The *Computer-Visualistik-Raum*: Veritable and Inexpensive Presentation of a Virtual Reconstruction

Bert Freudenberg Maic Masuch Niklas Röber Thomas Strothotte

Institut für Simulation und Graphik
Otto-von-Guericke-Universität Magdeburg
Universitätsplatz 2
39106 Magdeburg, Germany
office@isg.cs.uni-magdeburg.de

Abstract

This paper describes the development of the *Computer-Visualistik-Raum* (CVR), a Virtual Reality experience presented in the Exhibition "Otto the Great, Magdeburg and Europe" which took place in 2001 in the Museum of Cultural History, Magdeburg. The presentation deals with an archaeological excavation that was carried out at the Domplatz in Magdeburg in the 1960s. In the CVR, which consists of three consecutive rooms with a spherical projection chamber in its center, visitors can explore several variants of interpretations of the excavation findings.

The virtual reconstruction shown in the CVR is special in two ways. First, it tries to be truthful to the actual findings by *visually* stating the degree of certainty of details, where conventional systems only give textual or aural indications of these circumstances. This is achieved by employing non-photorealistic real-time rendering techniques, as well as by presenting alternatives instead of just one reconstruction.

Second, the whole system is based on rather inexpensive components (compared to specialized VR systems), that nevertheless allow a great deal of freedom in expression. A *game engine* provides distributed realtime-rendering capabilities to drive three standard PCs with GeForce3 graphics boards. Their rendering capacity is sufficient to even perform the spherical distortion and soft-edge blending without special hardware, allowing off-the-shelf beamers to be used.

1 Introduction

From 1959–1968, an excavation was carried out on the Magdeburg Domplatz. Remnants of a large building (40 m x 50 m) were found. Because of the unusual floor plan, the findings were categorized as foundation walls of the "Aula regia", the main palace of Otto the Great [1]. Further investigations, including a thorough analysis of the excavation data, did not take place until 1998.

In 1986, the historian Cord Meckseper attempted a reconstruction of this building, using the preliminary excavation data [2]. Based on his drawings, in 1997 students of our department built a virtual reconstruction in an animation course. This resulted in a short animation (3 minute video).

That work ignited the idea of presenting the virtual reconstruction in an exhibition about Otto the Great in the Magdeburg Museum of Cultural History, which was scheduled for 2001. First, there was the idea to show a virtual walkthrough, as video or maybe as a Quicktime VR movie. The work on this was sponsored from 1998 in a two-year project by Multimedia@LSA, a program of the State of Saxony-Anhalt and Deutsche Telekom.

In 1998 the archaeologist Babette Ludowici started an in-depth analysis of the excavation protocols, drawings, and findings. Then, in 1999, she found something that almost would have stopped the project: The analysis of the stratigraphic sequence invalidated the quadratic plan, it proved that remnants of two buildings stemming from different periods were accidentally mistaken as one [3].

Consequently, the concept had to be changed. Conveying a false impression of the original site should not easily happen again. So we started research into visually depicting uncertainty about virtual reconstructions. In 2000, four students began working on visualization components, based on a game engine. The new interpretation of the findings was again provided by Cord Meckseper and his assistant, Maike Kozok. In 2001 the hardware was funded and a company found to implement what we now call the "Computer-Visualistik-Raum," named after our degree programme *computational visualistics* [4]. Since the end of August, the exhibit can be visited in the Magdeburg Museum.

The paper is organized as follows: We first outline what we think is needed to create a faithful presentation of a virtual reconstruction. The Computer-Visualistik-Raum is described and how it helps to reduce costs compared to a conventional VR show. This is followed by some comments on our experience in this project, what went right, and what wrong. We close with some remarks on virtual reconstructions and how to present them in general.

