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AUGMENTED REALITY TECHNOLOGY APPLICATIONS

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Abstract: *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.*

Key words: *Augmented Reality, Virtual Reality, Augmented Reality applications.*

1. INTRODUCTION

In virtual manufacturing have significant impact areas such as facility layout and work-cell management, real-time exact collision detection, motion modelling and virtual-real environment interaction in training. There are connections between virtual reality (VR) and computer vision (especially camera self-calibration and stereo vision) in the context of depth recovery in virtual manufacturing. Some of the automation techniques resulting from these concepts can potentially reduce a lot of time and boredom for users involved in manually creating CAD-based virtual environments. 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.

2. THEORY 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 can not 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 [7].

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 [5].

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 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

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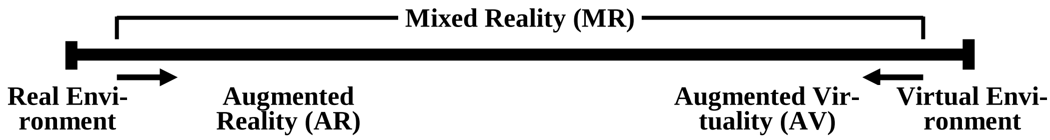

Fig. 1. Milgram's Reality-Virtuality Continuum.

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.

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 can not 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 [1].

3. APPLICATIONS OF AUGMENTED REALITY

As mentioned in previous steps of paper, an AR system generates complex view where the virtual areas are covered by real environment and offers the basic working place for the engineer. Assembling process of AR has new special tool for the engineering area which provides strong elements and hardware components for creation of construction ideas. Final assembling proposal include all functional 3D items of assembly without montage mistakes. The assembling application of AR was developed to determine the exact position and orientation for assembling process. Thanks to its possibilities if finds the utilization in many industrial spheres. The problem that must be solved during this visualization step is comprised of two underling causes. The first one has explanation in transformation processes of three-dimensional environment into two-dimensional image on the display. The main task of second one is necessary to knows exact position values of real basic coordinate system of general working table [6].

Many companies use variable devices for observing an exact position of working area. These techniques can be divided into these main groups:

- Motion capture by tracking sensors.
- Motion capture by camera (markers, colour).
- Laser tracking.
- Tracking devices.

While creating the application for utilization of elements of AR the main problem usually is the determination of position and orientation of working base that can be found in surface plane of working table, plane of referential object etc. These problems are usually understood in relation to static character of working base, what creates the assumption for utilization of AR based on markers in form of black and white referential marks. Example of such solution can be seen on following illustration (Fig. 2) [8].

Second possibility presents movable working base. In these cases there are known techniques as video tracking and optical motion tracking. Video tracking means utilization of database of known shapes and objects, what allows perception of bodies recorded by video-sequence as objects with three spatial characteristic values. Other possibility is optical motion tracker for AR that works on the principle of following the reference points while evaluating their mutual position with purpose to get the idea of total orientation and position of observed system. All mentioned techniques are mostly based on utilization

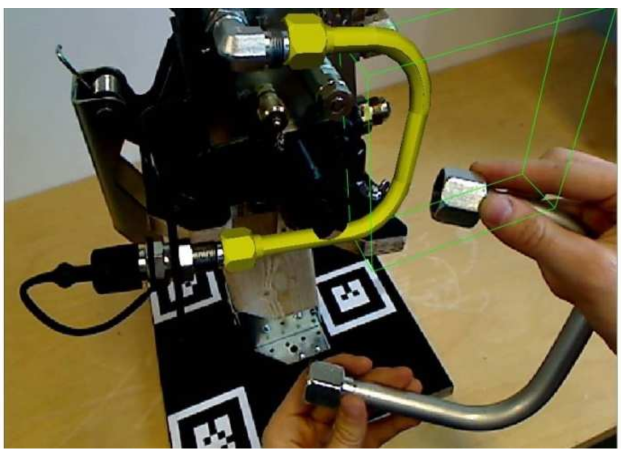

Fig. 2 Creation of assembly with use of referential markers (VTT Finland) [8].

