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Presenting an Archaeological Site in the Virtual Showcase

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Abstract

In this paper, we present our effort to use augmented reality technology to present an archaeological site inside the "Virtual Showcase". A scale model of the ruin of the roman "Heidentor" is complemented with virtual overlays to provide the visitor with additional information about the exhibit and interact with it in various ways. Using a custom authoring framework, it is possible to create complex interactive presentations that allow a visitor to explore different paths of a story about the history of the building.

Categories and Subject Descriptors (according to ACM CCS): H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities
General Terms: Human Factors, Authoring

1. Introduction

Archaeological sites and exhibits are static by nature, and presenting them and their history to a public audience always involves additional media to add information about their original state and the findings of the researchers working on the site. For presenting whole buildings or even historical settlements and towns, two approaches are possible: to have the visitors walk around on the site and examine the remains, or to present an overview of the findings on maps and scale models.

The first approach offers visitors a more direct impression of the dimension and environment of the findings, and also offers a lot more space for placing additional information. Of course, this requires visitors to travel to the site, but they are rewarded with a unique impression and possibly a nice day in the countryside. A lot of work has been done trying to improve the experience of outdoor archaeological sites, and to build information systems to make additional information available to the visitors [11, 12, 13]. Some sites hire actors to wear historical costumes and re-enact historical events to recreate the atmosphere of the time when the buildings were used. The visitors can imagine to be part of a *story* happening a long time in the past.

Presenting archaeology with scale models and replicas will never create the same fascination as visiting such a site. However, there are several aspects that sometimes make it the preferred or only possible solution. First of all, a model can be transported to any destination with reasonable cost, and it might be replicated to create additional exhibits. Moreover, maps and models give an overview of the whole building or area at once, and allow the illustration of abstract information such as traffic routes, dedication of different buildings or parts of a building, reconstructions of borders and many more. Recently, computer animation and virtual reality technology have been widely used to create impressive presentations about the background and history of historic sites. Beyond the state-of-the-art known from museum installations, some projects have tried improve the limited interaction capabilities of traditional VR-movies, trying to reproduce tactile or spatial qualities of the original [14, 15]. Although the availability and quality of rendered images and interaction techniques has increased dramatically over the last years, real models and artifacts are still unsurpassed in terms of visual quality and intelligibility.

The "Virtual Showcase" allows to overlay real exhibits placed inside a showcase with three-dimensional computer graphics and multimedia content within the same space. Presentations running inside the showcase can add a layer of dynamics and interactivity to the otherwise static exhibits, to create an exciting atmosphere and tell stories about the findings. These interactive presentations motivate the visitors to explore the subject on their own, and combine the advantages of traditional museum showcases and virtual reality presentations.

In the following sections, we present ongoing work on an archaeological presentation inside the virtual showcase, and on an authoring framework to support the creation of such interactive presentations. This is still work in progress, but we hope to be able to already provide interesting insights to the possibilities of enhancing exhibits with interactive virtual storytelling.

2. The Virtual Showcase

The Virtual Showcase [1, 3] (Fig. 1) is an assembly of monitors and half-silvered mirrors, accompanied by tracked shutterglasses and interaction devices, that allows to augment the space inside its glass casing with high-quality stereo computer graphics.

