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Quantum space time travel with the implementation of augmented reality and artificial intelligence

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Abstract
Traveling in time and space represents an old dream, which excited the imagination of numerous writers and artists. Virtual and augmented reality pushes this idea to a new level, and enable to achieve the first steps in this direction. In this paper, we give an overview of several cultural heritage applications using virtual and augmented reality. We show the large diversity of applications, the new possibilities they offer, and finally, their potential in involving the user. Four exemplary applications "Virtual Stratigraphy", "the virtual Cathedral of Siena", "Arche Guide, an personalized AR-Guide" and the "AR-Telescope" are briefly presented. Then, the results, success factors as well as limitations are discussed. We conclude each statement by presenting new results of current research.

Keywords: Artificial intelligence, quantum travel, augmented matrix, augmented reality, space travel matrix, gaming theory

1. Introduction
To travel in time and space is the dream of everyone, who is interested in history and cultural heritage. Countless books, movies and computer games covered this subject in the past. This dream expresses the wish of not only having access to knowledge, but also of experiencing and being part of a given situation, and here through clearly understanding it.
In the thirties of the last century Otto Neurath – member of the Vienna Circle and creator of ISOTYPE (International System of Typographic Picture Education) - promoted the idea of The Museum of the Future "(Neurath 1931) [5]. He developed the idea of bringing the museum to loca-tions where people are, instead of trying to attract them to common site-specific museums. The intention was to promote the democratization of culture and knowledge by making it available to a broad audience and designing it in an attractive and understandable way.
Virtual and Augmented Reality (VR/AR) push both ideas to a new level. Virtual Reality transports the user in a new world, in which he can interact, and so have the feeling of being part of it. Mobile and urban AR applications are no longer attached to a certain place, and offer the possibility to get additional information at any time. These applications are available at pub-lic places where people are walking by and attract people who would rarely visit a museum or an institute.
In this paper we present several applications of virtual and augmented reality in the area of cultural heritage. This field is growing, but still in development. For this reason, we also try to identify factors of success, and domains, for which further research activities are required.

2. Visualisation and Virtual Reality
2.1 Introduction
Real-time visualization and virtual reality cover a lot of different needs of cultural heritage. Those include:
Preservation and digital documentation of cultural sites worldwide dissemination and presentation of cultural assets Didactical potential of 3D graphics Virtual Reality as an attractive medium for presentation to a large public in this article we choose two projects we achieved in this area. The first one is of scientific nature and has for goal to document and enable 3D visualization of stratigraphy excavation. The second application is about presentation of cultural asset to a large public. The "Cathedral of Siena" has been modeled very accurately and can be visualized with high color and illumination fidelity.

2.2 Virtual Stratigraphy

One example for the successful application of virtual reality techniques in a traditional domain is "Virtual Stratigraphy". It enhances the possibilities of archaeologists to examine their data. During a stratigraphic investigation, i.e. clearing away and listing the situation and chronology of layers (strata) of an excavation place including all pieces of find, the volume which is examined will be destroyed. Only the most important pieces of find and the recordings of the scientists persist. It is difficult to get an idea of the original three-dimensional arrangement and of the temporal succession of the site out of this remaining data. This holds for experts and even more for interested laymen.

On an archaeological site, which is equipped with modern tools, the preparation of digital data can be easily achieved by using 3D scanner and digital cameras. But to bridge the gap be-tween traditional and virtual archaeology older recordings have to be made available in digital form. The developed system enables the archaeologist to produce three-dimensional models from the recordings consisting of the elevation values, material properties and other data. The system performs automatically as many steps as possible, so that also users, who are not familiar with 3D-modelling tools, can work efficiently.