2 Achieving Veracity

Virtual reconstructions have a very special appeal, as the computer simulates the complete spatial environment, which can be visited with the adequate equipment even in 3D. The interested visitor can get a most vivid impression of the site, an impression that cannot be achieved by any other means. A virtual reality environment allows a very intuitive understanding of how an ancient place looked like. Still images and animations resemble our every-day experience with photographs and television. Photorealistic images possess a convincing visual power, while interactive virtual walkthroughs additionally convey the immediate experience of "being there." Thus virtual walkthroughs provide an effective and convincing tool for research and visualization of lost architecture (for examples see [5]).

In the process of reconstruction it remains quite difficult even for experts to infer the original shape of a building merely from the data gathered by the excavation. Virtual reality enables them to use an intuitive and most flexible research method. However, the virtual reconstruction forces the experts to settle upon all visible details (even elements that could have passed unnoticed in the traditional 2D model) because open questions are directly exposed to the expert. This poses the problem of the veracity of the visualization. We found that different kinds of presentations (rendering styles, see Figure 2) can be used best to meet the different requirements for our visualization tasks.

Figure 1: A photorealistic reconstruction (3D Studio MAX)

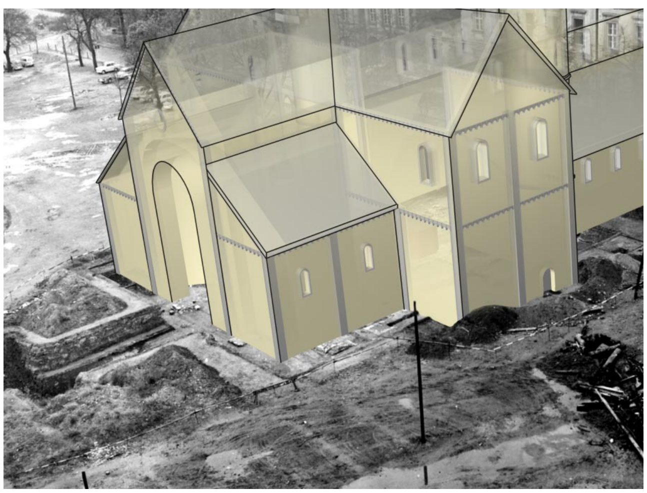

Figure 2: Hybrid rendering (photograph, shaded rendering, line drawing)

2.1 Non-Photorealistic Rendering

In a virtual reconstruction of a historical site, facts, assumptions and fiction exist side by side to create a convincing illusion of seeing into the past. Especially in a museum, exhibitors have to consider carefully what images they convey to the public, as people tend to take a given picture for scientifically proven truth. Viewers, however, cannot distinguish between what is scientifically proven, what is the result of careful reasoning, and what has simply been made up to fill in gaps in the image. Also, even experts are sometimes distracted by the amount of detail shown in a photorealistic image which may not represent their own level of knowledge with the object being portrayed. Therefore, non-photorealistic rendering methods have been developed and applied to the field of archaeology in recent years in order to extend the palette of available presentation options [6, 7]. The ability to select between different types of visualization enables a user to choose the form of presentation that serves the given communicative purpose best.

The use of non-photorealistic images is common in scientific and educational visualization. A non-photorealistic image can differ from a photograph in shape, color, light and shadow (see Figure 3). This can have essential advantages: First, different drawing styles may be applied to objects to encode various levels of importance, i.e. using bright lines for less important objects and strong lines to depict a more important object. Second, the abstraction of the scene can simplify a picture, as unnecessary and distorting details can be left out. Thus the image can hold several levels of detail, i.e. fine details in important areas and just rough outlines in less important or unknown areas. Also, styles can be mixed (Figure 4).

Figure 3: Two NPR renderings: cartoon style (left), sketchy style with shading indicating uncertainty (right)

So, a veritable presentation should not just present nice imagery, but also depict what is actually known about the depicted elements. Also, when visitors get involved in the decision process that has led to a visualization, they can evaluate what is shown much better than when only presenting the end result. This is what we set out to achieve with our presentation.