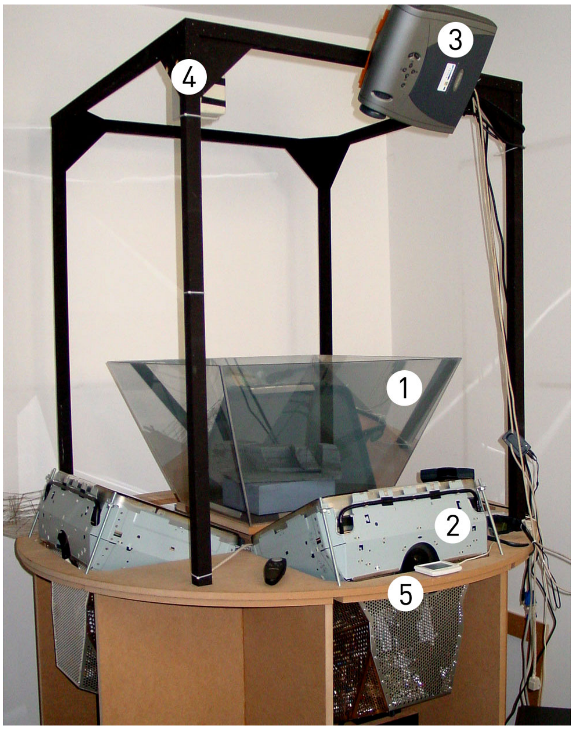

Figure 1: *The Virtual Showcase in our lab setup. The indicated parts are (1) half-silvered mirrors, (2) monitor for image generation, (3) light projector, (4) tracking system, (5) touch-pad for user interaction*

The half-silvered mirrors reflect the high-resolution images from the monitors, to create a virtual image plane inside the showcase. By using frame-interleaved stereo imagery and tracked shutterglasses, a truly three-dimensional image can be generated and aligned with the real content of the showcase. Since the eye position of the user must be measured to render perspectively correct images, we use a tracking system for locating the shutterglasses to calculate the viewpoint of the user. For museum installations, the magnetic tracking device used in our lab will be replaced by optical tracking hardware like the DynaSight system, which has been successfully used and provides an affordable tracking solution for our needs. An additional advantage of optical tracking solutions is that they do not require a cable connection between the tracked item (in our case the shutter glasses) and the base station, so that the user can walk around freely to explore the exhibit.

With our hardware setup, the virtual showcase can provide up to four users at a time with stereographic images, generated by the four monitors integrated in the casing. In addition to the graphics displayed by the monitors, we use a projector to illuminate the contents of the showcase [2]. Therefore, we can control the lighting of the real objects on a per-pixel basis, and hide or highlight parts of the exhibits by rendering the appropriate lighting directly onto their surface. Against a constantly lit background, the reflected virtual images look semi-transparent and often lack contrast and saturation. By selectively darkening the parts of the background that are "hidden" by virtual objects, we can further increase the overall visual quality and give an even more realistic look to the virtual parts of the presentation.

3. The Heidentor presentation

The Heidentor (Heathen Gate) [4] is an ancient roman ruin, located in Petronell-Carnuntum/Austria, and probably the most well known roman ruin in Austria (Fig. 2). Originally, the Heidentor was not a gate, but it had 4 pylons forming a so called *tetrapylum*, a double-passage arc, located at the intersection of two major roads. The pylons were supporting a 2-floor building on top of them. Today, only 2 of the pylons are still intact, and form an impressive, gate-like ruin that is visible from far away. The exact purpose of the Heidentor remains unclear; it might have been a tomb or a triumphal arch. Due to its impressive size and location in the countryside, it has inspired artists and storytellers over the last centuries, and a lot of myths focus on this historical site.

For the virtual showcase, we have built a scale model of the current Heidentor ruin, to be augmented with additional explanations and reconstructions of the original building. The focus of this presentation lies on user interaction; users should be able to interactively explore the model and discover explanations about the historical facts as they go along. The interactive features should help to gain attention and raise interest in the subject by offering the possibility to explore it individually instead of just watching a linear presentation.

The scale model was built out of cardboard based on exact

Figure 2: *The Heidentor ruin, located in Carnuntum/Austria. A low-tech augmentation device is used on site to show a possible reconstruction of its original state.*

Figure 3: *An animated virtual character introduces the Heidentor. Here, the real model remains dark, and is fully replaced by a stereoscopic image of the reconstruction.*

archaeological plans and measurements. It was then laser-scanned to obtain a virtual model. A virtual model of the real object is necessary to render occlusion of the virtual content correctly. In addition, the virtual model can be used for purely virtual presentations outside the showcase and during development of the presentation as a placeholder for the real contents of the showcase.

For the virtual part of the presentation, we use two different historical reconstructions of the original building, as well as photographs, sketches and a video. As the visitor approaches the exhibit, she is introduced to the subject by an animated virtual character (Fig. 3). The character tries to get the attention of the visitor, and presents the model of the ruin inside the showcase. After the introduction, the visitor can either use virtual buttons to advance the presentation in a linear fashion, or use the provided tools for interactive exploration to get additional explanations for certain parts of the building.

