

Use of Augmented Reality in Education

Sašo Zagoranski, Saša Divjak
University of Ljubljana
Trzaska 25, Ljubljana
Slovenia

email: Saso.Zagoranski@guest.arnes.si, sasa@fri.uni-lj.si

Abstract: - The basic idea of Augmented Reality is overlaying virtual objects on a real world image thus "augmenting" the real world image which we currently see. This technology could be very useful in various domains like medicine, automobile, plane industry and space research. The paper presents the first experience with the design and implementation of a personal companion, a tool which could serve as an interactive virtual laboratory. The aim of this research is to implement such system in educational processes.

Index Terms-- Augmented reality, computer simulation, fiducial markers, ARToolKit.

I. INTRODUCTION

As the name itself implies, Augmented Reality is a reality made better. If we would compare Virtual Reality – a completely computer generated world – and the real world around us, Augmented Reality would fall somewhere in between, since it's basic idea is overlaying virtual objects on a real world image thus "augmenting" the real world image which we currently see.

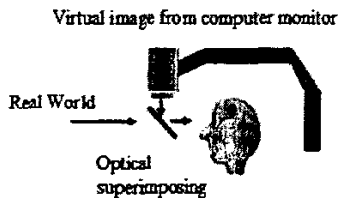


Fig. 1 – The concept of augmented reality

This is accomplished by capturing the images by a camera, which is connected to a computer. To this images some virtual objects are superimposed. Of course both worlds, real and virtual should be correlated in space. The images could be sent to a monitor or even better to a *Head Mounted Display (HMD)*. There are two types of HMDs, opaque and see-through. In the first case the user can only see the image supplied by the computer, so the computer supplies the image of the environment plus any visible virtual object, while in the second case of HMDs the user can actually see the real world

image without having to rely on the image supplied by the camera. In this case the application only supplies the virtual objects.

The possible implications of this very simple idea are numerous. The technology could be used anywhere from the field of medicine, automobile and plane industry to the field of space research. Imagine a surgeon in the middle of a procedure, operating on a patient's broken leg. With the use of AR we could assist the doctor by overlaying an X-Ray of the broken bone on the patient's leg. Information about the patient's condition (heart beat, blood pressure) could also be displayed. Such Augmented Reality can also be used to enhance a shared physical workspace and create the potential of a virtual face-to-face collaboration. By means of see-through head mounted displays the users are allowed to collaboratively view 3D virtual models superimposed on the real world. The remote users image is completely virtual and potentially arbitrary number of remote users can be viewed at once. Such approach could be very intuitive, it leads to real world collaboration and supports the work in groups. The users of such AR conferencing reported in comparison to traditional video conferencing a significantly higher sense of presence for the remote user.

Another, less attractive but also less expensive and in some cases more appropriate alternative of the augmented reality could be called desktop AR since the basic idea is to present the combined world on a normal computer screen as it is shown on figure 2.

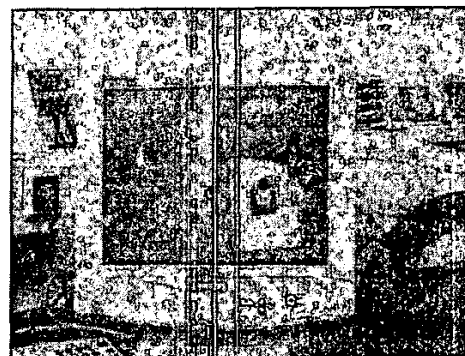


Fig. 2 – Desktop augmented reality

In this example a virtual snowman is superimposed to the image of the real world and visualised on the computer screen.

In the following paragraphs the possibilities of the use of such technology in education will be investigated.

II. PROBLEM FORMULATION

One of the popular approaches how to use computers in education are computer based simulations and visualisations of various natural phenomena. Visualization brings together two disparate fields, the traditional sciences (like physics, chemistry, biology, for example) and computer graphics. This is particularly useful in the domain of physics and chemistry. One of the problems of such simulations is that the students have sometimes difficulties with understanding abstract visualisations even if they are presented in 3D space. The problem is how to decrease the gap between the real world which surrounds us and the abstract models which are used in simulations. The most frequent solution to this problem is found in some educational movies where the real life phenomena are presented and some abstract or virtual information is mixed to such sequences.

In the past we tried to solve the problem of understanding of abstract models with the possibilities offered by VRML and Java3D. The figure 2 shows a mix of realistic and abstract model of a steam engine which was simulated in such a way.

