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# COMBINATION OF SIMULATION SOFTWARE AND VIRTUAL REALITY FOR TECHNOLOGICAL WORKPLACES DESIGN

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**ABSTRACT**
*With the advent of high-resolution graphics, high-speed computing, and user interaction devices, virtual reality (VR) has emerged as a major new technology in recent years. An important new concept introduced by many VR systems is immersion, which refers to the feeling of complete immersion in a three-dimensional computer-generated environment by means of user-centered perspective achieved through tracking the user. From a manufacturing standpoint, some of the attractive applications include training, collaborative product and process design, facility monitoring, and management. Moreover, recent advances in broadband networks are also opening up new applications for telecollaborative virtual simulation environments in these areas.*
**Keywords:** virtual reality, simulation software, technological workplaces design

## 1. INTRODUCTION

Sophisticated computer simulations, what might be called virtual factories, call for a distributed, integrated, computer-based composite model of a total manufacturing environment, incorporating all the tasks and resources necessary to accomplish the operation of designing, producing, and delivering a product. With virtual factories capable of accurately simulating factory operations over time scales of months, managers would be able to explore many potential production configurations and schedules or different control and organizational schemes at significant savings of cost and time to determine how best to improve performance.
Since a factory model running in simulation mode would run thousands of times faster than real factory operations and would probably cost much less as well, managers would have a rapid, nondisruptive methodology for testing various manufacturing strategies. Improvements suggested by real operations could be tested without risk in the simulation. Simulations could also assist in training tool operators and floor managers, who would be able to use factory models in simulation mode much as pilots use simulators to gain experience in flying real airplanes, especially under stressful or unusual conditions [1].

## 2. VIRTUAL REALITY SOFTWARE

Virtual Reality (VR) requires more resources than standard desktop systems do. Additional input and output hardware devices and special drivers for them are needed for enhanced user interaction. But we have to keep in mind that extra hardware will not create an immersive VR system. Special considerations by making a project of such systems and special software are also required.
Beyond input and output virtual reality hardware, the underlying software plays a very important role. It is responsible for the managing of I/O devices, analyzing incoming data and generating proper feedback. The difference to conventional systems is that VR devices are much more complicated than these used at the desktop – they require extremely precise handling and send large quantities of data to the system. Moreover, the whole application is time-critical and software must manage it: input data

must be handled timely and the system response that is sent to the output displays must be prompt in order not to destroy the feeling of immersion [5].
Every VR application must be effective by means of performance and interaction. This requirement can be only fulfilled when all system parts – input, interaction and output – are properly integrated one with the other. Nowadays, even the best hardware cannot support this by itself – it needs software assistance for precise control, resources management and synchronization.

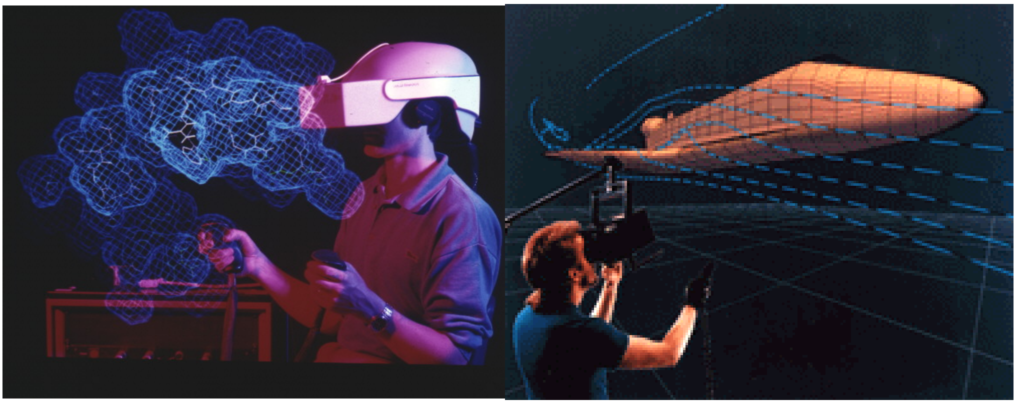

*Figure 1. VR simulation of molecules in chemistry and simulation in area of product design*

Nowadays, huge amounts of information are stored in computer memory and flow through computer networks. These streams of data will be growing rapidly in the near future (datahighways). The real problem will be rapid retrieval and comprehensive access to the relevant information for a particular user. Standard computer interfaces are not capable to guarantee this any more. Virtual reality with its broader input and output channels, autonomous guiding agents and space metaphors offers the enhancement of human perception and makes information searching and understanding faster. To make the interaction and communication with virtual worlds successful we cannot think just about one of previously listed interaction techniques. For each application area, other subset of them will be needed to guarantee the optimal performance. Ideally, not only software but also hardware should be transparent to the user and should provide maximum freedom and naturalness. To achieve this, however, both refinement of hardware devices and software paradigms for interaction are necessary.