Since the model is enclosed inside the showcase, visitors cannot interact directly in the space of the model. Instead, we use a virtual laser pointer to enable users to point at parts of the model that they are interested in (Fig. 4). When a part is selected, it is highlighted and the appropriate information is shown. This might be an image or a video displayed on a plane inside the showcase, possibly accompanied by audio commentary, or a whole scene involving virtual actors and audiovisual information.

Another possibility for user interaction is a virtual clipping plane, to "cut away" the virtual model and make the real model underneath it visible (Fig. 5). This helps the visitors understand the relationships between the ruin that can be seen today, and the original state of the building. The same technique can also be used to blend between and compare different possible reconstructions of the same building.

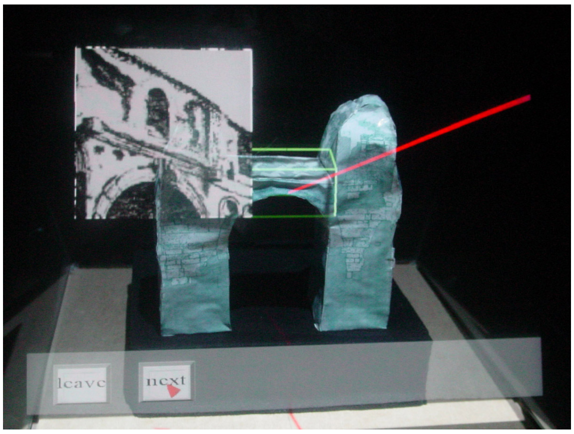

Figure 4: *Using a virtual laser pointer to explore additional information. Here, a sketch of the reconstruction of a similar building is shown.*

In the future, we want to include human-like actors scaled correctly to recreate a historic scene that could have taken place at the Heidentor.

4. Authoring Presentations

Authoring presentations for augmented reality environments is a complex task, and therefore often an expensive undertaking. Not only the virtual content has to be modeled, but also the relation to the real content and the desired user interaction has to be taken into account. For an interactive presentation, the graphics has to be rendered in real-time, which

Figure 5: *Blending between the real model and its reconstruction with a virtual clipping plane.*

increases the hardware requirements and limits the choice of software platform to realtime-capable APIs.

4.1. Related Work

Possible choices of graphics APIs for realtime rendering include the low-level OpenGL API and the more high-level scenegraph APIs like VRML, Performer or OpenInventor. Unfortunately, although these toolkits offer an object-oriented interface for constructing scenes and provide basic services like event handling, they all lack native support for the advanced animation capabilities of current modeling software and cannot provide the high-level user interaction support we need for creating interactive presentations for the virtual showcase. Realizing complex presentations with these frameworks is a tedious task, and therefore not feasible for projects with limited budget and resources.

Scriptable frameworks like VRML offer means to extend the framework and implement custom applications without re-compilation, but still require programming skills and a lot of effort to create even simple AR applications. Recently, also the C++ based APIs like Performer and OpenInventor have been extended to provide scripting facilities [7, 8] – but they are too much targeted towards developers and do not provide the high-level abstractions and content-oriented design paradigms we are looking for. Fuhrmann et al.[9] proposed a Perl-based preprocessor to generate VRML geometry from high-level descriptions of VR presentations. This approach produced complex, interactive geometry from simple descriptions, but was geared towards linear sequences of 3-dimensional "slides".

Macromedia Director is an established tool to create web applications, interactive CD-ROMs and kiosk applications and has been extended to support the creation of 3D applications. It is well known by designers and can be extended by scripting and by creating plug-ins implemented in C++. However, we didn't find sufficient support for AR requirements and hardware – tracking devices, advanced rendering techniques and distributed rendering, to name the most important ones.

Recently, visual modeling of applications with the Unified Modeling Language [17] has been proposed as an approach for prototyping and implementation of multimedia presentations [18]. UML is a graphical language that is used across different domains to visualize abstract information in standardized *diagrams*. While UML is already well-known amongst programmers and computer scientists, it is increasingly used by managers, designers and professionals from various areas to communicate their ideas. Therefore, UML is an ideal communication tool to be used in interdisciplinary projects.