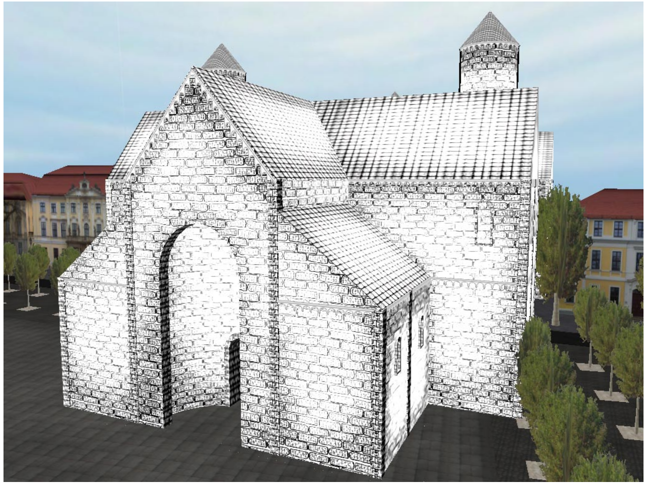

Figure 4: Mixing photorealism and NPR in one scene

2.2 Show Concept

The actual show concept was developed and implemented by our industry partner, emergent media AG Magdeburg [8]. This installation of the CVR is divided into four sections that are consecutively walked through by the visitors (see Figure 5):

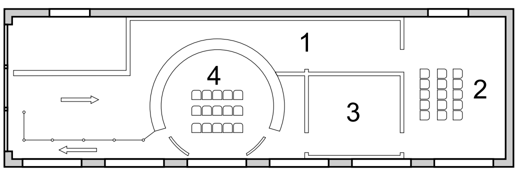

Figure 5: Layout of the CVR inside the museum (25 m by 7.25 m)

1. The journey begins in the "Time Tunnel," a long room with "time fragments" taking visitors from the 21st back to the tenth century. These "fragments" are large-format reproductions of historically important pieces of art that, alongside with ambient sound installations, mark the stations back to the medieval ages.

2. In the following room, visitors learn about the discoveries that shattered the hitherto image of Otto the Great's palace and invalidated older theories. A large two-screen projection wall shows a DVD presentation explaining the long way of scientific research that was necessary to arrive at the current interpretation of the excavation findings.

3. The next room provides visitors with a hands-on experience to this scientific research process. Three interactive stations let the visitors explore the archaeological excavation, study historic sources, and create comparing reconstructions.

4. The last room is a spherical projection hall giving visitors an idea of what scientists now believe to be a probable version of Magdeburg around the end of the first millenium.

All parts are synchronized by a show-control system. The flow of visitors is managed by automatic doors between the rooms and audio comments. The spherical projection in the last room was chosen because it gives a really good sense of space due to the wide field of view (210 degrees). Also for this reason, the projection extends vertically from eye-height almost to the dome's apex. Forcing visitors to look up provides an immediate comprehension of height (see Figure 6).

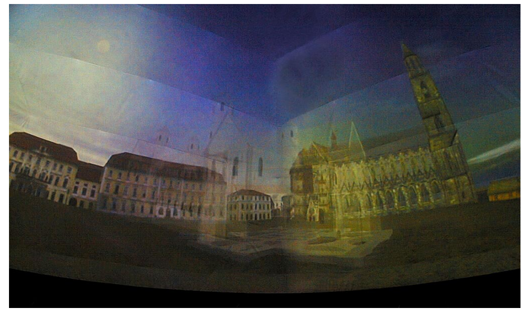

Figure 6: Transparent reconstruction in today's surroundings as projected in the dome

The presentations in the first rooms povide visitors with the knowledge necessary to evaluate the scene shown in the final room. As visitors leave the show, they not only take home an image of how Magdeburg looked a thousand years ago, but also that this image certainly is not to be taken literally.

3 Cutting Costs

There are basically three kinds of costs involved in a virtual exhibit. These are staff cost, hardware costs, and software costs. We shall deal with each of these in turn in this section. A way to distribute costs is reusing at least part of the installation; this is described, too.