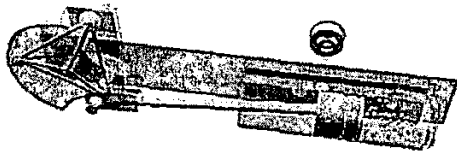


Fig. 3 – Superposition of a 3D model of a steam engine with its abstract model

The use of augmented reality could have such an effect of superimposed real environment and abstract models still improve. In fact it represents a similar approach as it is offered by educational movies with sequences from real life mixed with virtual objects. In addition to this AR gives the possibilities of the user interaction with such mixed world.

III. PROBLEM SOLUTION

In our project we are using the open-source *ARToolKit* library, which enables the easy development of a wide range of Augmented Reality applications. The toolkit has been

developed at the University of Washington by Prof. Hirokazu Kato and Dr. Mark Billinghurst.

Accordingly to the basic concept of this software the user should create some images with characteristic patterns. He should also prepare some virtual models, described in VRML format. These models are later associated to the corresponding characteristic patterns. The camera supplies the frames to an application which searches the current frame for known patterns, which are stored in a database of registered patterns. If a match is found the software displays the virtual object attached to the found marker. Our entire system is based on recognition of *fiducial markers*. Fiducial markers are selected points on an image that are used as a frame of reference in locating objects. Our application (based on the *ARToolKit* library) then searches each frame for registered patterns and displays virtual objects associated with them. If we move in the real world the real objects signed with fiducial markers the same movements, translation or rotation in the space, will be made on the associated virtual objects. This means that we could put fiducial markers on real objects that are visualised on the screen and on these objects could be superimposed additional artificial or even abstract objects that will give a deeper explanation of some presented phenomena.

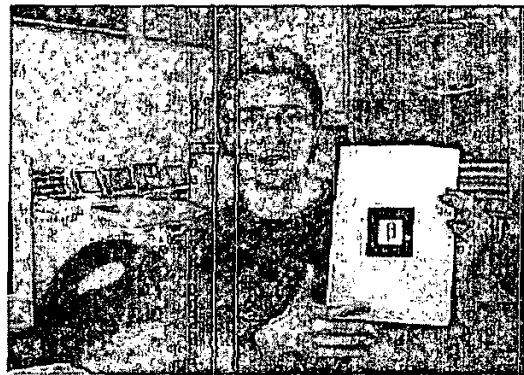


Fig. 4 – The fiducial marker placed on a real object in the real environment

In the next example a virtual model of a steam engine was superimposed in a real environment. The user can observe the mixed system on his screen, interact with the model and change its characteristics such as transparency of some selected parts. The model can even be animated in real time or substituted by some more abstract alternative.

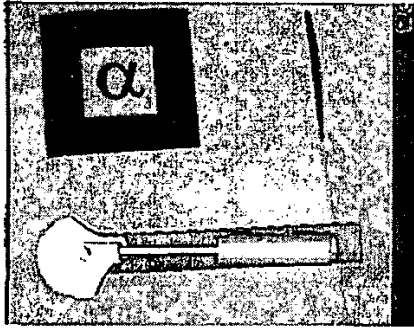


Fig. 5 – Virtual model of steam engine superposed in real world

The virtual model is in fact defined in well known VRML format and can be obtained by some 3D modeler software or even created by 3D scanning of real objects.

The applications of such visualisation in education can be numerous. The question is if such virtual objects could replace a variety of expensive experimental models in normal classrooms. Certainly such substitutes are more appropriate for the work at home where the real equipment could not be available. The teacher or the student in such community could have a personal gallery of different virtual models which could be associated to the fiducial markers during his lectures or assignments. Such virtual laboratory could be downloaded from Internet or it could be available on CD. It could represent the accompanying didactic material for topics in chemistry, physics, biology and other similar sciences.

The concept of desktop augmented reality leads to the conclusion that such approach could be particular useful in the case of distance learning when an interaction between remote locations is planned. Such particular cases are the videoconferencing activities which as itself offer to the participants only a virtual supplement. The participants of the virtual community could download the gallery of models from a remote site. The models could be changed or even personalised for each student by the teacher. The remote visualisation itself could use the technical possibilities offered by videoconferencing systems. The combined live image of the real and virtual world could be for example presented as a shared application in NetMeeting and accompany the usual talking head.