4.2. The APRIL Authoring Framework

To allow people to create compelling, interactive presentations for the virtual showcase, we developed a high-level authoring framework for AR presentations called APRIL. APRIL allows non-programmers to create interactive presentations without programming skills, and supports larger projects by defining a story-centered authoring workflow that integrates with state of the art content creation tools. APRIL provides concepts for hardware-configuration, story authoring, animation and interaction in an XML-based file format, using an UML-statechart representation of the presentation as a skeleton for development. The full specification of the APRIL language can be found online [5].

The APRIL player software is based on our Studierstube augmented reality framework [7], which in turn incorporates OpenInventor as its graphics API and other base technologies like OpenTracker for input device abstraction and data processing. APRIL hides the complexity of this basic framework and provides developers with the concepts and tools for creating interactive presentations.

An APRIL presentation is specified in an XML file, containing different sections for device configuration, content management, animation, interaction and storyboard. Each of these sections can be exchanged, to easily create different variations of the same presentation for different hardware platforms or user requirements. In the following sections, we describe the most important concepts that APRIL offers to the presentation author.

4.2.1. Interaction

For interacting with a volumetric display like the virtual showcase, Balakrishnan et al. [10] list a wealth of possible interaction tools and techniques. We found that from this list, only a few techniques are sufficiently useful, robust and easy to learn, given the target location in a museum. The types of user interaction directly supported by our interaction toolkit are:

- *Head tracking*
  A central component of all virtual showcase installations is tracking the user's head and rendering the graphics displayed dependent on the user's estimated eye point position. Head tracking can also be used for detecting new users approaching the installation, and, for example, triggering a restart of the presentation.
- *Buttons*
  Buttons are the most basic hardware interaction tools that can be used in a virtual showcase installation, but due to their robustness and versatility are a very important interaction tool for presentations. Buttons can be used as simple presentation controls ("next scene", "previous scene"), but can also change behavior depending on the context of the presentation. Buttons can also be embedded into the floor or realized as photo-sensors to detect the user's movement. In addition, buttons can be easily simulated by rendering them onto the display surface, if the presentation runs on a different hardware setup with fewer or no hardware buttons installed.
- *Hotspots*
  Hotspots are "virtual buttons" in presentation space - they are parts of the real or virtual content of the presentation, and mark significant parts of an artifact that can be selected by the user. A typical scenario lets a user select a hotspot to display additional information about parts of an object. Note that, since hotspots are located in presentation space, and are therefore behind the half-silvered mirror optics of the showcase, no direct interaction (e.g. pointing) is possible - the user has to use indirect pointing techniques (see below) to be able to select them.
- *2D Pointing*
  2D Pointing is realized by connecting a trackball, trackpad or touchscreen to the showcase that can be used like a normal computer mouse to perform 2D input and pointing. The 2D input can be either used directly to select virtual buttons or other 2D user interface components on screen, or it can be mapped to a plane in 3D space to perform constrained 3D input in presentation space - for example, to select hotspots located on the ground plane of the showcase, to choose between various artifacts displayed inside the showcase. This could be used on maps of whole sites to select single buildings or locations.
- *3D Remote Pointing (Raypicking)*
  Since it is not possible to reach inside the showcase and interact directly in presentation space, we have to use remote pointing techniques to freely select objects or hotspots in the showcase. Remote pointing is realized by using a laser pointer metaphor, selecting the nearest object that is intersected by the beam. The ray can be generated either by using a fully tracked pointer, or by using a 2D-point on the display surface and constructing a beam originating from the users eyepoint. By using this technique, users can intuitively and precisely point at parts of the presentation.
- *Timeouts*
  Besides direct user interaction, also the absence of user actions can be used to drive presentations. We provide a timeout mechanism, to be able to trigger events if for a certain period of time, no significant user interaction took place.