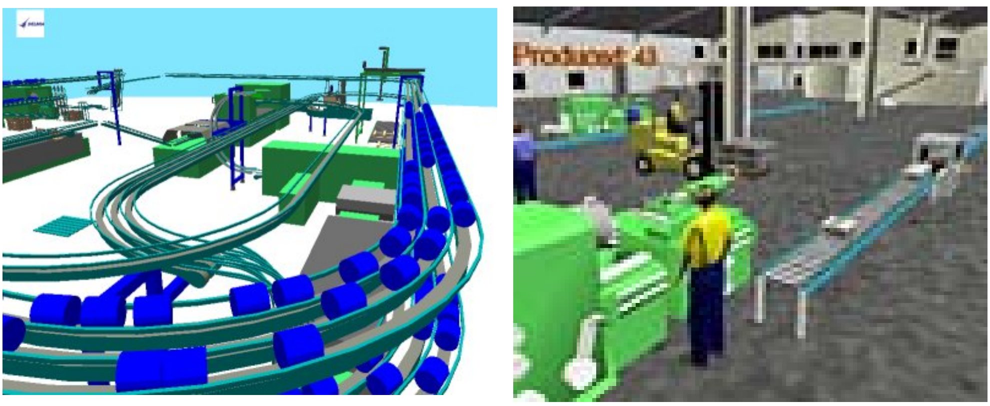

*Figure 2. Data pruning and application in manufacturing simulation*

Virtual reality may be a clone of physical (real) reality or a kind of closer not defined (cyber)space that has it own rules. In both of these cases a simulation of the environment has to be done. In case of newly defined cyberspace the task is relatively easy – we can invent new laws or use simplified physics. The real challenge is to simulate the rules of physics precisely, because they are very complex phenomena: dynamics of objects, electromagnetic forces, atomic forces etc. For the human-computer interaction purposes a subset of them has to be considered. Newton's laws are the basis when simulating movements, collisions and force-interaction between objects. The simulation, collision detection and animation of autonomous objects, may be a very complex and time-consuming task, so other approaches must be applied than in standard (i.e. non-real time) animation. The simulation process that manages the behaviour of the whole environment (including interaction between different users) should be run in the "background" – decoupled from the user's interaction in order to support the full performance. The updates between these application parts are realized by means of asynchronous operations [7].

The construction and maintaining of physically based, multi-user and therefore distributed virtual environments is not an easy task. Beside usual expectations – high efficiency support for lag minimization – it demands hardware independence, flexibility and high-level paradigms for easy programming, maintaining and consistent user interface. A few prominent examples of VE toolkits and systems (i.e. VE shells) are: MR (Minimal Reality), NPSNET, AVIARY or DIVE.

## 3. SIMULATION OF MANUFACTURING WORKPLACES IN VIRTUAL REALITY

A complete VR system is a large software system, consisting of many modules. Every VR system contains an object manager, renderer, device drivers, communication module, navigation and interaction module, and, usually, physicallybased simulation, sound rendering, scientific visualization, application-specific modules, etc. The visual part of a virtual world is represented by a hierarchical scene graph. Everything is a node in this graph: polyhedra, assemblies of polyhedra, LODs, light sources, viewpoint(s), the user, etc. Most of the functionality and interaction presented below will operate on the scene graph, i.e., it will, eventually, change some attribute(s) of some object(s).

For creation of virtual reality for verification purpose were used following components [4]:

- virtual reality environment creation system Vizard
- head mounted display Emagin Z800

Vizard system for virtual environment creation is package of high-end graphical tools designated for graphical applications creation including virtual reality, scientific visualizations etc. Vizard uses powerful engine based on object-oriented programming which includes full usage of OpenGL and DirectX possibilities. VR environments created in Vizard environment are optimized with usage of VizardLAXMI tools for achieving of full graphical performance. Selection of this application is usage was because its support of wide range of VR hardware and conversion formats. Output visualization was performed with HMD E-magin Z800. This HMD is equipped with OLED visualization technology with high contrast. HMD has integrated motion sensor for head position and orientation location.