3.1 Staff

The nice educational concept we imagined should be presented in a nice environment, too. We figured that we would attract many more visitors if the presentation room itself was attractive. A simple projection screen in a cinema-like room might have been sufficient to show what we had in mind, and indeed, that was all the Museum ever wanted. We considered making the show interactive for a large audience, but the exhibition planners thought that would be too demanding for their average visitor. So the group-interaction was discarded. The next option was to have the museum guides control the presention, with the possibility to adapt the flow of the presentation to the audience's interests. That would have demanded trained personel that is available all the time, which was deemed much too expensive.

So what we opted for was an autonomously running system that would not require human resources beyond the security guards who have to be there anyways. Still, to retain the option of having guided tours, for example with school classes, the system should run in real-time rather than playing back a canned show.

3.2 Hardware

Using the best available hardware you can easily create an impressive VR experience. In our lab there is an older SGI Onyx, but first, we could not just take it out for a 100 day trip to the next museum, because it is still used for ongoing research. And second, it would just not be sufficient to run a three-wall projection because it only possesses a single graphics pipe. Besides, the graphical quality of that old machine is easily topped by current PC based graphics solutions.

Of course, using a distributed PC solution is more complicated than a single three-pipe Onyx. But the amount that can be saved well compensates that complexity. So, we opted for a three PC solution connected by a simple ethernet network. The PCs have gigahertz processors and GeForce3 graphics boards, which is plain consumer hardware (see Figure 7).

Figure 7: The technics rack: To the left the show-control system can be seen, in the upper right there are two DVD players, at the bottom the 4 PCs running the game engine

Another expensive hardware component usually is needed for distorting the images to account for the spherical projection wall, as well as the soft-edge blending for overlapping beamers. We replaced this by a software solution built into the game engine.

The CVR itself is assembled of steel-tube framing covered by heavy black fabric. For the spherical projection room, a geodesic skeleton made of steel was filled with black wooden plates (see Figure 8). On the inside, a sewn canvas was attached. The three projectors have hoses attached to exhaust air.

3.3 Software

In order to use relatively cheap hardware, most special-purpose functionality had to be implemented in software. Here, a game-engine provides a nice framework to present 3D contents.

The Shark3D engine by Spinor GmbH, Munich, is a component based 3D engine. It has some special features specially targeted at location-based installations [9].

Figure 8: The dome during installation

To project an image onto a non-planar wall, it has to be distorted. This can be done by video hardware, but that is expensive. A cheaper way is to render a distorted image. The GeForce3 graphics board provides enough bandwidth to make this possible. In the engine, a mesh can be defined onto which the whole framebuffer is mapped as a texture. So all that was left to do was create that mesh and import it into the engine (see Figure 9).

Since three projectors are used to cover the huge field of view, the three PCs have to run synchronously. Again, the game engine already provides networking capabilities and multiple view ports.

Another matter was integrating the NPR rendering into the engine. One way of doing this was described in detail in [10]. Bringing this into the Shark3D engine was also relatively easy because of its component based design.

All in all, the decision to use the Shark3D engine instead of some other frame work was a desicion we did not regret.

3.4 Reuse

Reusing the content of the presentation would be rather hard, because it is taylored to the virtual reconstruction walkthrough. But the hardware was designed to be modular and transportable. Starting 2002, it will be installed in the "Experimental Factory," part of a local science park for R&D start-ups, after the museum exhibition. There, it will be used for further research by the university, it can be hired by local companies for development purposes, as well as being temporily relocated to public fairs and exhibitions. In fact, the museum application of the CVR is its first use, and the funding we got was included in the basic equipment of the "Experimental Factory."

4 Lessons Learned

Visitors generally commented positively on our exhibit. So, it is a success in the end. Still, there are a few experiences we would like to share.

We were very glad to have chosen the Shark3D engine for the realtime visualization. It came equipped with a lot of functionality, like the scene synchronization on multiple PCs, or support for distorted projection. It was easy to extend; for example, the integration with the show-control system took only a few days. Also, it runs very stably: In the ten weeks from the start of the exhibition until now, it did not crash once, a quality that cannot be overestimated.

