Proceedings of the International Conference on Theory and Applications of Mathematics and Informatics - ICTAMI 2004, Thessaloniki, Greece

VIRTUAL REALITY & LOGISTICS

by
Konstantinos Pehlivanis, Maria Papagianni, Athanasios Styliadis

Abstract: This paper is about the applications of virtual reality in logistics. Virtual reality involves the use of advanced technologies, including computers and various multimedia peripherals, to produce a simulated environment that users perceive as comparable to real world objects and events. With the aid of specially designed transducers and sensors, users interact with displayed images, moving and manipulating virtual objects, and performing other actions in a way that brings on a feeling of actual presence in the simulated environment. It permits users to experience and interact with a life-like model or environment, in safety and at convenient times, while providing a degree of control over the simulation that is usually not possible in the real-life situation. Logistics is the process of planning, implementing and control of cost effective processing of materials and or human potential. In logistics the adjustment of time, place and capacity plays a central role. Insight in dependency and risks is essential for high quality decisions. Virtual reality plays a key role in these decisions.
Keywords: Virtual reality, Logistics, Computer simulation, Virtual environments.

1. Introduction

Product life cycles are getting shorter and customers want variations. Production system flexibility is the key factor and systems are getting more complex. Time-to-market is critical; this means faster manufacturing system designs and faster ramp-up processes. Production simulation and virtual manufacturing tools are valuable in shortening the design steps. Virtual production system speeds also the production ramp-up, because the operators know better the planned system and can study the parameters and features of the new system before anything is installed to the factory store. Time-to-customer, punctuality and throughput time, are important competition factors in manufacturing. The products are usually complex systems consisting of components, which are manufactured in different factories, sometimes in different countries. The production systems have to be flexible and able to react to changing production capacity requirements. All this makes planning and management of production networks a complex task.

The unique features and flexibility of virtual reality give it extraordinary potential for use in work-related applications. It permits users to experience and interact with life-like models or environments, in safety and at convenient times, while providing a degree of control over the simulation that is usually not possible in real life. These characteristics make it indispensable in applications where planning and testing is necessary for decision making about planning of operations. The applications that appear to be most promising are those that employ virtual reality for visualization and representation, distance communication and education, hands-on training and orientation and navigation.

Logistics management is increasingly being seen as a source of competitive strength. Its effective use provides potential for cost reduction and the opportunity for increasing market share. The rapid development of economy and technology of the recent years influenced logistics management fundamentally. On the one hand problem dimension and complexity increased on the other hand the potential for problem solving increased as well if we consider the progress in Information Technology as to its performance in data-processing and communication. In economy the changes are caused by a growing globalization of the markets and an increasing extension of the business network which created new challenges for logistics management. At the same time information technology, partly a catalyst in economic development provided new facilities for communication and data processing which open new perspectives for an efficient decision support in logistics management.

