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APPLICATIONS OF SYSTEM SIMULATON TO INTEGRATE AND MODEL VIRTUAL AND AUGMENTED REALITY

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ABSTRACT

Reality is something that we experience around us and it is present in the world in which we are living. On the contrary virtual reality is a world which is not present around us in the physical state yet we experience it by using modern day technology. Though it is not real we are still trying to make it very much similar to the real world environment so that we can interact with the real world by seeing it, hearing it, touching it, smelling it and feeling it. Though the virtual world is so fantasizing and fun to watch it should satisfy three of the following conditions: total realism, physical interaction and no boundaries. To make our virtual world more interactive we use the technology of programmable matter and claytronics. The programmable matter is the matter which consists of tiny modular robots that can change its shape accordingly and can transform from one shape to another.

Keywords: Virtual Reality, Augmented reality, Simulation.

1. INTRODUCTION

A constant competition of businesses demands short product cycles and fast changes of products: the dynamics of innovations increase; the product life cycles become shorter; at the same time, the products become more complex; the keen competition forces companies to respond to changes of the market. It is important, that either the production processes are adjusted as quickly as possible to new circumstances or new production processes are planned in the way that they yield the required results straightaway [1,37].

The keywords digital factory and virtual production refer to a new approach, how to cope with the above mentioned challenges [2]. In this context, the discrete simulation of the behavior of production facilities is of particular importance. At first, the development of a simulation model is essential.

Therefore, the considered system is analyzed and a computer-internal model is developed. This includes the modeling of functions, processes, behavior patterns or rules, which are to reflect the actual interrelations of effects in a business in this model [3].

The modeled aspects are linked together in the way that all functions of the model represent a whole. For various problems, extensive models with a complex behavior are required. However, an increasing size and complexity of the simulation model lead to more work for modeling, a higher error-rate and runtime, and to more work for interpretation when analyzing the results. Errors in modeling result in misinterpretation and false results in a simulation. In this context, the design of the user interface is very important [4]. For the usual, little intuitive WIMP-Interface (Windows, Icons, Mouse, and 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 the form of spread sheets and of two-dimensional, abstract illustrations of the production system. This seems to be adequate for simulation experts, but it is not acceptable for a multidisciplinary planning team consisting of people from diverse departments of a company. Therefore, the development of a simulation tool having more than an intuitively understandable user interface is required.

2. TECHNOLOGIES SO FAR

2.1.VR-technology

The rendering of virtual three-dimensional worlds is made by image computations of abstract, mathematical 3Dmodels (e.g. polygons) describing a virtual world [42]. In case of real-time-rendering images are computed with at least 20 images per second in order to facilitate navigation in a virtual scene. 3D-rendering systems are programmed via an abstracting interface in the form of a low-level graphic library like OpenGL or Direct3D and they have specific graphic hardware for a fast execution of arithmetic operations. High level libraries (e.g. OpenInventor, Performer, OpenSG, OpenScene-Graph) support comfortably the programmer with a structured view on the 3Dmodel data by means of a hierarchically built scene graph when organizing, constructing, handling, and interacting with the virtual 3D-world. PCs with graphic hardware display scenes of up to several hundreds of thousands polygons in real-time. More than one million polygons are often required (e.g. by using 3DCADmodels). The virtual scenes of manufacturing plants are so complex that they cannot be displayed in realtime on a single PC without the application of specific techniques [5]. The reduction of complexity (approximation) [6–8] and the computation of hidden objects (visibility culling) [9, 10] are two main approaches for real-time rendering.

2.2. AR- technology

Augmented reality (AR) is a new form of the man machine interaction [12]. Computer-generated information is shown in the user's real field of view. The shown information is context-dependent concerning the viewed object. Therefore, AR can replace the common installation manual, e.g. by showing installation details in the technician's field of view (Fig. 1).