The main problem was coordinating all the parties and people involved, and trying to satisfy everyones interest, which led to enormous delays. For one, there was a rather conservative fraction in among the exhibition staff in the museum, who rejected to show anything that was not 100 percent scientifically proven. The exhibition itself is unassailable. It got the title of an "Exhibition of the European Council," as well as the patronage of the German Federal President, Johannes Rau. But there was a permanent reluctance to the employment of "new media" in general, and the efforts of a small local group of computer scientists (us) in particular. Also, the funding was not secured until a few weeks before the exhibition opening.

That is why emergent media AG could not really start building the CVR well in advance, and there were still unpolished sequences when the exhibition began. For example, there was not enough time to integrate all visualization techniques developed prototypically by us into the final presentation. Also, some scenes were taken out – literally – in the last minute on request of the archaeologist. The result was a rather dull experience in the dome, which stood in strong contrast to the visually overwhelming video presentation in the second room. Only after a few weeks it was replaced by a more

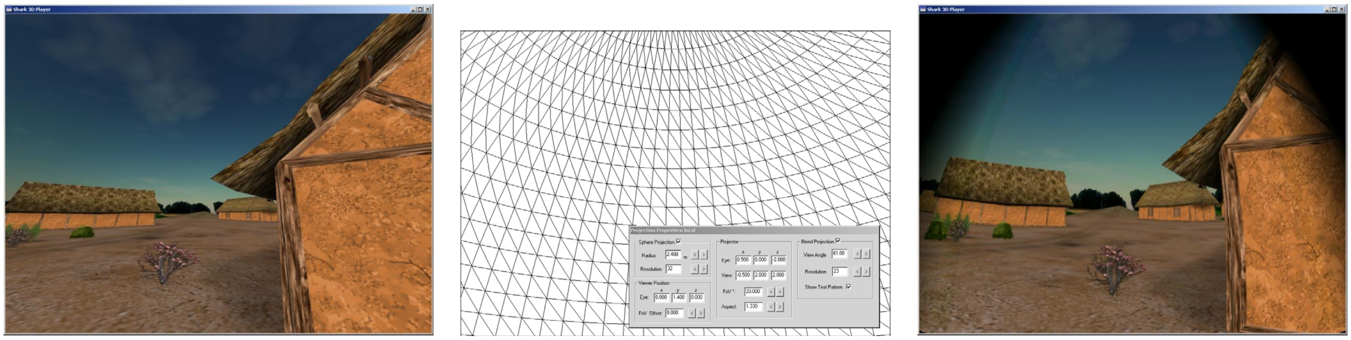

Figure 9: Spherical distortion and soft-edge blending inside the Shark3D game engine: Original frame buffer contents (left), mesh used for distorting (center), distorted image with soft-edge blending (right)

compelling version. Fortunately, visitors did not know what they missed, so it still was a nice experience for them.

5 Conclusions

All in all the project was a challenging experience, beneficial for all participating. The key to a veritable exhibition is a carefully balanced presentation that not only shows the result, but also explains the process of scientific research. This is achieved by taking the museum visitor behind the scenes in order to explain the conclusions, assumptions, or even guesses that are necessary to form a complete picture of past times. Encoding the degree of certainty directly into the visual appearance of a virtual model unambiguously depicts the trustworthiness of certain parts of a reconstruction. Especially this rather unusual presentation style resulted in positive response from visitors.

Accepting this challenge does not necessarily require expensive proprietary VR hardware for the presentation of virtual reconstructions in public exhibitions. In our experience, moderately priced hardware components in combination with game-engine technology can be used even for ambitious installations.

The interactive exploration of three-dimensional reconstructions will be the key to the future and lead into an era of new understanding and faster developments. Virtual reality techniques are moving into focus because they are available for low budgets now. With the new flood of nice, photorealistic images it has to be chosen carefully what to present to the audience. The visualization of uncertainty and presentation of facts and assumptions in a veritable way is an important key to the acceptance of computer-based visualizations as a new medium in the field of archeology.