4.2.2. Animation & Behaviors

In reaction to user interaction, properties of objects in the scene can change over time. APRIL allows to encapsulate objects, implemented in OpenInventor, as components that can be re-used across presentations. A component is treated as a black box at the authoring level that hides away the complex details of its implementation and exposes a clear interface through input and output fields. For controlling the values of a component's fields, APRIL offers four basic possibilities:

- *SET*
  A property can be set to a new value at a given time *t*. For example, the object could disappear by setting its *visibility* property to FALSE.
- *ANIMATE*
  A property can be animated over time to a new value, specified as an absolute value or as an offset to the original value. This is done by the player software by linearly interpolating from the old value to the new value, changing the property over time.
- *CONNECT*
  The value of the property is connected to another property of another component. Whenever the value of the "master" object changes, the value is updated. This allows us to encapsulate more complex calculations in components and simply connect the output to another property.
- *CONTROL*
  The property can be controlled by the user, by using either a tracked input device or by rendering a user interface component onto the screen.

With these atomic commands, arranged on a timeline, complex scenes can be composed out of components.

4.2.3. The Story

We have already seen that, because of its operation in a public setting with possibly untrained visitors, interaction tools that can be used for VS installations are limited to very simple, robust ones. However, we want to drive complex, interactive presentations with these tools.

To overcome this apparent contradiction, we introduced the concept of state-engine driven stories. The "story" of the presentation is represented as a UML state-engine, where states represent behaviors exposed by the components of the presentation, and transitions denote possible user interactions (Fig. 6). Within a state, the animation commands described above can be used to change the properties of com-

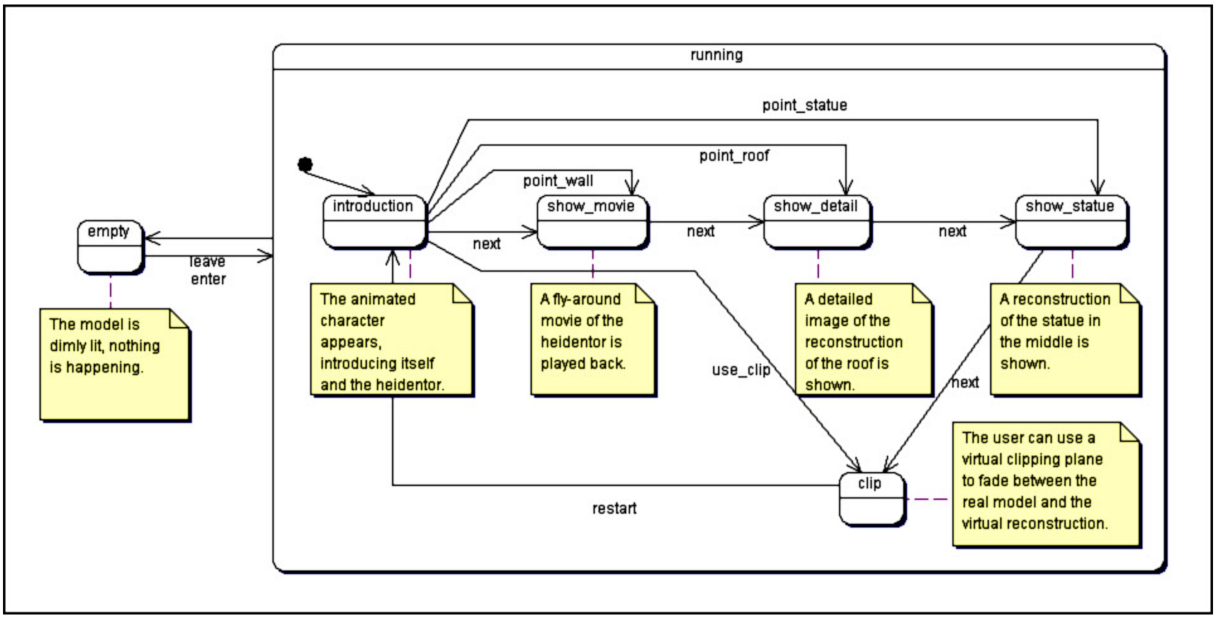

Figure 6: *The Heidentor presentation, modeled as a hierarchical state machine. Nodes in the graph represent behaviors, edges represent possible user interaction.*

ponents. Lighting effects can be realized using the light-projector to hide or highlight real objects inside the showcase.

