Virtual Reconstruction of Medieval Architecture

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Abstract

We describe the reconstruction of a medieval building as an example of how the use of 3D computer graphics can facilitate the reconstruction of an ancient site. We suggest that different stages of a virtual reconstruction imply the use of different rendering techniques, as the style of visualization has a significant impact on both the reconstruction process and the presentation to non-expert viewers.

The use of computers as means of re-creating lost cultural heritage, such as ancient buildings, has become a growing field of application for computer graphics, not only for presentational purposes: The computer-based reconstruction of a building enables virtual walkthroughs and allows to validate a research model better than any other media [1]. Researchers, however, face a classical dilemma: On the one hand, they can actually only supply information about details that have been excavated. Consequently, artifacts that do not have an excavation basis cannot be depicted. On the other hand, there is a demand for visualizations that are as realistic as possible. Simply leaving out details, like doors, is as wrong as depicting objects that have not been excavated. So, researchers have to extrapolate missing data in order to convey a comprehensive visualization of the reconstructed site.

The re-creation of a medieval site especially suffers from this lack of data, as we are going to illustrate by the example of the virtual reconstruction of the "Kaiserpfalz", the lost palace of Otto the Great in Magdeburg, Germany. However, we also argue that a computer-based reconstruction process helps to reveal deficiencies that would remain unnoticed if traditional methods were used.

1. The Excavation

Archaeologists do, in general, hardly ever have the luck to discover a medieval site that has remained undisturbed. Often, it is not even sure where a building that is mentioned in the chronicles was located, let alone how it may have looked like.

This also applies to our example. Although the royal court of Otto I in Magdeburg with its various different buildings, including the King's hall, is often mentioned in the chronicles, the precise location of the buildings themselves has not been handed down by written historical sources. These merely suggest that the King's hall must have been located in the vicinity of the Gothic cathedral. During excavation works carried out on a large square by the cathedral from 1958 until 1968, substructures of a large stone building were laid open. The walls that were found covered an area of more than 2,000 square meters (see Figure 1). Although some larger artifacts, like the base of a spiral staircase, were found, the excavation in general revealed only few facts about the building's architecture. Moreover, not all of the foundation remains could be uncovered because a public street crossed the area. Archaeological finds, as fragments of pottery found in the soil layers surrounding the foundation walls, suggest that the building in question was erected in the 10^{th} century and abandoned in the 13^{th} century. This gives strong evidence for identifying the building remnants as the so called "Kaiserpfalz", the King's hall of the residence of emperor Otto I in Magdeburg.

2. The Reconstruction

Since there is neither a picture nor a detailed description of the original palace, and since the excavation did not provide enough facts to establish a scientifically valid model, the re-

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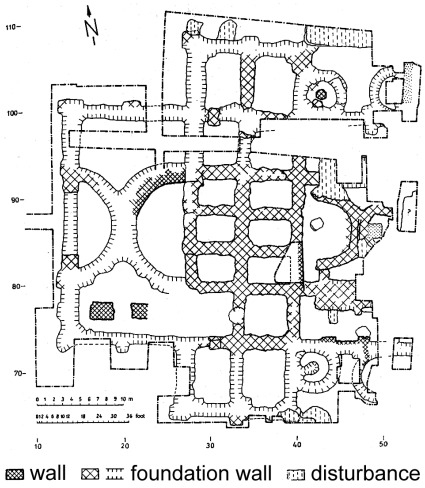

Figure 1: *A map of the excavation site which served as basis for the reconstruction of the building.*

construction must be considered to be speculative by nature. However, the degree of speculation varies. We can categorize the sources of data used to complete the reconstruction:

findings: artifacts that actually have been excavated,
deductions: facts that can be derived directly from the excavation,
analogies: facts that have no excavation equivalent, but can be deduced from similar buildings of the same architectural period,
assumptions: details that are assumed because "something had to be there", but which have no excavation basis.

In the "Kaiserpfalz", examples of these data sources are the parts of the foundation that were *found*. We *deduced* that there must have been walls supported by the foundation. In *analogy* to other period buildings, we inferred that these walls were made of coarsely carved stone. We *assumed* the palace to be a two-story building, because the walls were too narrow to support three levels, and too thick for one level only.

In general, using excavation results and deductions is "safe", whereas the use of analogies and assumptions is dangerous. This is especially true for medieval buildings, as most of them were either destroyed or substantially modified in later centuries. In addition, in the Middle Ages there were no standardized construction regulations in Europe, as opposed to the Roman empire. A master-builder constructed the palace, and he alone was responsible for the success of the building project. For this reason only local influences could have served as architectural patterns. As a consequence, analogies cannot be regarded as reliable information sources. Also, our assumptions have a weak basis because only very occasionally writings or paintings describing medieval life have been preserved.