A possible didactic scenario could be that the set of patterns which are registered for fiducial markers would be used as a set of possible alternatives in multiple choice tests. The teacher could for example ask the students to associate to these markers the corresponding virtual models according to the learned topics. In chemistry these could be different models of molecules selected from a family. In the study or history of arts these models could be virtual 3D copies of scanned sculptures or reconstructed historical objects. In the

study of music we could use in such a way a group of 3D virtual music instruments.

Another possible educational use of desktop augmented reality is a better visualisation of remote experiments which are sometimes available on Internet. The basic idea of such experiments is to offer to the students the access to costly equipment and to have some possibilities to control it remotely. The frequent problem of such remote laboratories is that they could lack of the feeling of real world and could be too abstract or not enough attractive. A desktop AR could offer in such cases the live image of the real equipment and to superimpose to such real environment some artificial data or animated virtual objects.

Another educational use which could be supported by such mixed visualisation is the presentation of the natural phenomena that are usually invisible. This leads to the concepts which were developed in the domain of scientific visualisation. Scientific visualization encompasses and unifies the fields of computer graphics, image processing, computer vision, computer-aided design, signal processing, and human-computer interaction. Within the scientific visualisation there are several approaches how to represent for example field lines and equipotential planes. In the next figure a Java3D simulation of the Earth and the Moon is presented and the gravitational lines are shown.

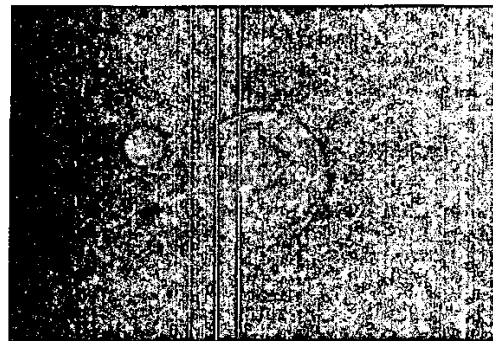


Fig. 6 – Visualisation of gravitational field surrounding Earth and Moon

A similar approach could be used in the mentioned applications of augmented reality. In the next figure the presentation of electric field lines between some charged spheres is demonstrated. The field lines are represented by arrow glyphs.

A possible didactic scenario could be such that the teacher or the student accomplishes a real experiment and adds to it the corresponding 3D representation of invisible field. This could be even feasible in a classical classroom if the real experiment and such 3D representation are mixed and projected on the screen.



Fig. 7 – Visualisation of electric field lines

Such 3D visualisation of vector and scalar values is currently obtainable by means of some simulation package which computes the field lines or equipotential planes according to the known physical laws and creates corresponding VRML model. One example of such simulation program could be the modification of the program VRMLviewer which was written in Java and permitted the simulation of physical phenomena and their visualisation of in VRML environment. VRMLviewer was developed as a visualisation alternative to view experiments created by the program xyZET which was developed at IPN, University of Kiel.

IV. CONCLUSION

The usage of augmented reality can permit individual experiments based on abstract models. This could be useful in the case of personalised learning without having multiple instances of real experimental equipment. In the case of classrooms it is easy to change immediately the experimental equipment and the time consuming setup of such experimental classroom represents no problem. Considering the broadband internet technologies it could be used even in the case of remote experiments on internet that are useful in the case of expensive equipment. The complaint with such experiments is often that the feeling of real environment is not present. The usage of desktop augmented reality is therefore most appropriate where the virtual environment can not be avoided as this is the case of videoconference based education and other cases of virtual educational communities.

REFERENCES

- [1] M. Billinghamurst, " Augmented Reality in Education, <http://www.newhorizons.org>
- [2] M. Billinghamurst, H. Kato, Collaborative Augmented Reality, <http://www.hitl.washington.edu/publications/r-2002-87/r-2002-87.pdf>
- [3] J. R. Cooperstock, The Classroom of the Future: Enhancing Education through Augmented Reality, <http://www.cim.mcgill.ca/~jer/pub/hcii01.pdf>
- [4] The magic book, <http://www.hitl.washington.edu/magicbook/>
- [5] B.E.Shelton, Augmented Reality and Education:Current Projects and the Potential for Classroom Learning, <http://www.newhorizons.org>

- [6] H.Kaufmann, Construct3D - An Augmented Reality System for Mathematics and Geometry Education, <http://www.ims.tuwien.ac.at/index.php>
- [7] W. A.S. Buxton, Living in Augmented Reality: Ubiquitous Media and Reactive Environments, <http://www.dgp.toronto.edu/OTP/papers/bill.buxton/augmentedReality.html>
- [8] S.Divjak, Approaches of distance teaching of natural and technical science, Annals of European Academy of Science, 2003