A Concept for 3D Mapping with Augmented Reality Technologies

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ABSTRACT

Augmented Reality (AR) is a new form of human/computer interaction (HCI), whereby computer data is superimposed onto real life photographs and all kinds of information can be displayed to the operator depending on the content.
In this article, a possible application of AR technology will be introduced using the example of the damage mapping carried out on the monumental sculpture "Bavaria" in Munich. Techniques such as AR have great potential in this area, especially when combined with a complete, laser scan recording of the 3D geometry of the object. Using this technique, the virtual object, whose precision depends on the quantity of measured points, can be superimposed with a 1:1 scale 3D photograph. Damage mapping can be carried out on the virtual object and on computer simultaneously, and then converted into a corresponding damage map. In this way, effective documentation, visualisation and structured data records are created, which can be managed in a content management system (CMS). The application is supported by 3D user interfaces, information filtering and automatic integration mechanisms.
We at ArcTron GmbH, are currently still in the development stage of this system. In the future, it will provide a 3D information system, specifically conceived for 3D documentation in archaeology and monument heritage at a variety of different levels.

Initial Proposal

The requirements for computer-supported, scientific classification of archaeological excavation features are computer-supported recordings and the integration of work carried out by various specialists in an information and communication system.

Existing, potential IT solutions for mastering this task have only been inadequately exploited until now. At ArcTron we are working on methods and techniques of 3D mapping and documentation. Our aim is to develop a total concept using existing object surveys, which will enable all recorded data, geometries and other documented descriptions to be efficiently collected, managed and represented.

Fields of Application in 3D Mapping

3D mapping is the structured collection and management of information in an information system. During data collection, the data is reduced down to that which will later be of use. The most important data comes from the recording of a point cloud and the wire mesh model generated from this. Other factual and general data is also collected (photographs, video sequences, sketches etc.).

All existing recording techniques (e.g. laser and stripe light scanning, total station surveying, photogrammetry, hand drafting, photography etc.) have certain technical merits. If the task formulation is adequate, these various advantages can be combined to produce the best-possible, most efficient result.

On the other hand, no single method alone can meet the ever-changing, diverse demands made by object recording. It is essential to combine available methods and technologies in order to avoid inefficiency.

Damage mapping	Archaeology/ Stratigraphy
- Segmentation of the object - Surveying damage - Documenting damage	- Finds/ Feature mapping - Finds/ Feature classification

Table 1 Main focuses of 3D mapping

The aim of our research is to examine how far 3D mapping can be realised using AR/VR technologies. Other main focuses of our research are:

- The evaluation of existing recording methods
- Assistance for recording and recording instruments/ mobile data collection
- Integration in a total system (CMS/ ArchaeoData/ Aspect3D)
- Classification of processed data (Organisation system)
- Modifying and adding information (context relative infor mation)
- Processing and monitoring data, attaching information to the 3D model (Ranze 1999)
- Structured storage of recorded data (Database)
- A modular tool for recording and logging the work stages
- Displaying information ("context awareness") (Rose 1995)
- Filtering information (Julier 2000)
- User friendly Power Management AR technology has proved itself to be useful in the following situations:
- Supporting communication and provision of filtered information (Julier 2000)

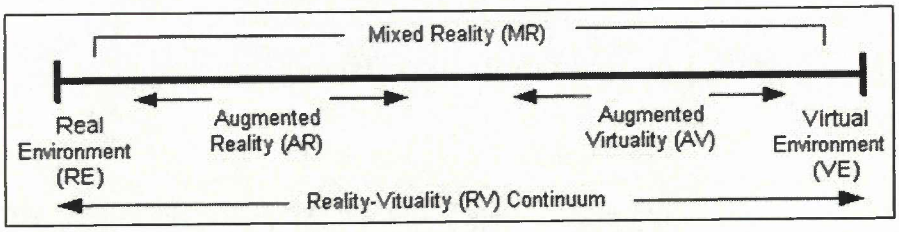

Figure 1 Definition of Augmented Reality (AR)

- Displaying information that is not directly accessible/visible (clearness)
- Direct, in situ collection and recording of object information (illustration)
- Generating and processing new information
- Structured data storage in a content management system (CMS)

AR & VR and the Mapping Process

[1] Technology

(Fig.1) An AR system generates a composite view for the user. In order to be able to see the view, it is necessary to use display equipment known as a Head Mounted Display (HMD). It displays a combination of a real image and a computer-generated image and enhances the picture with additional information. The superimposed image is continuously recalculated depending on the users' head movements.