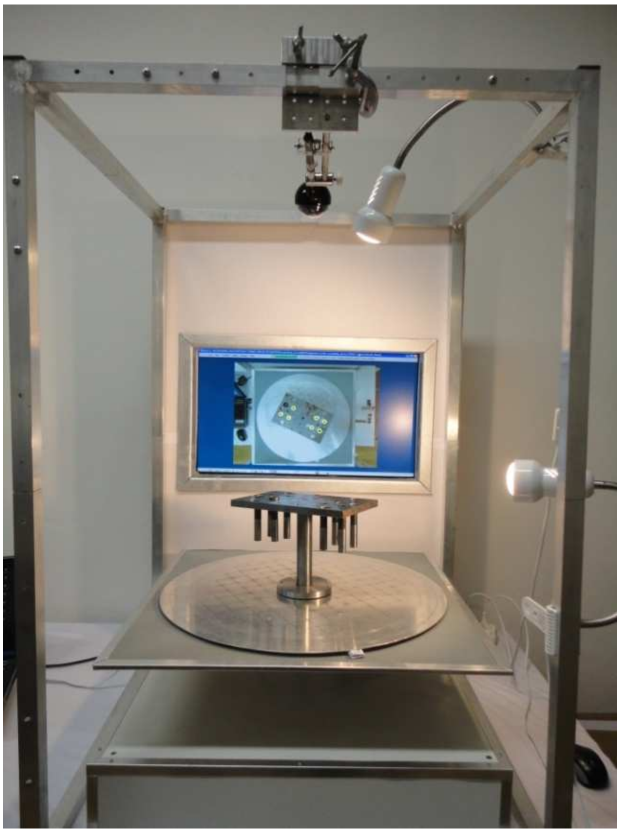

Fig. 3. Positioning working table with fixed part.

of commercially oriented tools, in area of hardware and software. Next part of this chapter describes the innovative solution for determination of position and orientation of working base with use of principles of Open Source philosophy. Device described in this article presents new variant that is not bounded to expensive hardware and subsistent software. Working base is not static. It allows the rotation around its own axis and at the same time also the tilting in all three directions of working space. Main part of working plane is situated at special gyroscopic head, while the tilting motions are realized with use of mechanism working on the principles of pantograph. Main motion of pantograph is controlled through step engines that are launched with software running in classical PC environment. At the picture there is this positioning table displayed with real part fixed on its working plane (Fig. 3) [3].

2.1. Acceleration

Accelerator uses the piezoelectric phenomenon, what means that while it is in motion it also generates electric charge that is proportional to the mechanic stress generated from acceleration that is called by this motion. Inner electronics of the sensor converts generated charge to voltage with evaluated values.

These values are recorded, evaluated and stored in cells of so called position array that presents the input data objects for software calculations for quantification of concrete position change of device in whatever direction axis.

2.2. Rotation

Working base described in previous part has beside the tilting movements also the possibility of rotational motion around the central axis of the device. Value of actual rotation is at all time monitored with sensor, while these data obtained in real time are again sent to the adequate cell of the position array. Advantage of this solution can be found in possibility of rotation the workbase also by manual action of the user. Rotary freedom can be after setting to desired position blocked with use of electromagnets.

4. SOFTWARE FOR AUGMENTED REALITY

When thinking about creation of application including the elements of AR it is necessary to think about making a bridge connection between real world, of which image presents the essence of data transfer at input interface and program section for management of virtual data, what in final consequence allows the combination of both spatial environments – real and the virtual one. This bridge connection is usually solved with use of commercial sensors and their subsistent commercial software tools for management of obtained 3D data. In the frame of procedure described in this article we have chosen Blender, software working on the principles of Open Source philosophy, what makes it more flexible, wider exploitable and more powerful tool removing the necessity of thinking about price affordability. Blender presents universal software tool for description of 3D computer graphics with integration of features for animations, realization of motion systems in accordance to physics etc. Platform of Blender is built on programming language called Python, what allows its user to free access to all relations and computations formulas. Whole calculation and graphical environment can be adapted exactly to the needs of the application, for creation of which the Blender was selected. All main programming operations are at he level of program structured managed with use of visual scripting (see Fig. 4) that is based on connections of blocks and creation of loops, what fluently approaches to the creation of program sections building the logical core of the application [2].

For interconnection between real video input and visualization core of the application there are shots from real environment used taken by video camera. Following picture (Fig. 5) offers the scene taken by camera with added virtual element. That video shot is displayed also at user's working screen. At the beginning of the process the input of visualization core needs to have some input video device initialized, for example video camera. After creation of connection between camera and application, the camera takes the scenes of reality that are in the form of picture files stored to the desired location of the computer's hard drive. This process of permanent saving and

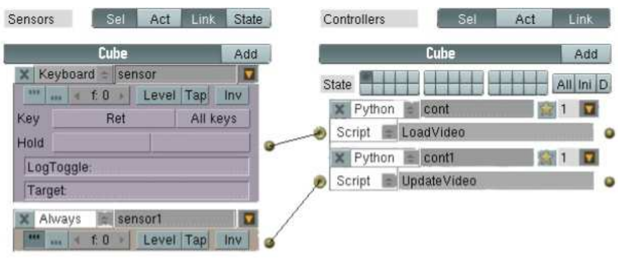

Fig. 4. Visual scripting in Blender environment.