Iterative Development of the Model

In a conventional reconstruction, as is carried out by archaeologists, the analysis of the excavation results in 2D models (i.e., architectural drawings) that serve as basis for the discussion. Their evaluation leads to further refinement. Eventually, a scale model is manufactured provided that the discussion among the experts resulted in a consensus. A 3D scale model is so expensive that once it has been built, only fundamentally new research findings will result in manufacturing a new model. Thus, the 3D model is usually not involved in the discussion process.

A computer-based reconstruction, however, not only adds a new visual quality to archaeological research. A virtual reconstruction can be regarded as a continuous (evolutionary) process in which the 3D model experiences constant refinement. Furthermore, the experts can choose the most appropriate manifestation of the model for the task at hand: an abstract non-photorealistic image as a basis for discussion or a virtual walkthrough, or another adequate form of presentation.

We experienced that the virtual reconstruction forces the experts to agree upon all visible details, elements that could have passed unnoticed in the traditional 2D model, because open questions are directly exposed to the expert. An example is the question of how the palace was illuminated, which needs not be considered in a hand-drawn reconstruction.

For the "Kaiserpfalz", we used 3D Studio MAX to develop the model of the building and the environment. The basic structure of the reconstruction was modeled by computer science students in an animation course. The refinement and the final texturing were done by three advanced students in close cooperation with archaeologists and historians.

3. The Visualization

The computer-based 3D model of a reconstructed site can be presented in various ways. The most obvious (and most often published) form of doing this is creating a photorealistic rendering. But scientists who present their research results with photorealistically rendered images carry a high responsibility, as people strongly tend to take a depicted reconstruction as established scientific truth. However, there are alternative visualization methods. We found that experts feel more comfortable with non-photorealistic visualizations in a discussion among fellow researchers, whereas visitors of a museum prefer a visualization style which is as realistic as possible.

3.1. Non-Photorealistic Images

With so little knowledge about the overall appearance of the building, archaeologists and historians have difficulties in agreeing on details. We experienced that at an early design stage, images that serve as a basis for discussion should not

be rendered in a photorealistic style [2]. We therefore decided to present experts different models rendered as line drawings which leave room for discussion, in contrast to photorealistic renditions which always suggest a final form, even if there are doubts. This is especially important for the first reconstruction, where details like the texturing of the walls only distract from elementary questions about the overall 3D shape of the building. Figure 2 shows two alternative models that represent possible variants of the palace.

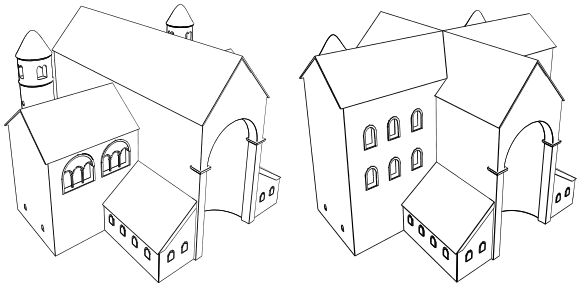

Figure 2: *Different variants of the building as presented to and discussed by experts.*

3.2. Photorealistic Images

Photorealistic images like that depicted in Figure 3 allow a very intuitive understanding of what an ancient site looked like. Still images and animations resemble our every-day experience with photographs and television, while interactive virtual walkthroughs additionally provide the immediate experience of "being there" [3]. Undisputedly, a photorealistic rendition has a convincing visual power, but a great effort has to be made for the construction of such a model to make it look "right", which often means making it look as realistic as a photograph. Every little detail has to be modeled, every surface has to be covered by an appropriate texture.

Figure 3: *A photorealistic rendition of the building.*

The acquisition of adequate textures poses a serious problem to such a visualization. Original structures from the 10th century are hard to find, as they have been either modified by humans in the last centuries or deteriorated due to environmental influences. Since we want to depict materials in their original state we have to estimate their former appearance. Therefore, we interpolated the stone textures by mixing the structure of ancient stonework with the appearance of present-day stone surfaces.

4. Concluding Remarks

The iterative development of the 3D model is a factor that cannot be overestimated as a means for empowering archaeologists to research and present their model of a reconstruction. In the reconstruction process, knowledge about the investigated building is gained. Currently we are working on an interactive system, AncientVis, to model the source of data (excavation, deduction, analogy, assumption) and for visualizing geometric models taking certainty into account [4]. Eventually, the virtual reconstruction of the "Kaiserpfalz" will be presented as an interactive walkthrough in an exhibition.

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