1) Combines real and virtual space
2) Interactive in real time
3) Registered in 3-D

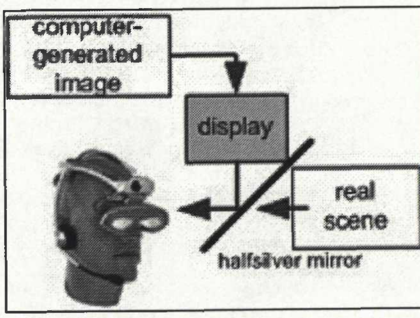

Figure 2

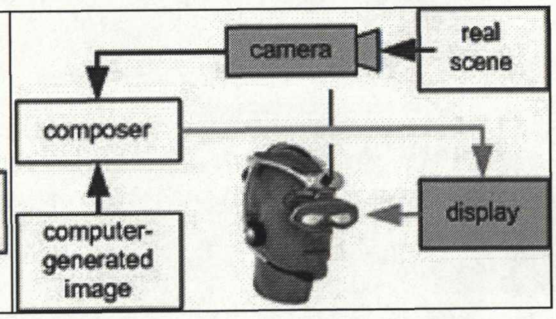

Figure 3

[2] See-through Head Mounted Display (st-HMD)

There are two different see-through HMD'S used in AR and VR systems, the optical see-through HMD (ost-HMD) and the video see-through HMD (vst-HMD).

The optical see-through HMD (Fig.2) combines a real and a computer-generated image by using an optical mechanism with a half-silvered mirror. In this way, the surroundings can still be directly observed. The Video see-through HMD (Fig.3) records and displays the surroundings to the user using a video camera. The software (Video composer) ensures that the video of the surroundings and the computer-generated images (constructed using a Scene generator) coincide.

[3] Tracking Systems

The position and orientation of the user's head must be known so that virtual objects can be correctly placed. Tracking is the method of measuring the position of bodies moving in 3D space. When location (3 positional coordinates) and orientation (3 independent angle coordinates) are measured at the same time, we call it a 6 Degrees of Freedom measurement (6dof).

It is important for the system to be able to react to the movements of the user in real time and deliver the calculated images without delay. The time lag is calculated from the time that elapses between the movement of an object and it is realisation through the computer.

Measurement Data Collection in the Field

Basically, there are two approaches to data collection in the field:

[1] Examination of existing plan documents

Existing 2D drawings or 3D models form the basis of the documentation that can be examined, especially the geometry. The user is shown these in a see-through display.

The concept of using a combination of existing recording technology (laser scanners, stripe light scanners, total stations, photogrammetry, hand drafting) is an allusion to work carried out on a prototype system called CyliCon that was developed by Siemens (Navab 1999, 2000).

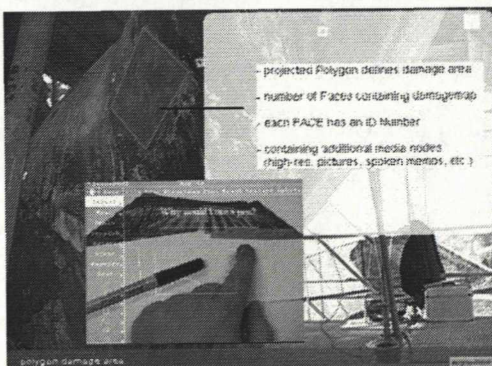

Figure 4

Figure 5

Furthermore, the focus of this work lies in the direct integration of data into the generated geometric model and it's storage in a Content Management System.

[2] Collecting measurement data

Stripe light scanners are employed for high-accuracy, 3D digitisation (to a tenth of a millimetre) and reconstruction as well as for documentation in the field of heritage (Schaich 2000). The plausibility of measurement data is checked by overlaying the generated model on the real object. The model can be visually compared to the real object in situ. The individual systems and the combination of these have not been extensively tested. In order for the systems to be constructively employed in our ever-changing working conditions, the interaction of the components must be examined and adjusted for each case for the following reasons:

- Every object is unique
- Operational possibilities outside of laboratory conditions
- Environmental influences
- Minimum calibration input

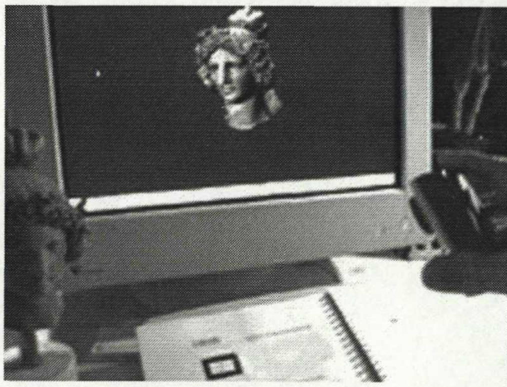

Figure 6

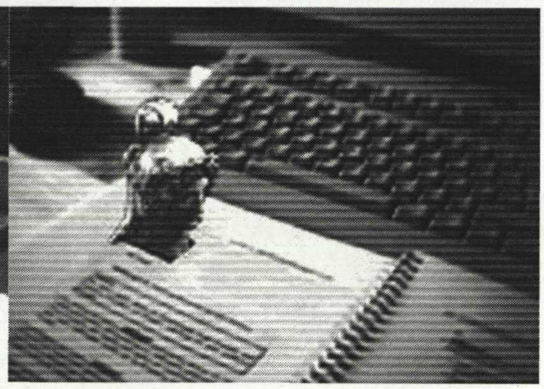

Figure 7

3D Mapping Scenarios

[1] Scenario 1 - Plausibility check

The system supports the user by displaying the data that has already been recorded (Fig.4-5). The plausibility of the data can be checked the same second that it is recorded and the data can then be linked to a suitable context. Additional information can be inserted at the correct position on the object.