2. Virtual reality

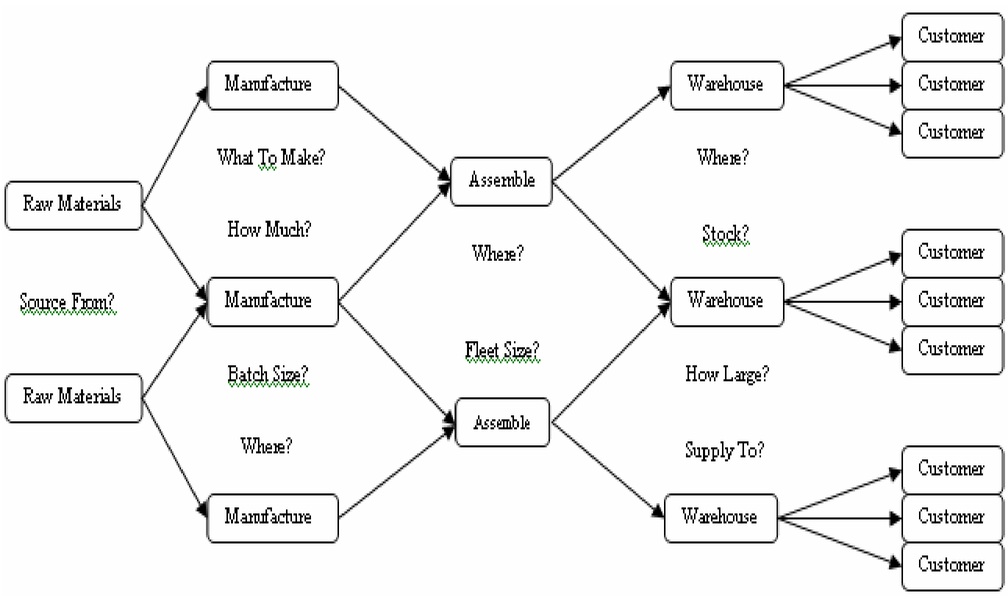
Virtual reality involves the use of advanced technologies, including computers and various multimedia peripherals, to produce a simulated environment that users perceive as comparable to real world objects and events. With the aid of specially designed transducers and sensors, users interact with displayed images, moving and manipulating virtual objects, and performing other actions in a way that brings on a feeling of actual presence in the simulated environment. One of the cardinal features of virtual reality is the provision of a sense of actual presence in and control over the simulated environment. This feature is achieved to greater or lesser extents in the various applications of virtual reality, depending upon the goals of the particular application and the cost and technical complexity its developers are willing and able to assume. In the most technically advanced applications of virtual reality, known as "immersive" virtual reality, the user is essentially isolated from the outside world and fully enveloped within the computer-generated environment. Multimedia peripherals such as visual display units and speakers are integrated into a helmet worn by the user, presenting stimuli appropriate to the simulated setting. At the same time, the system tracks the user's responses to the stimuli from the virtual environment via position and force sensors mounted to the helmet and a hand-held control device, data glove and/or body suit, and modifies the simulation accordingly. For example, if a user turns to look backwards over the left shoulder, a sensor will detect the change in position and orientation of the head, and adjust the visual display so that the display corresponds to what the user would see from that pose if the scene were real. If the user reaches out toward an object in the virtual environment, sensors sensitive to movements of the fingers and to the position of the hand enable the system to detect when the user's hand intersects with the virtual object, and adjust the display to mimic pushing, lifting, or rotation of the object. The user may also be stimulated by electromechanical pin-arrays that excite cutaneous receptors and by inflatable air chambers that excite deep pressure receptors of the fingertips and palm of the hand. The interactive nature of virtual environments makes it a natural extension to the 3-D graphics that enable engineers, architects, and designers to visualize real life structures before actually building them.

A significant savings in resources can be realized by testing out virtual reality models prior to physical construction. Wilson (1997) relates how prior simulation of a planned building's layout revealed serious architectural shortcomings such as inadequate access to delivery vehicles. Similarly a, wheelchair virtual reality system [Murphy, 1993] helps to ensure that a proposed building is accessible to people with disabilities. In this fully immersive system, testers wear a data glove and head-mounted device, sit in an actual wheelchair on rollers, and explore a simulation of the proposed structure to determine its suitability for people with disabilities. The magnitude of door widths, turning radii in small spaces, and even measurements that are not typically listed in building specifications such as faucet heights can all be verified before construction. Although one may argue that such information could be obtained by simpler means, the fact remains that the virtual environment encourages designers and users to interact to construct a truly accessible building [Delaney, 1998].

The use of such "virtual prototypes" to augment or replace physical prototypes can significantly reduce product development time and costs [Wilson, 1997]. Where changes are required, machine components can be readily modified and layouts can be quickly rearranged. Moreover, by allowing users to view the product design in ways that are less ambiguous to non-experts, virtual reality promotes direct collaboration with other industry personnel or customers at an earlier stage in the design or manufacturing process. In the fashion industry, for example, a virtual environment has been developed that allows clothes to be displayed to retailers at their convenience [Stanger, 1997]. In an effort to respond more quickly and accurately to market demand, designers create virtual fashion collections which are then modelled to buyers by 3-D mannequins who, in response to verbal instructions from the designer, parade the garments in a variety of poses and settings. Although virtual reality prototype garments would not entirely replace the need for the creation of real model collections, they introduce an element of designer-retailer collaboration which, in theory, can enhance the quality and suitability of clothes as well as the speed with which they are available for sale.

3. Applications in logistics

Logistics is the process of planning, implementing and control of cost effective processing of materials. In logistics the adjustment of time, place and capacity plays a central role. Insight in dependency and risks is essential for high quality decisions. Below is a schematic diagram which shows some of the fields of interest for logistics:



Logistics systems can be arbitrarily complex and difficult to understand. Some of the characteristics needed for modelling are listed in the table below:

<table>
<tr><th colspan="2">Material Handling Parameters</th></tr>
<tr><td>Conveyors
Accumulating
Non-accumulating
Indexing and other special purpose
Fixed window or random spacing
Power and free</td><td>Storage Systems
Pallet storage
Case storage
Small part storage
Oversize items
Rack storage or blocked stacked
Automated storage and retrieval systems with storage-retrieval machines</td></tr>
<tr><td>Transporters
Unconstrained vehicles, Fork Lifts
Guided vehicles
Bridge cranes and other overhead lifts</td><td></td></tr>
</table>