Transitions in the story can be bound to any of the interaction tools listed above; if a transition is bound to a button, for example, this means that if the story is currently in the source state of the transition, pressing the button triggers a transition to the destination state, and all the behaviors defined there are played back.

By simply changing the mapping of transitions to interaction tools, the same presentation can be run in different modes – a fully interactive presentation, or a linear, movie-like presentation driven by timers and automatic transitions, if no interaction tools are available. Since APRIL separates presentation content and hardware configurations, the story developed for the virtual showcase could then also be run outdoors at the real location, using outdoor AR equipment [6] and GPS tracking of the participants.

Modeling the presentation as a state engine allows users to walk through multiple paths of a complex, nonlinear story by using comparably simple interaction tools. This encourages visitors of the Heidentor presentation to leave the linear path of the presentation, and start exploring the exhibit on their own, with the environment reacting accordingly to their actions.

5. Authoring workflow

Recently, the need for authoring tools for AR-presentations that allow rapid, incremental prototyping and the use of informal, “sketchy” content has been identified in the AR community [16]. APRIL supports such an approach, by starting with the story specification as a document that can be used as a communication tool, a sketch board and repository for ideas and illustrations, and can be iteratively refined throughout the design process. At all times, the story specification is also an executable prototype and can be used to test the story and the available components with the actual target platform, using placeholders and sketches for content that is not yet developed.

The first step in the APRIL workflow (Fig. 7) is research of the subject of the presentation. Raw material (text, images, video, sound, models) is collected, and the idea for the presentation is developed, possibly in sessions with domain experts and museum staff. This brainstorming phase results in the story document, the UML model of the flow of the presentation.

The story document acts as a specification for content creation (using the raw material found in phase 1) and component authoring. Components can be re-used from a set of default components or earlier presentations, and for sophisticated interactive presentations new, customized components will be developed.

Integrating the components, interaction tools and content items is the goal of the final phase, story integration. The result is the complete presentation specified in the APRIL mark-up language.

Independent from the story authoring, for each showcase hardware setup there is a configuration file, describing the arrangement of displays, interaction hardware, speakers, and other aspects of the available hardware. Therefore, a single presentation can be run on multiple showcases with different hardware configurations, and there are even hardware configurations for ordinary desktop computers, for development purposes. During story development and testing, it is not necessary to run the presentation on real VS hardware; the same presentation can be run in an "emulation mode" on the developers PC.

Media content, components and hardware description files are re-usable parts of a showcase installation, and are only loosely coupled by the story to contribute to a specific presentation. The same media, components or hardware can be used to tell other stories about the same or completely different subjects.

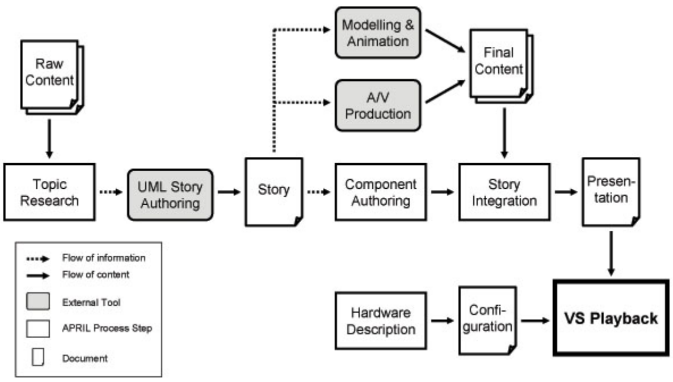

Figure 7: *The APRIL workflow.*

6. Future Work

At the moment, the Heidentor presentation follows a comparatively simple storyline, and only the basic content has been created. With the help of our authoring framework, we hope to be able to rapidly develop this presentation into an immersive story, without any programming skills required to create complex interaction possibilities.

A thorough evaluation of the virtual showcase as a platform for archaeology and architecture presentations based on real scale models, of the proposed interaction tools and of the authoring environment will take place to verify our results in real world usage scenarios. Currently, our students use the APRIL authoring framework to create presentations about various subjects on different platforms. This will serve as a first test of our toolkit and will supply us with different usage scenarios to base the evaluation on.

Acknowledgements

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