References

[1] Ernst Nickel. Magdeburg in karolingisch-ottonischer Zeit. *Zeitschrift für Archäologie*, (7), 1973.

[2] Cord Meckseper. Das Palatium Ottos des Großen in Magdeburg. *Burgen und Schlösser*, (27), 1986.

[3] Babette Ludowici. Ottonische *aula regia* oder unbekannter Kirchenbau? Ein Arbeitsbericht zum Stand der Auswertung der Grabungen von 1959–1968 auf dem Magdeburger Domplatz. *Archäologisches Korrespondenzblatt*, 30(3), 2000.

[4] Otto von Guericke-Universität Magdeburg. Computervisualistik. `http://www.computervisualistik.de/` and `http://isgwww.cs.uni-magdeburg.de/master/`.

[5] Maurizio Forte and Alberto Siliotti. *Virtual Archaeology : Re-Creating Ancient Worlds*. Harry N. Abrams, 1997.

[6] Maic Masuch, Bert Freudenberg, Babette Ludowici, Sebastian Kreiker, and Thomas Strothotte. Virtual Reconstruction of Medieval Architecture. In M. A. Alberti, G. Gallo, and I. Jelinek, editors, *Computer Graphics Forum: Proceedings Eurographics 1999, Short Papers*, pages 87–90, 1999.

[7] Thomas Strothotte, Matthias Puhle, Maic Masuch, Bert Freudenberg, Sebastian Kreiker, and Babette Ludowici. Visualizing Uncertainty in Virtual Reconstructions. In *Proceedings of Electronic Imaging & the Visual Arts, EVA Europe '99*, page 16, Berlin, 1999. VASARI, GFaI.

[8] Emergent Media AG. Homepage. `http://www.emergent-media.de/`.

[9] Spinor GmbH. Shark3D Engine. `http://www.spinor.com/`.

[10] Bert Freudenberg, Maic Masuch, and Thomas Strothotte. Walk-Through Illustrations: Frame-Coherent Pen-and-Ink Style in a Game Engine. In *Computer Graphics Forum: Proceedings Eurographics 2001*, volume 20, pages 184–191, Manchester, UK, 2001.

Acknowledgments

The authors wish to thank the people who worked together with us most closely to make this project happen: Sebastian Kreiker, Matthias Puhle (Exhibition "Otto der Große, Magdeburg und Europa", Kulturhistorisches Museum, Magdeburg); Babette Ludowici (Archaeologist, Geisteswissenschaftliches Zentrum Geschichte und Kultur Ostmitteleuropas e.V., Leipzig); Maike Kozok, Cord Meckseper (Institut für Bau- und Kunstgeschichte, Universität Hannover); Jobst von Heintze, Christoph Bode, Frank Godenschweger (emergent media AG, Magdeburg); Folker Schamel (Main developer of the Shark3D engine, Spinor GmbH, Munich); and last, not least, the many students involved in the project, especially Christian Mantei and Bernd Eckardt for preparing images for this paper.

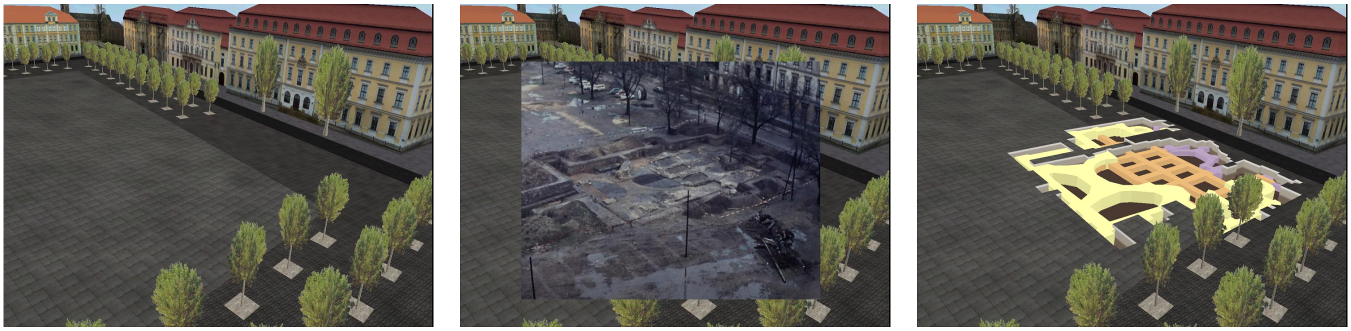

Figure 10: Establishing the virtual excavation model inside today's environment using photographs from the excavation site.