The tasks within Logistics management are focused on planning and control; today's requirements may be summarized as follows. An efficient use of scarce resources alone doesn't suffice any longer; dynamic aspects are the longer the more decisive. High flexibility and fast reactions to internal and external changes are important qualities. As to the design of computer supported planning and control systems, *adaptability* is required which means, planning and control directives have to be permanently updated to guarantee a remaining on track with the development of the system's environment. This concerns not only the system state, but also the knowledge about the future, expressed in forecasts. Considering today's potential in information technology, a support should provide more than data administration, an active direction towards goal fulfilling solutions is expected which implies a certain degree of intelligence. Not only the environment is changing fast, the system itself is subject of changes. A system design is therefore never finished, future changes and extensions have to be easy to implement and the system has to be *extendible*.

The benefits of using virtual reality for modelling logistics systems are significant:

- Cost

- Repeatability
- Control over the time base
- Legality and safety
- Dynamic and transient effects
- Non-standard distributions
- Interaction of random events
- Fosters creative attitudes
- Promotes total solutions
- Makes people think
- Communicating good ideas

Fields of interest for virtual reality in Logistics would be:

Layout Planning and Concept Creation

3D visualization tools are needed to improve communication in concurrent engineering teams. In this step the facility floor space needs and production principle is verified. Logistic solutions can be evaluated also. Quick modelling is a benefit here.

Production Simulation

The aims usually are to test and verify plans, check the material flow routing and control principle, verify the buffer size and location and search for bottlenecks. The data should be real production data if available, or data from similar products or variants in the same product family. This is an iterative analysis, the engineers should return back to cell level studies, if some parameter need more detail study, for example cycle time need to be shorter. One of the main requirements here is validated simulation model. Flexible, parametric model building is advantage.

Training of operators

The emulation and simulation model is great tool for training of operators; the system parameters can be studied with simulation model. The software training with the real data can be done and this speeds up the ramp-up phase. If the control software has been integrated with the simulation model, the operators have the same user interface as in the real life and the simulation gives an holistic view to the manufacturing system.

Operational Use

While some models are used to plan and design, other models are used in the day-to-day operation of manufacturing facilities. These “as build” models provide manufacturers with the ability to evaluate the capacity of the system for new orders, unforeseen events such as equipment downtime and changes in operations. Some operations models also provide schedules that manufacturers can use to run their facilities. Simulation can complement other planning and scheduling systems to validate plans and confirm schedules. Before taking a new order from a customer, a simulation model can show when the order will be completed and hoe taking the new order will affect other orders in the facility. Simulation can be used to augment the tasks of planers and schedulers to run the operation with better efficiency.

4. Conclusions

To cope with today's requirements in economy and industry an efficient management of Logistics on all levels is essential. The use of simulation in the development process for an adequate decision support in Logistics management allows testing various solution approaches before their realization. The better a simulation platform corresponds to their application environment the easier the development process will be. The ability of Virtual Reality to provide realistic simulations of data, objects and environments, with which users can interact and manipulate in an intuitive and realistic manner, opens up a vast wealth of possibilities for Logistics systems applications.

References:

1. Banks, J., Carson J.S. and Nelson B.L. (1996). Discrete-Event System Simulation. 2nd ed. Prentice Hall. Upper Saddle River. N.J. 1996.
2. Law, A.M., and Kelton W.D. (1991). Simulation Modelling and Analysis, 2nd ed. McGraw-Hill, New York.
3. Robinson, S. (1994). Successful Simulation. A Practical Approach to Simulation Projects. McGraw-Hill International.
4. Geist, M.R. and Popp H. (1998). Supporting sales with virtual reality (VR) applications. Wirtschafsinformatik.
5. Hall, CR., Stiles RJ. and Horwitz CD. (1998). Virtual reality for training: Evaluating knowledge retention. Proceedings of the Virtual Reality Annual International Symposium, Atlanta, GA.
6. Agostino G. Bruzzone, Pietro Giribone and Roberto Revetria (2000). Simulation as Educational Support for Production and Logistics in Industrial Engineering. Proceedings of the 2000 Winter Simulation Conference.

7. Janusz K. Grabara and Sebastian Kot (2001). New Tools of Engineering Education for Logistics Training. Proceedings of the International Conference on Engineering Education 2001, Oslo, Norway.
8. Anu Maria (1997). Introduction to Modeling and Simulation. Proceedings of the 2000 Winter Simulation Conference.
9. Subhashini Ganapathy S. Narayanan and Krishnamurthy Srinivasan (2003). Simulation Based Decision Support for Supply Chain Logistics. Proceedings of the 2003 Winter Simulation Conference.

Authors:
Konstantinos Pehlivanis
Maria Papagianni
Athanasios Styliadis