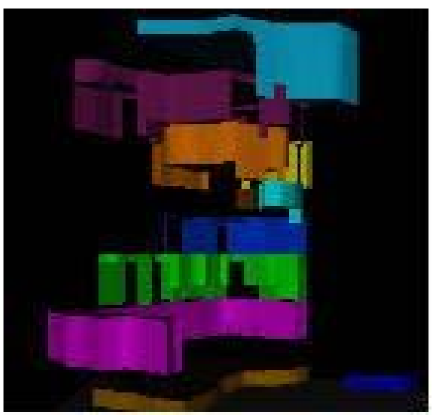

Fig 1: 3D visualization of different strata

Furthermore, interaction techniques were developed particularly for the archaeological investigation in VR. Suitable input devices were selected and integrated into the system. Using consistent interaction metaphors a research system for experts as well as a system for e.g. museum presentations for the layman has been created. The three-dimensional and interactive visualization of the individual layers with representation of the pieces of find in their find situation opens completely new possibilities for the archaeological research. The data can be presented in different ways: individual layers can be faded in or out according to different criteria, represented partially transparent, coloured accordingly to relevant parameters and brought in connection; intersection planes can be moved axially parallel or unconstrained through the volume, measure rasters can be blended in or measurement may be supported by interactively selecting points in an excavation place. Temporal successions of the accumulation are also representable in animations. Thus, a suitable presentation of the virtual excavation site makes it possible both for the expert and also for the layman to achieve a better and more detailed conception of the archaeological data and to gain new insights.

2.3 Example of the virtual cathedral of Siena

The goal of the project „Virtual Cathedral of Siena "was to develop and evaluate a new approach to presentation of cultural heritage assets using high-end immersive virtual reality technologies. Important issues were the implementation of new methods for knowledge transfer (digital storytelling, virtual characters and agents), high-realistic rendering, new interaction techniques and paradigms as well as high quality stereo display (Behr *et al*., 2001) [6].

One of the biggest challenges was the modelling and visualizing of such a complex building like the cathedral. To improve the visual realism we used more than 400MB of textures as well as a physical based lighting simulation method (radiosity), to simulate shadows and other light effects.

The operation of the system was very intuitively. On a touch-screen a graphical user interface was shown, which looked like an ancient book. By using the displayed controls in this book, the user is able to browse through the book and depending on the position of the viewer in the cathedral, the presented information was adapted accordingly. A map of the cathedral allows him to navigate around.

Fig 2: Library of the Cathedral of Siena with the virtual guide

Fig 3: Interface of the exhibit. Touch screen with the layout of an ancient book

Furthermore a virtual tour guide named Luigi was integrated into the system. Luigi is a virtual character with a realistic appearance, who is able to provide the visitor with assistance and information via speech output (Behr *et al*., 2001) [6].

The results of this project can be applied for research and teachings, e.g. to integrate new theories on the history and then to present and discuss them with others. Findings and fragments could be stored in an accompanying database and linked to visual elements in the virtual environment. Furthermore the effect of restoration could be visualised.
Based on our experience we believe that this kind of exhibits is well suited for museums: They are very attractive, allow knowledge transfer and are affordable (PC based).

2.4 Lessons learned
One of the challenges we encountered while creating this presentation was the building of the models. The cathedral has a very complex architecture and during time some parts of the building moved a bit. The modelers had to control the position and rotation of each column and each arch, which slowed down the modeling process.
Another challenge was the fact that the "Virtual Cathedral of Siena" had to be presented for 6 month on EXPO 2000 in Hanover. This meant that the interaction device had to be very robust and the visitors understand the interaction metaphors very quickly. The touch-screen we used for interaction has proven to be a very robust interaction device and visitors learned very quickly how to use it, therefore we used this interaction device for several other projects.

2.5 Current research activities in VR
One essential of the current research activities in the VR area is the generation of perfect real-time images. Although a lot of progress has been achieved in the last year, only a little attention has been drawn to the output display itself. This appears to us to be a crucial issue in order to present high quality results. For this reason, new work on display calibration and display resolution has been started (Kresse *et al*, 2003) [7]. The second issue concerns the resolution of the dis-play itself. During the last years, this one didn't increase as one could have expected. A new level has been reached with the construction of the Heye Wall (Heye Wall 2004) [8], a high resolution and stereo tiled display (Kresse *et al*, 2003) [7]. The screen is 5 meter wide; six by four units and 48 projectors and 48 PCs in total achieve a resolution of 18 mega pixel (6144 x 3072 pixel resolution).
They are arranged together in a steal construction one meter behind the screen. The modular system can be scaled arbitrarily. One major development, which had to be carried out, was the color calibration and color matching of the projectors.

