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AUGMENTED VIRTUAL REALITY APPLICATIONS

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Abstract: *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-centred perspective achieved through tracking the user. This is a huge step forward compared to classical modelling and CAD/CAM packages, which inherently impose major imitations on intuitive user interaction. Lately, with the emergence of complementary areas of VR such as augmented reality (AR), one can address crucial problems of registration between virtual and real worlds.*

Key words: *augmented reality, virtual reality, applications of augmented reality*.

1. INTRODUCTION

Virtual reality is a technology that encompasses a broad spectrum of ideas. It defines an umbrella under which many researchers and companies express their work. The phrase was originated by Jaron Lanier, the founder of VPL Research one of the original companies selling virtual reality systems. The term was defined as "a computer generated, interactive, three-dimensional environment in which a person is immersed." There are three key points in this definition. First, this virtual environment is a computer generated three-dimensional scene which requires high performance computer graphics to provide an adequate level of realism. The second point is that the virtual world is interactive. A user requires real-time response from the system to be able to interact with it in an effective manner. The last point is that the user is immersed in this virtual environment. One of the identifying marks of a virtual reality system is the head mounted display worn by users. These displays block out all the external world and present to the wearer a view that is under the complete control of the computer. The user is completely immersed in an artificial world and becomes divorced from the real environment. For this immersion to appear realistic the virtual reality system must accurately sense how the user is moving and determine what effect that will have on the scene being rendered in the head mounted display [5].

2. DEFINITION AND TYPES OF AUGMENTED REALITY

Augmented Reality (AR) is a growing area in virtual reality research. The world environment around us provides a wealth of information that is difficult to duplicate in a computer. This is evidenced by the worlds used in virtual environments. Either these worlds are very simplistic such as the environments created for immersive entertainment and games, or the system that can create a more realistic environment has a million dollar price tag such as flight simulators. An augmented reality system generates a composite view for the user. It is a combination of the real scene viewed by the user and a virtual scene generated by the computer that augments the scene with additional information. The application domains reveal that the augmentation can take on a number of different forms. In all those applications the augmented reality presented to the user enhances that person's performance in and perception of the world. The ultimate goal is to create a system such that the user cannot tell the difference between the real world and the virtual augmentation of it. To the user of this ultimate system it would appear that he is looking at a single real scene [8 and 11].

The discussion above highlights the similarities and differences between virtual reality and augmented reality systems. A very visible difference between these two types of systems is the immersiveness of the system. Virtual reality strives for a totally immersive environment. The visual, and in some systems aural and proprioceptive, senses are under control of the system. In contrast, an augmented reality system is augmenting the real world scene necessitating that the user maintains a sense of presence in that world. The virtual images are merged with the real view to create the augmented display. There must be a mechanism to combine the real and virtual that is not present in other virtual reality work. Developing the technology for merging the real and virtual image streams is an active research topic.

The computer generated virtual objects must be accurately registered with the real world in all dimensions. Errors in this registration will prevent the user from seeing the real and virtual images as fused. The correct registration must also be maintained while the user moves about within the real environment. Discrepancies or

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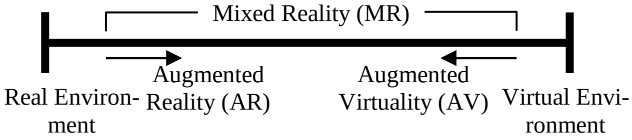

Fig. 1. Milgram's reality-virtuality continuum.

changes in the apparent registration will range from distracting which makes working with the augmented view more difficult, to physically disturbing for the user making the system completely unusable. An immersive virtual reality system must maintain registration so that changes in the rendered scene match with the perceptions of the user. Any errors here are conflicts between the visual system and the kinesthetic or proprioceptive systems. The phenomenon of visual capture gives the vision system a stronger influence in our perception. This will allow a user to accept or adjust to a visual stimulus overriding the discrepancies with input from sensory systems. In contrast, errors of misregistration in an augmented reality system are between two visual stimuli which we are trying to fuse to see as one scene. We are more sensitive to these errors.