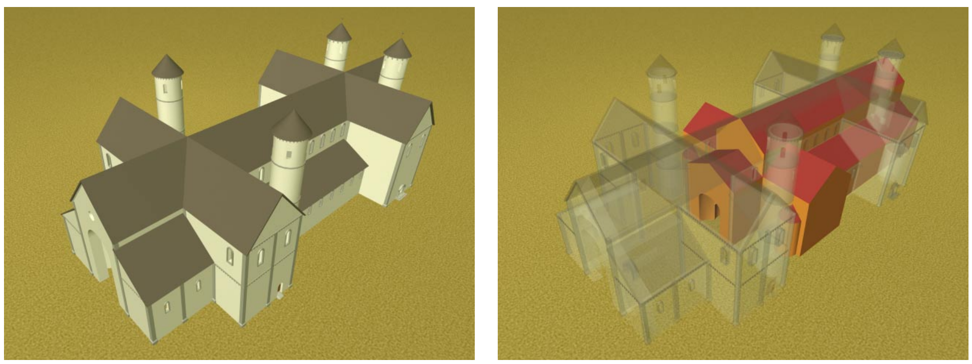

Figure 11: Transparent rendering of two phases of the building, showing spatial relations

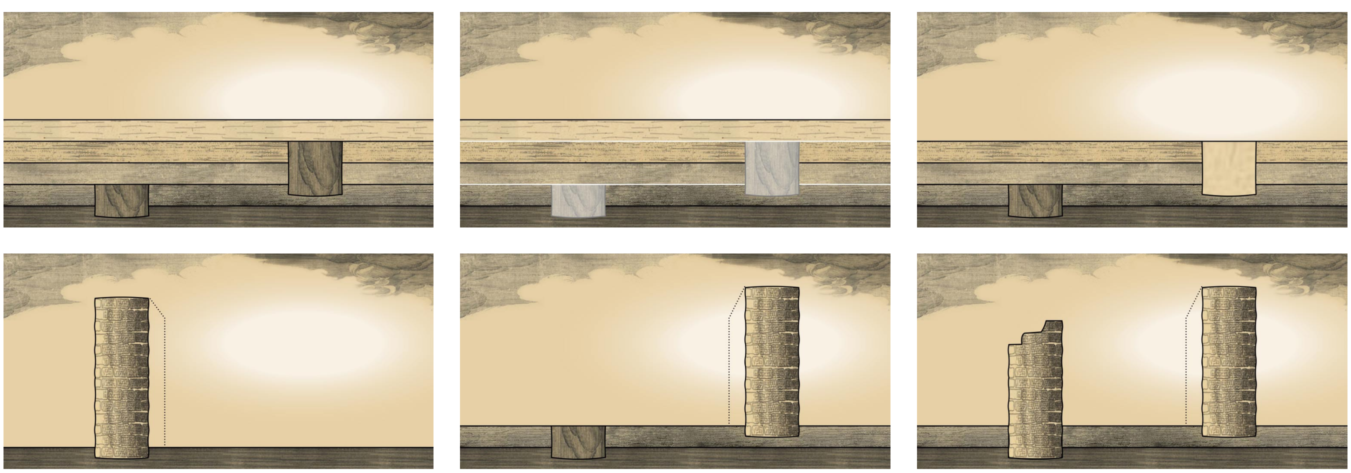

Figure 12: Visual explanation of soil layers leading to conclusions about temporal order of buildings (Macromedia Director)