Creation of virtual environment started with defining of new virtual environment its parameters and behavior. This action was followed by objects importing and their allocation in virtual environment. Arrangement of each object followed primary 2D drawing so the workplace virtual shape was build in 1:1 ratio to its real model. Purpose of our virtual model is verification of design proposal with reference of robot access to workpiece during work mode. In order to fulfill this goal it is necessary to define motion action of robot which can be controlled by user. In this way can designer verify correct proposal of workcell design.

One of the main goals of using a VR system for design verification is the potentially high degree of "reality" which can be experienced when immersed in a VE. In order to achieve this, the VR system needs to be able to visualize object behavior at interactive frame rates. Other tasks of a VR system in the context of design verification are geometrical and spatial analyses. In order to check serviceability of a proposal, the VR system has to track the work space necessary for the objects move and it has to report collisions. During verification it is often necessary to simulate kinematics in order to perform a sensible design study. Real-time collision detection of polygonal objects undergoing rigid motion is of critical importance in many interactive virtual environments. In particular, simulation algorithms, utilized in virtual reality systems to enhance object behavior and properties, often need to perform several collision queries per frame. It is a fundamental problem of dynamic simulation of rigid bodies and simulation of natural interaction with objects [6].

Virtual reality is one of the enabling "technologies" for all kinds of physically-based visualization in VR and other applications. Main advantage of virtual reality application usage is possibility of creation and simulation of new technological unit before its realization. Usage of virtual reality in such way as a verification tool can help to minimize errors which may occur by creation of new workplaces. Paper presented simplified procedure of creation of such model with exemplar selection of software and hardware components which is followed by main description of system function principle. It presents step by step actions which have to be done in order to proceed from idea of new workplace thru 2D drawing design and 3D models creation and till import of virtual models in virtual reality environment and virtual parameters set up.

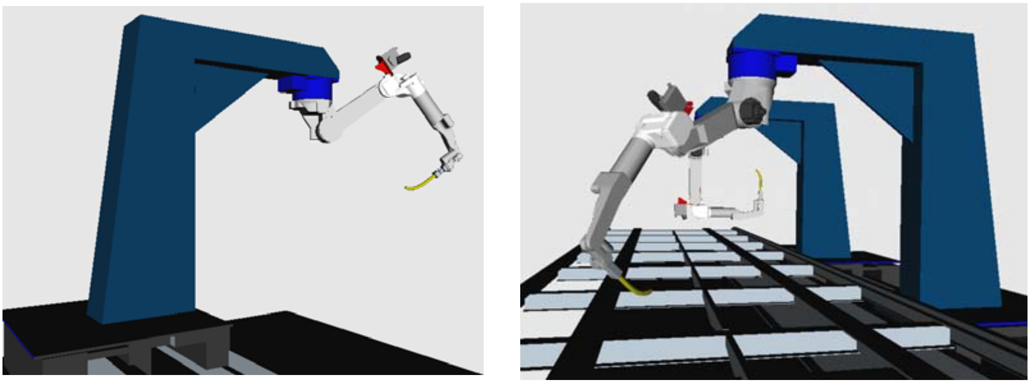

*Figure 3. Simulation of manufacturing workcell in virtual reality*

## 4. CONCLUSION

To develop virtual manufacturing technology effectively it is essential that an interface layer be created between VR software and manufacturing software. Current examples of VR software are based on hardware specifications such as 3D Studio® by AutoDesk, Open inventor™ by SGI, WorldToolKit® by Senses (now acquired by EAI), Performer™ by SGI, CAVE™ (Computer Assisted Virtual Environment) software library by VRCo, and Division library (now acquired by PTC), which is geared toward a room-sized VR implementation driven by multiple SGI processors. More recently, implementations of Virtual Reality Modeling Language (VRML) have been used, and VRML has also become an ISO standard. Cosmo Player is a useful VRML browser conceived by SGI and acquired subsequently by Computer Associates. Noncommercial highly parallel graphics multicomputer known as pixel-planes are also available, mainly for research purposes. Examples of manufacturing and automation software include simulation software, control software, and layout design software, among others.

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