Milgram describes a taxonomy that identifies how augmented reality and virtual reality work are related. He defines the Reality-Virtuality continuum shown as Fig. 1.

The real world and a totally virtual environment are at the two ends of this continuum with the middle region called Mixed Reality. Augmented reality lies near the real world end of the line with the predominate perception being the real world augmented by computer generated data. Augmented virtuality is a term created by Milgram to identify systems which are mostly synthetic with some real world imagery added such as texture mapping video onto virtual objects. This is a distinction that will fade as the technology improves and the virtual elements in the scene become less distinguishable from the real ones [12].

Milgram further defines a taxonomy for the Mixed Reality displays. The three axes he suggests for categorizing these systems are: Reproduction Fidelity, Extent of Presence Metaphor and Extent of World Knowledge. Reproduction Fidelity relates to the quality of the computer generated imagery ranging from simple wireframe approximations to complete photorealistic renderings. The real-time constraint on augmented reality systems forces them to be toward the low end on the Reproduction Fidelity spectrum. The current graphics hardware capabilities cannot produce real-time photorealistic renderings of the virtual scene. Milgram also places augmented reality systems on the low end of the Extent of Presence Metaphor. This axis measures the level of immersion of the user within the displayed scene. This categorization is closely related to the display technology used by the system. Each of these gives a different sense of immersion in the display. In an augmented reality system, this can be misleading because with some display technologies part of the "display" is the user's direct view of the real world. Immersion in that display comes from simply having your eyes open. It is contrasted to systems where the merged view is presented to the user on a separate monitor for what is sometimes called a "Window on the World" view.

The third, and final, dimension that Milgram uses to categorize Mixed Reality displays is Extent of World Knowledge. Augmented reality does not simply mean the superimposition of a graphic object over a real world scene. This is technically an easy task. One difficulty in augmenting reality, as defined here, is the need to maintain accurate registration of the virtual objects with the real world image. This often requires detailed knowledge of the relationship between the frames of reference for the real world, the camera viewing it and the user. In some domains these relationships are well known which makes the task of augmenting reality easier or might lead the system designer to use a completely virtual environment. The contribution of this thesis will be to minimize the calibration and world knowledge necessary to create an augmented view of the real environment [11].

3. ASSEMBLING BY AUGMENTED REALITY

We created an assembling application which provides flexible tools for working in the augmented reality environment. We started with the creation of basic simply scripts which were connected in to the more difficult logical loops by virtual tools of the application that offers unlimited possibilities of augmented designing. Virtual application allows executing an extended connection between behaviour conditions and elements in the same virtual composition. All these operations were realized by special logical component called Behaviour Building Blocks (BBs). BBs provide the tool that uses a simple graphical interface to create necessary logical joint for information package. All BBs from virtual library comprises an input/output pin that can be linked and configured by requests and orders from the user. Application environment and special tools provide possibilities to harvest or observe information about the data flow between single BBs. This method, where the program or composition is realized by logical connection between BBs is called visual scripting. In the following examples, we would like to explain some basic logical loops (Behaviour graph) and structures which were applied in the particular parts of the mentioned application [2 and 4].