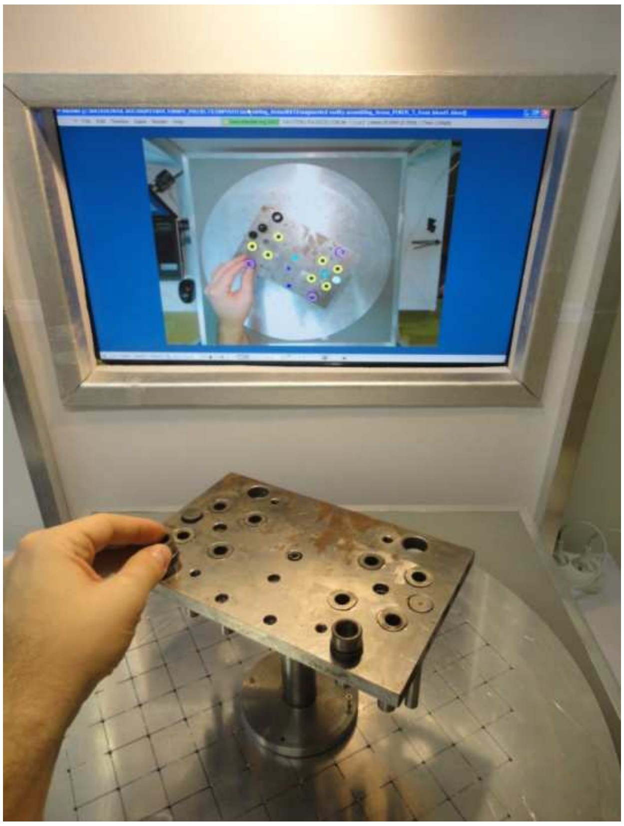

Fig. 5. Combination of real and virtual environment.

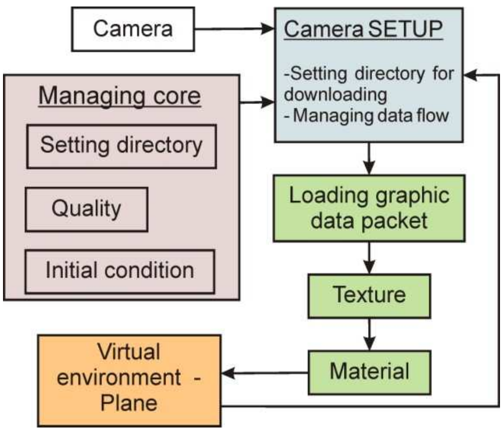

Fig. 6. Algorithm for creation of AR environment.

rewriting of old video frames is managed by logical loop of visualization core of the application. Its principle is presented in diagram (Fig. 6). Every saved frame is subsequently loaded in the form of the texture and assigned to desired surface of virtual object [4].

Saved and loaded files are located at the same location of hard drive what keeps the process of continual actualization simple. With sufficient number of repeat cycles of whole activity, the application provides simplified version of real video sequence. Quality and properties of video are given by parameters defined in application settings (frames number, frames resolution, colour scale, richness, sharpness, effects...), that can be programmable modified according to the user's needs.

5. CONCLUSIONS

This article deals with area of implementation possibilities of augmented reality for purposes of realization of assembling processes. It concerns software issues regarding open source tools that can be used for creation of augmented working environment. It also deals with hardware matters, especially with positioning device that was constructed for the purposes of assembly realization. In environment of Blender programming interface there was a new application created that presents a practical bridge coonection between the real working table and elements of AR generated in the computer. Program focuses on some specific problems where engineer needs to know exact positions and orientations of single parts with respect to auxiliary objects. Implementation of augmented reality elements in this manufacturing area shows that these solutions can be developed for utilization in more industrial spheres. In the end the article mentions another exploitation possibilities which practically lie in every assembling activity, including the molds building, composite hand lay-up processes, rapid prototyping applications, etc.

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REFERENCES

[1] J.N. Marcincin, *Augmented Virtual Reality in Manufacturing Engineering*, Metody i techniky zarzadzania w inzinierii produkcji (Editor: Jozef Matuszek), ATH Bielsko-Biala, 2006, pp. 29–42, ISBN 83-89086-44-1.

[2] J.N. Marcincin, J. Barna, *Visualisation Technologies in the Process of Making Composite Structures*, Trends in the Development of Machinery and Associated Technology, Vol. 14, No. 1, Zenica, 2010, pp. 365–369.

[3] Marcincin J. N., Barna J., Marcincinova L. N., Fecova V., *Principles of Product Assembly Visualization by Augmented Reality Usage.* In: Annals of DAAAM for 2011 & Proceedings of the 22nd International DAAAM Symposium, Vienna, 2011, pp. 1049-1050.

[4] J.N. Marcincin, J. Barna, M. Janak, L.N. Marcincinova, V. Fecova, *Utilization of Open Source Tools in Assembling Process with Application of Elements of Augmented Reality*, ACM SIGGRAPH Conference on Virtual Reality Continuum and its Applications to Industry, Hong Kong, 2011, pp. 427–430.

[5] I. Neaga, I. Kuric, *Virtual Environments for Product Design and Manufacturing*, Proceedings „CA Systems and Technologies“, Žilina, 1999, pp. 60–65.

[6] S.K. Ong, A.Y.C. Nee, *Virtual and Augmented Reality Applications in Manufacturing*, Springer-Verlag London, ISBN 1-85233-796-6.

[7] J. Vallino, *Introduction to Augmented Reality*, Rochester Institute of Technology, Rochester, 2002 (`http://www.se.rit.edu/~jrv/research/ar/`).

[8] `http://www.vtt.fi/`