant points by the modeler) to emphasize important points. If a sensor is activated the appendant object is classified as significant and reported to the visualization. For example full storages or machines missing some parts can be identified by sensors. Integrating the sensors into the elements of the library of the simulator allows an implied application of the sensors during modeling.

3.2 Integrated Data Model

The outlined system receives data from various sources for/from different modules. In order to avoid inconsistencies and to make adjustments automatically available for all modules the simulation and visualization data cannot be saved separately. A common data model which can be accessed online without restrictions is required. The exchange of any structural element is only done in the AR/VR-environment and the modified model will be available in the entire system. Appropriate interfaces between the data model and the common IT-systems are available. In this way 3D-CAD-data can be taken directly from the company internal 3D-CAD-systems and simulation models can be exported to standard simulators.

3.3 Automated Data Generation

The 3D-models for the VR/AR-system have to be taken directly from the extensive CAD-data. A time-consuming, manual preparation in two steps is usual: Conversion (CAD-system to VR-system) as well as reduction of complexity and data preparation of the 3D-models; generation of additional information (lighting, shading, material). Especially the first step is time-consuming since the proceedings of the automatic reduction of complexity working without manual postprocessing cannot be applied in reality. If quick adjustments in the CAD or simulator model are made and an immediate visualization is necessary, the workflow will be affected negatively. Consequently a solution is required whereby the first step is completely automated and the second is reduced to a quick and semi-automated process with the help of libraries (figure 3). This procedure allows an extensively automatic visualization of highly complex data without manual post processing. The 3D-models used in the AR/VR-environment are to be generated from the company internal 3D-data (e.g. 3D-CAD-models). For this purpose information about colors, material properties, and textures are to be considered.

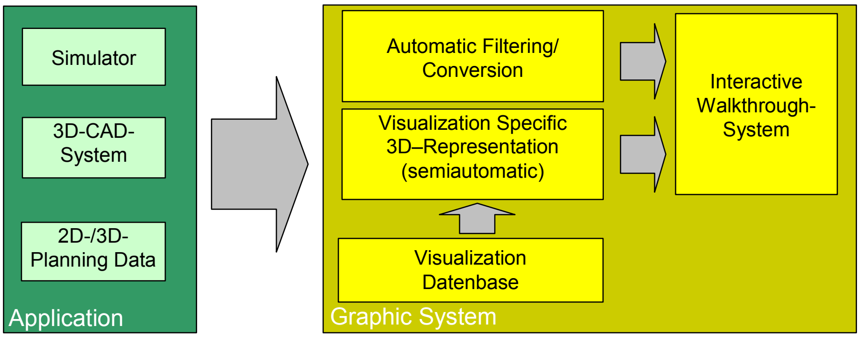

Fig. 3: Process of data generation

3.4 Image Generation

The system for the image generation is to meet the following requirements: On the one hand it is to offer scalable graphics power with high performance and image quality for diverse applications. On the other hand it is to facilitate an automatic and fast data preparation of the data from other applications which are to be visualized.

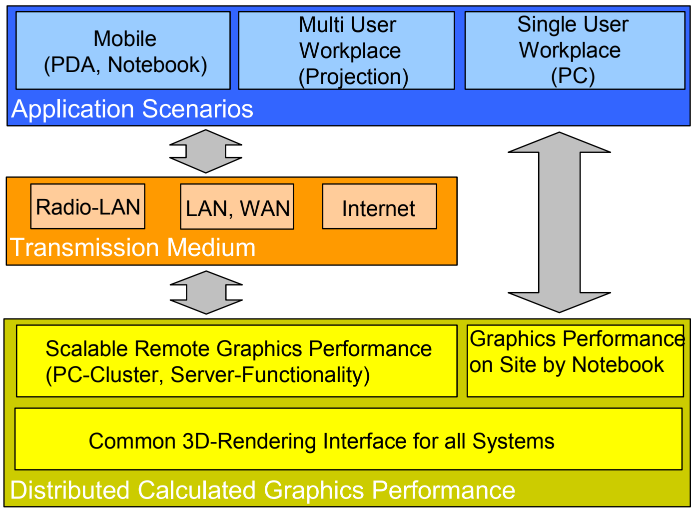

Fig. 4: Scalable graphics power using distributed image generation

An all-purpose solution is needed for the visualization requirements with varying performances existing on hardware platforms in diverse fields of application, e.g. mobile PDA (data capture), desktop PC (simulation), portable notebooks (presentation), or PC-cluster for high-end VR-systems (large-format projection for a number of persons), see figure 4. Only one scalable graphics system is available for all platforms. This system allows the visualization of very large and stereoscopic VR-scenes with any topology (single objects like robots, subassemblies and product lines as well as manufacturing plants and production sites). The virtual scenes of manufacturing plants are so complex that they cannot be displayed in real-time on a single PC without the application of specific techniques. The graphic system is to obtain a high-quality, photo-realistic display by means of new techniques (real-time shadows, reflections) and a high performance of the display on various platforms (PDA, monitor, powerwall). In order to cope with the different performances of the hardware platforms a distributed image generation is advisable: The virtual scenes are computed in parallel by a scalable PC-cluster. The computed image data is transferred to the client by an appropriate transmission medium (WLAN, LAN, Internet). Efficient clients (PC or notebook) can undertake a part of the image computation or compute 3D-images in situations without network access to the cluster (presentations on a notebook) on their own.

4. References

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