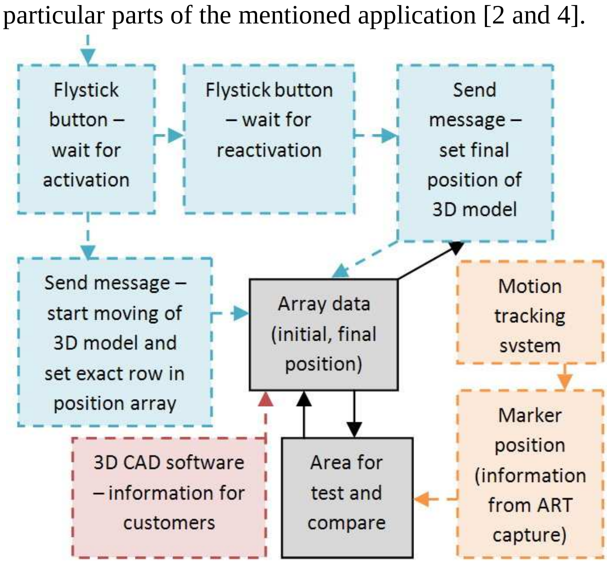

Fig. 2. Visual scheme for basic elements of assembling process of augmented reality.

One of these new structures is an application which leads to the building of an assembly and allows seeing the exact position of a particular part of the assembly. This method called augmented assembling provides flexible tools for working in virtual environment. By confirming the keyboard button (in this case the button called ENTER) or flystick button the application enables to see a new part and a short animation which displays trajectory of the movement from initial to the final position of the part. By confirming the button again, the user will see the final position of the model, giving them time for putting the real model into the same position of the virtual model which appears on the screen. To simplify, by means of this application the user is able to see augmented reality where the correct 3D part is moved on the virtual trajectory and this movement is repeated as long as the user does not put the real part on the same place of the virtual model.

The algorithm displayed in Fig. 2 provides schematic information about the process where data from the marker and motion tracking system are harvested and evaluated by computer and then implemented into the 3D environment of the mentioned virtual application. The first part of the algorithm comprises three basic areas such as area for testing and comparing, area for setting position (initial, final position) and area for moving trajectory. At the beginning, after confirming flystick button, the application reads data from array which was created before the main initiation by the user. This data include information about the names of models and their values of initial vectors and final parameters of position.

Then the harvested data from behaviour graph called ART capture are sent into the area for testing and comparing where they are compared with each other and with array data (initial, final position). Then the 3D models from the first row array are applied into the marker position (information from ART capture) and they are rewritten for the fixed position from array. After the area of movement trajectory is activated by a logical loop, the animation is displayed where the 3D model provides trajectory for the applying of an assembling (virtual template or virtual advice for user's work) (Fig. 3) [6].

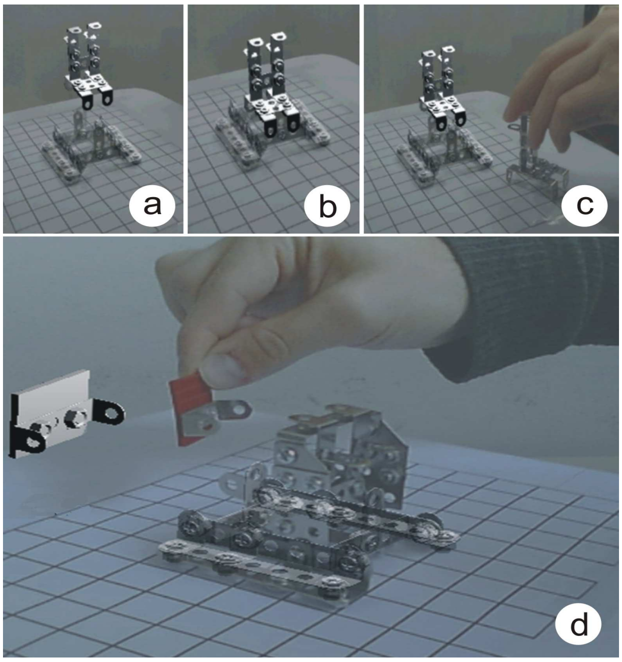

Fig. 3. Augmented assembling process where the 3D part is moved on the virtual trajectory: *a* – position value of initial vector; *b* – final position for the part; *c* – real and virtual part in the same environment; *d* – next assembling part.