Fig 4: The Heye Wall, a tiled display with 48 beamers and PCs (Heye Wall, 2004) [8]

Another goal is to make Virtual Worlds more intelligent and believable. In the research project "Virtual Human" we are working on Avatars, which look very realistic and have a believable behavior. Avatars have to react on the actions of the users and should be able to act reasonable by them self. By this means, the user can get into a dialogue with the Avatar, who can help him or give him information in a much more natural way than by text boxes or audio files.

3 Augmented Reality
3.1 Introduction
With Augmented Reality we are entering a complete new way of visualization in spatial environments. Visualization in AR is no longer projecting on separate flat surfaces like monitors, PDAs or projection screens, but places digital data into the real world. Like placing signs and markers in cities and on roads one is able to place information right on the spot where it affects. Further more these digital signs are able to react to external influences like changing data sources or user interactions. This is a big step but also a challenge for designing user interfaces and visualizing information.
Although researchers have been developed Augmented Reality applications for years we are just at the beginning of the era of this new technology. Different from the UMTS development with Augmented Reality there are lots of good ideas and potential applications that are emerging. But on the technology side the development of appropriate hardware and flexible software is still a challenge.

3.2 The Archeology Guide project
The goal of the European project Archeology Guide was to provide new ways of information access at cultural heritage sites (Vlahakis *et al*. 2002) [2]. Together with partners from Greece, Italy, and Portugal, we developed a mobile augmented reality system, which allowed visitors to see computer-generated reconstructions on the ruins of an archaeological site, and get information in context with his/her position.

Fig 5: Augmentation of the virtual reconstruction of the Hera Temple (Olympia, Greece)

The system consists of a mobile computer unit, and a binocular display with a camera attached in front of it. Internally, a Global Positioning System (GPS) and orientation sensor keep track of the visitor's current location on the site to provide background information as well as the respective overlays. Additionally, an optical tracking system determines the exact position and view direction of the visitor in order to exactly place the virtual augmentations into the visitor's view. The developed approach based on

Fourier analysis of the image (Stricker 2002) [10] and allows optical tracking without markers being attached to the surrounding even in outdoor condition. Several trials proved the validity of the approach and strongly promoted the introduction of new media in this area.

Fig 6: Test of the Archeo Guide System (Vlahakis *et al*. 2002) [2]

3.3 The AR-Telescope

The augmented reality telescope "xc-01" represents a very pragmatic special solution and a good approach to successfully turn ar-technology into real applications (Becker 2004) [4]. The base idea consists in embedding an augmented reality system into a classic coin-operated telescope. This approach provides two major advantages: on the one hand, the usage of a telescope is familiar to everyone, what ensures a large acceptance of the new device, and one the other hand, the device is fixed at a given place, so that it technical realization is strongly simplified.
The system comprises a high-resolution camera, a high-contrast LCD-display, a precise hardware tracking system, an air condition for outdoor use, and finally a small pc-unit. All these components are integrated into a strong vandalism proven steal case. The user sees in real-time video of the real scene augmented with virtual information. The tracking of the telescope orientation is achieved with help of two sensors placed at its rotation axis.

Fig 7: The augmented reality telescope

The AR-Telescope is a powerful information system as well as an entertaining and storytelling media center. The virtual reconstruction of ruins in archeology, the projection of rock formations in geology and the visualization of buildings coming into being in architecture are just a few examples. Furthermore it allows mapping a city's data i.e. information about traffic, sights, population and pollution onto the real view of the city. Located at an elevated spot this enables an informative view of the town for interested inhabitants.
To create applications for the xc-01 we developed a visual drag and drop editor. With this tool one can join very quickly different media and thus design an augmented reality application. Different objects and functionalities of a palette are just dropped onto images of the scene and place in 2D at their right position. The authoring palette contains for example the following modules:
Tracking and camera configuration Animated and interactive 3D scenes Video and 2D animations Light simulation Occlusion objects We noticed that the quick and simple way to generate content was a feature, which strongly contributed to the success of the AR-Telescope.