- Tracing areas of damage with a finger (Fingertracking MIT)
- Recording visual details (digital photography/ damage documentation)
- Refining the mesh in order to document the exact positions of damage
- Voice memos for making notes and determining damage classes
- Virtual surveying tool for determining the amount of damage
- Arranging the objects in the 3D virtual illustration

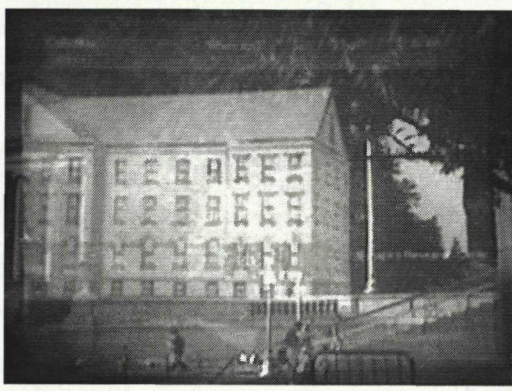

Figure 8

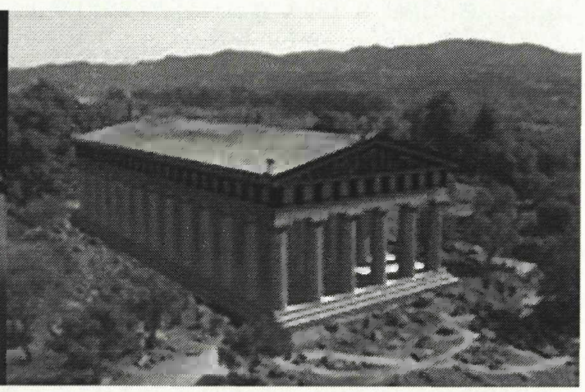

Figure 9

[2] Scenario 2 -Excavation documentation

Recordings taken using an Laser scanner (LS system can produce exact documentation of an excavation. Automated integration mechanisms assist with the structured storage of information in the database and it's integration in the CMS (Fig.5).

- Finds, finds complexes etc. can be recorded on site using digital finds labels.
- Finds locations are directly incorporated into the 3D information system using finds symbols.
- Features can be described, classified and digitally recorded on site.
- Visual representation of the excavation is possible at any time.

[3] Scenario 3 - Magic Book Metaphor - Documentation

The "Magic Book" (ARToolkit) (Azuma 2001) metaphor is a new form of interpretation and leads to a new understanding of damage mapping. Using markers on the printed pages of documentation, the object in question or a section of the excavation can be viewed in 3D either via a web cam on a monitor, controlling a virtual camera in a special documentation application (Fig.6), or using a st-HMD for viewing the object directly on the documentation page (Fig.7).

- Visual monitoring of the section in question

- Easy access to the corresponding source data

FURTHER FIELDS OF APPLICATION

AR/VR as a resource for historical contexts

One of the best prospects for the use of AR/VR is offered by the constant trueness-to-scale (see Archeoguide (Fig.8-9), Reconstruction of historical buildings (Höllerer 1999, Stricker 2001). At a very early work stage, the user can view realistic images of the historical situation without the mental burden of the compilation procedure, as is the case when using conventional two dimensional graphic or screen based three dimensional representations.

CONCLUSION AND FUTURE WORKS

Future research will increasingly concentrate on system specification and prototypical implementations as well as the further development of data management and the database. AR offers us the opportunity to reduce the duration of the working process and to link information to the correct locations. An improvement of the information technology infrastructure would also reduce the cost of projects and maintenance and optimise the running of projects. The developments in this area correspond to the general situation, which is characterised by:

- a continuous increase inthe complexity of projects,
- optimising and improving the efficiency of the conception and planning processes,
- increasing specialisation of applications and among professional planners
- globalisation of the market (virtual organisations).

Thanks to the growing distribution and development of the basic technology, future projects may include the following:

- Integration of superimposition technology for quality assurance (data accuracy).
- Mapping instructions for complete, integrated and uniform documentation.
- Devolution of existing data (for future scientific evaluation, restoration).
- Transfer of captured data into superior information systems, e.g. GIS/WCS and georeferenced data.

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