The position is determined by the tracking system which brings the real and the virtual world together. This has to be highly precise in order to project the virtual objects exactly onto the real objects. Previous systems use infra-red, ultrasonic or electromagnetic tracking for rotational position sensing. Alternatively, GPS-systems or the inertial tracking can be used. Another solution approach is the image-processing systems. They optically identify real objects directly from a video display. One of the mostly used systems is the ARToolKit from HITLab of the University of Washington, Seattle, WA. This system works on specific graphical patterns (marker) [13–15]. There are also first approaches already working without such markers (natural feature tracking) [16–18]. One of the objectives of the AR-technology is the seamless integration of virtual objects into the real world. Here, an occlusion of real and virtual objects is possible (occlusion problem), e.g. a real pillar occludes a virtual machine. In order to avoid this problem, the virtual object is laid semi-transparently over the real image. However, the correct spatial overall impression of the scene disappears here, which eventually leads to confusion of the user [19]. Currently, there are first approaches eliminating this problem by either developing a 3D-model of the reality preliminarily and then using this as an alphachannel by the image generation of the virtual objects or by identifying the occlusion optically [20,21].

- A CPU.
- An energy store such as onboard battery.

- A network device.
- A video output device such as LCD or LED.
- Sensors like pressure sensors and photo sensors.
- A means of locomotion
- A mechanism for adhering to other catoms.

By this technology catoms can change and in this way we can make our virtual world its shape into anything depending upon our requirements and interest more realistic and interesting. One

Fig.1. AR-scene: installation details are shown via special glasses n the user's field of view.

PHYSICAL INTERACTION

A virtual realistic system should not only be able example of the claytronics technology is to make us see the real world in a virtual blinky blocks which can change their background but should also have the ability to color according to a specific pattern. interact with the user. In simple words we

Till now we are able to visualize fifty

should be able to touch and feel what is in the percent of our virtual world. It is virtual world. Moreover it is not practically consisting of a cubical room with possible to include all the elements used in the speakers installed everywhere. The sight different types of virtual world. Therefore we of the walls of our virtual room will not need something that can change its shape matter since our eyes contain a lens that according to our requirements, something that project the whole 3D picture of our can be called matter but can change its shape, virtual background onto our retina. To size and color according to our need. We call it make the environment more realistic we

programmable matter. Developed by Carnegie

Mellon University, US by the great scientist Seth can include solid interactive objects Goldstein in June 2002, made of programmable matter that will

catoms or programmable matter is ready to bring a revolution in today's

change its shape according to the modern electronics. According to him catom is background. Now the question that defined as: arises out of everybody's mind is can our virtual world be infinite as our real A

group of tiny modular robots that can communicate world?

with each other and can change their shape, size and

color according to the surrounding catom. In this way

they create voids which move towards the edge to

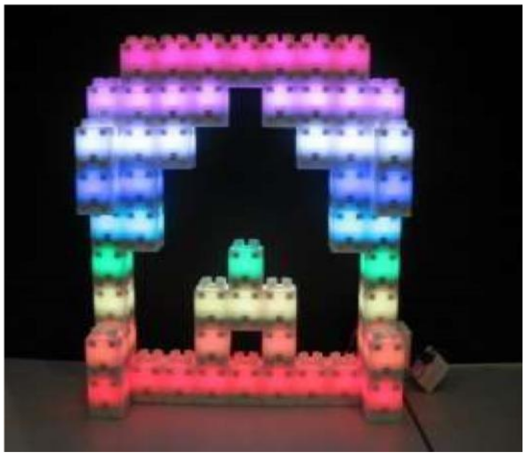
give it a different look each time it is disturbed.[6]

In its basic design, the catom is a millimeter size unit that comprises of:

INFINITE WORLD

When we look at our design of a virtual world we would come to know that it is a cubical room of some inches which is not even closer to our real world. So in order to make our virtual similar to the real world we have to make it infinite without any boundaries which is in first thought looks next to impossible. But modern engineering has found

a solution. The first step that was initiated in the direction of making the virtual world infinite is known as virtual sphere. As the name suggest it is a giant 10 foot sphere that is rested on a special platform that allows the sphere to move in any direction depending on the users step. Today it is used in military training, home gaming and some shows.



Another technology that emerges after the virtual sphere is known as Cyber-walk Omnidirectional treadmill. It includes simple engineering techniques. It comprises of straps which is bound on a platform. These straps move horizontally allowing the user to move in horizontal direction. Further the platform move vertically allowing the user to move in any direction in two dimensions. This enables the user to walk endlessly on the same platform which gives the feeling of an infinite world.