Fig 8: Example of information augmentation

A second imminent success factor of the AR-Telescope is its ease of use. The basic handling works the same way as a common telescope works. Thus its interface metaphor is familiar to everyone who has ever used a common telescope before. Due to the divergent target group the whole interface design has also to be very clear and intuitive. We have to keep in mind that there will be highly technical experienced young people using the device as well as completely computer averse people. By moving the head of the device it simply works like a pointing de-vice in the augmented reality surroundings. In order to focus objects and positions of interest one has only to move its head to the right position, or in other words one only has to look at it. At the center of the screen there is a crosshair to support this task. Selecting should be a very intuitive task. The ideal way to select information in the surroundings would be just by focusing on it. No buttons to press and no right-clicks confusing the user. Icons placed in the environ-ment indicate localized information. Focusing on one of them with the head of the AR-Telescope does not immediately pop up the underlying information, what would be confusingly in areas with dense information. It first returns a visual feedback that there is a progress going on, and after a second the underlying information pops up. Then, it disappears in the same manner after leaving the focus.

3.4 Lessons learned

The use of a fixed installation such as the AR-Telescope provides a lot of advantages:
Working with an urban but fixed positioned Augmented Reality device using hard-ware tracking improves the visual quality while bringing this technology to public places. Due

to the high-resolution encoders of the AR-Telescope there is nearly no jitter compared to other technologies, such as computer vision.

The user does not carry any equipment with him, what with current hardware is still not affordable.

The necessary infrastructure, which would be necessary for mobile devices, is not required.

On the other hand the fixed position limits the user's point-of-view in a spatial environment. Virtual objects can only be seen from one perspective even if there are interesting features on their backside. A good solution to this problem is to set up several devices in the area. A de-fined route between the spots helps the visitor – especially tourists who empirically like to be guided – to find the right way and the interesting sites. Another approach would be to use ultra-light devices, such as handheld PC or even mobile phones. In this case, it is the AR- functionalities should be reduced to the augmentation of snapshots or the visualisation of pre-recorded views.

The intuitive usage of AR applications and hardware is an essential success factor. Similar to other new technologies there is danger to overstrain users and thus to deter them from using. That applies to the visual quality of content in AR, too. To achieve this an interdisciplinary collaboration between software engineers, hardware engineers and designers is essential.

3.5 Current research activities in AR

The current research activities and challenges we consider are twofold.

3.5.1 Increasing the mobility: The current hardware, such as wearable computer and head-mounted display is still too bulky and not robust enough for daily use, especially large public. The goal is here too developed as mentioned above new software solutions, which work on standard well-established and ultra-light devices such as pocket-PCs. The definition of the new standard of the graphics library OpenGL Embedded System (OpenGL ES) offers new opportunities. The challenge is to transfer concepts of high-end graphics to this platform (Ultra, 2004) [9].

3.5.2 Stable and accurate autonomous tracking: The current tracking solutions still not sat-iffy the tracking requirements of mobile applications. The first priority is to achieve ac-curacy and robustness in order to insert precisely the 3D virtual objects at the right place and without any jitter. Then, real-time performance must be achieved in order to enable applications with limited CPU-power and battery. Finally, the system should be autonomous, and do not require special infrastructure in the environment or time-consuming preparation. New results in computer vision and in the same time the development of cameras with better photometric properties (linlog cameras) offer today new promising possibilities (MATRIS, 2004).

4. Conclusion

The paper presents different applications of virtual and augmented reality to cultural heritage, discusses project results on base of concrete realizations, and proposes new research directions to further push the current limits of the technology.

We also show the potential of virtual and augmented reality in several areas, including preservation and documentation of an archaeological site, scientific visualization, dissemination and presentation to a large public, and finally knowledge transfer.

We consider VR/AR as the right medium to bring culture and knowledge to everyone. On the one side, the technology attracts people, and on the other side, the introduction of graphics on small devices offers new possibilities and allows ubiquitous access to information.

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