4. TRACKING IN AUGMENTED REALITY

Tracking the position and motions of the user in virtual reality systems has been the subject of a wide array of research. One of the most commonly used methods to track position and orientation is with a magnetic sensor such as the Polhemus Isotrac. Position tracking is needed in virtual reality to instruct the graphics system to render a view of the world from the user's new position. Because of the phenomenon of visual capture, user of a virtual reality system will tolerate, and possibly adapt to, errors between their perceived motion and what visually results. With an augmented reality system the registration is with the visual field of the user. The type of display used by the augmented reality system will determine the accuracy needed for registration of the real and virtual images. The central fovea of a human eye has a resolution of about 0.5 min of arc. In this area the human eye is capable of differentiating alternating brightness bands that subtend one minute of arc. That capability defines the ultimate registration goal for an augmented reality system. The resolution of the virtual image is directly mapped over this real world view when an optical see-through display is used. If it is a monitor or video-see through display then both the real and virtual worlds are reduced to the resolution of the display device. Considering one of the Sony cameras that are in the lab, these have CCD sensors of 8.8×6.6 mm (horizontal $\times$ vertical) with a cell arrangement of 768×493. Using a mid-range 20 mm lens yields a 25 field of view across the standard 512 horizontal digitization which is 0.05/digitized-pixel or 2.5 minutes of arc/pixel. This indicates that single pixel differences are resolvable in the central fovea. The current technology for head tracking specifies an orientation accuracy of 0.15 falling short of what is needed to maintain single pixel alignment on augmented reality displays. These magnetic trackers also introduce errors caused by any surrounding metal objects in the environment. This appears as an error in position and orientation that cannot be easily modelled and will change if any of the interfering objects move. In addition, measurement delays have been found in the 40 to 100 ms range for typical position sensors which is a significant part of the 100 ms cycle time needed for real-time operation. Augmented reality researchers are looking at hybrid techniques for tracking [9 and 10].

5. VIRTUAL COLLABORATIVE ENVIRONMENT

The term global virtual manufacturing (GVM) extends the definition of VM to include, and emphasize, the use of Internet/intranet global communications networks for virtual component sourcing, and multisite multi-organization virtual collaborative design and testing environments. Companies that commit to GVM may be able to dramatically shorten the time to market for new products, cut the cost of prototyping and preproduction engineering, enable many more variations to be tried out before committing to manufacture, and Increase the range and effectiveness of quality assurance testing. Virtual prototypes can be virtually assembled, tested, and inspected as part of production planning and operative graining procedures; They can be demonstrated, market tested, used to brief and :rain sales and customer staff, transmitted instantly from site to site via communications links, and modified and recycled rapidly in response to feedback [3].

Manufacturers and their worldwide subcontractors and main suppliers can establish agile manufacturing teams that will work together on the design, virtual prototyping, and simulated assembly of a particular product while establishing confidence in the virtual supply chain. Using the most advanced VR systems, geographically remote members of the team can meet together in the same virtual design environment to discuss and implement changes to virtual prototypes. Examples of recent developments in virtual collaborative environments include projection of gestures and movements of multiple remote designers as voice-activated avatars to help explain the intention of the designer to others in real time using high-speed ATM networks.

When a single factory may cost over a billion dollars (as is the case in the semiconductor industry), it is evident that manufacturing decision makers need tools that support good decision making about their design, deployment, and operation. However, in the case of manufacturing models, there is usually no test bed but the factory itself; development of models of manufacturing operations is very likely to disrupt factory operations while the models are being developed and tested [1].

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 [7].

6. CONCLUSIONS

This article approaches general steps of augmented assembling process and explains some virtual elements needs to execute the augmented reality. This mentioned application include special logical loops and elements of programming scripting which provide powerful tools for working with virtual environment. By means of possibilities of the application the user is able to see augmented process where the 3D part is moved on the virtual trajectory and this movement is repeated as long as the user does not put the real part on the same place of the virtual model. Further innovations could be oriented to assuring more complex view on whole process. This can be achieved for example by loading of text information about particular parts and their instructions.

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