Until now our model of a virtual universe is almost complete. The only thing remaining is to implement all the above discussed technologies onto a single unit. However in order to make our virtual world more fascinating as well as adventurous some extra features can be added into it.

1.1. Automated data generation

The 3D-visualization of CAD-models being developed with CAD-systems, e.g. CATIAV5 from Dassault Systems or HLS-Modul for MicorStation from Bentley Systems, often takes place in a VRsystem. At first, the model is exported by the CADsystem, and secondly, it is represented in a VRsystem. The viewer can move freely in the model and see it as a whole. In case of CAD-models that are more complex, the entire model cannot be viewed on the computer in real-time. In the field of industrial construction and planning, an intensive process is necessary. In this context, several problems occur:

1. The format of the data of the CAD-system must be converted into a format that can be handled by the VR-system. The exported data is often incorrect because of bugs in the software or because of the imprecise definition of the 3D-formats.

2. The exported scene is approximated by polygons whereas the user can determine the level of the approximation. In order to achieve a high precision, a large number of polygons which do not allow a representation in real-time, are necessary. Consequently, a data preparation of the highly polygonal scene usually takes place (the reduction of complexity) in order to facilitate a representation in real-time.

3. The data of the CAD-system is designed for a high precision construction, but not for a visually pleasing impression in the VRsystem. So, the visual impression is improved by a mostly manual creation of additional information, e.g. light, shadow, material, and textures.

For all of these three steps, there are methods and programs providing a solution to these problems.

However, the intervention of people is necessary in order to do the workings that cannot be done automatically yet. For example, a strong reduction of polygons leads to bugs that have to be reworked manually with 3D-modeling programs. The topology of the scene raises difficulties during the reduction of polygons (e.g. the scene of a production line). Time consuming work-step is necessary in order to be able to see a large CAD-model in a VR-system. This workstep is disturbing, if modifications that are to be shown immediately in the VR-system are made quickly in the CAD-system or in the simulator. Consequently, a solution is required whereby the first and second step is completely automated and the third step is reduced to a quick and semi-automated process with the help of dedicated libraries (Fig. 4). This procedure allows an extensively automatic visualization of highly complex data without manual post processing. Suitable algorithms for this procedure have been developed. These algorithms allow a close to real-time display of very complex scenes up to 10^{14} polygons. If the main memory is not sufficient, the virtual scene is stored on the hard disk. Even in this case, a close to real-time visualization of the scene is possible. These procedures cannot render more quickly or produce a higher quality of the display then other specialized methods. The advantage is the display of an arbitrarily structured scene (e.g. production lines) without having the need for changes of the structure of the 3D-models. This process is fully automated and does not need any manual rework. The procedures do not have any assumptions of the topology of the scene and provide comparable approximation qualities for different structures. This procedure allows an extensively automatic visualization of highly complex data without manual post processing.

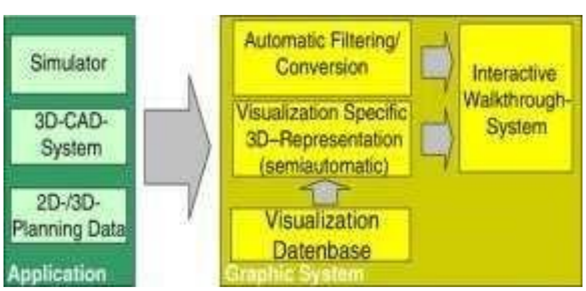


Fig.4. Process of image generation.

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. So far, our methods are implemented in a prototypical walkthrough system. The next step is to implement specialized import filters that can read data from several CAD prog

4. CONCLUSION

Nowadays businesses face increasing dynamics of innovations, shortened product life cycles, and a continuing diversification of the product range. Consequently, the planning of production systems plays an important role. Errors within the planning cannot be easily fixed and involve time-consuming and cost-intensive reconstructions.

The described approach explicates that the development and planning of complex production processes and systems can be supported significantly by a VR/ AR-aided simulation. The presented system can be applied in every stage of the modeling (actual analysis, modeling, experiments, evaluation, adjustments, and presentation of the solution). In particular the cooperative planning of production systems is supported.

The described concept of an integrated complete system is to be improved in the near future.

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