VISUALIZING UNCERTAINTY IN VIRTUAL RECONSTRUCTIONS

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The virtual reconstruction of lost buildings as means of recreating lost cultural heritage has become a strongly growing field of application for computer graphics [1]. Research results of historians and archeologists are used by computer scientists to create computer models as base for visualizations. Typically, off-the-shelf software is employed that allows generating images with the quality of photographs (see, for example, Figure 1).

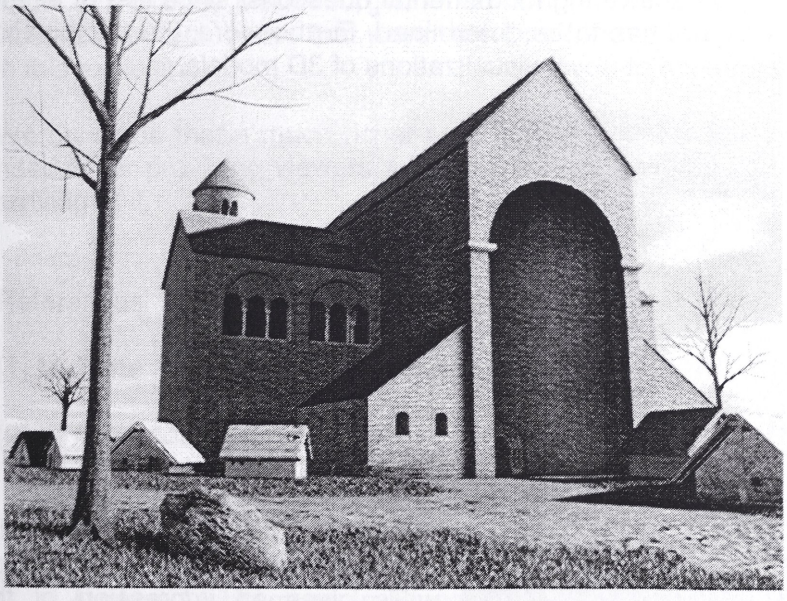

Figure 1: A photorealistic image of the virtual reconstruction of the area around the Kaiserpfalz of Magdeburg, rendered with a standard 3D rendering tool (original image in color).

Although this method can be used to illustrate to an audience how certain buildings may have looked like, this practice is subject to a number of fundamental problems. For non-experts, it is striking how carefully specialists are in choosing the words to describe their excavation findings or interpretations. Often verbalizations like "These findings suggest that this could have been a [...]"

are used. But these cautious statements—conveying uncertainties or even speculations—are represented as proven facts in computer models that are used to create visual materials. The wary character of the verbal messages is lost. A photorealistic image always bears the danger of being taken for reality and making a viewer believe too strongly in that specific visualization. The images settle in the viewer's mind, pretending a certainty that does not exist to this extent.

A new field in computer graphics, the so-called "non-photorealistic rendering," offers promising alternatives that aim at avoiding those unintentional visual fixations [2]. Non-photorealistic visualizations (like the one shown in Figure 2) provide scientists with methods to handle uncertain knowledge in computer models. Here, attributes describing reasons or alternatives can be stored along with the usual geometric data. From this data, visualizations can be generated that are honest with respect to the degree of certainty, the reasons, and the alternatives.

Figure 2: A sketch-like rendition of the reconstructed building. Here, the same 3D model as in the previous image is used, but the "sketchy" character of the line drawing proposes a preliminary design state. This type of image does not pretend that the expert knows exactly how the building has looked like in the 10th century.

Especially in the discussion process between experts it becomes obvious that a photorealistic graphic with too much detail distracts from answering fundamental questions, since first of all in a reconstruction the building's overall structure has to be determined. Furthermore, the combination of different techniques enables the generation of novel visualizations of 3D models.

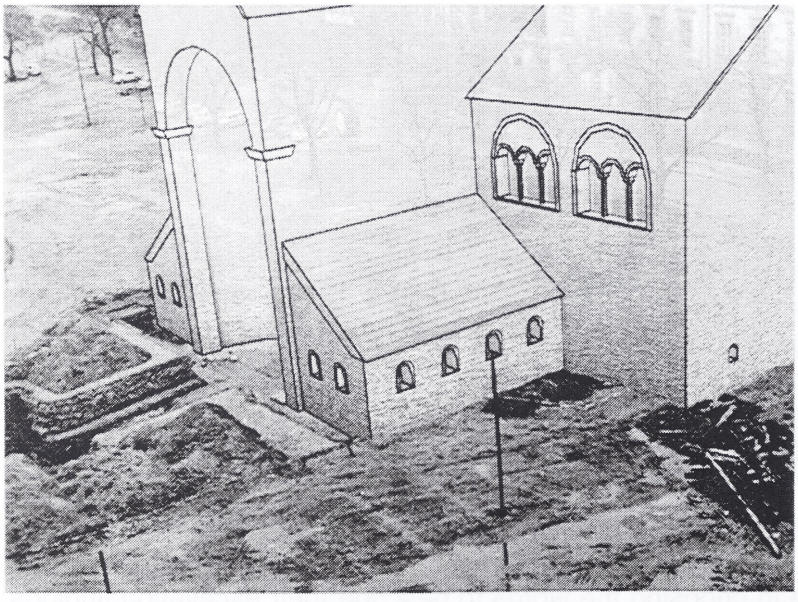

Figure 3: The visualization of the reconstruction over its foundation walls gives an impression of the former position and appearance of the building.

In Figure 3, several techniques were applied to illustrate the fact that the uncertainty of a reconstruction increases with growing distance from the ground: the further away we get from the excavation basis, the more insecure is the reconstruction. In order to visualize this increasing uncertainty, a fading photorealistic image (depicting the assumed appearance of the building) and a line drawing (maintaining the overall shape) were combined in this picture to visualize the building in question above its excavated foundation walls. Based on a photography of the excavation site, the camera positions of the rendered images were adjusted to match the original position of the photographer. Eventually, these three were combined to visualize the reconstruction in its original location. With the aid of AncientVis (see Figure 4), a system which is proposed in [3], we can render images with less detail, using techniques for emphasizing and deemphasizing, and we can reuse and develop the 3D model, thus undergoing a constant refinement.

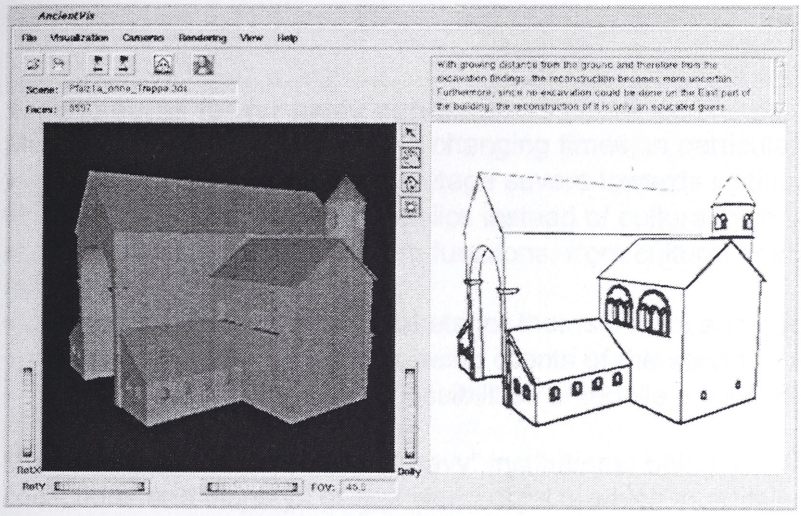

Figure: 4: A screenshot of the prototypical system AncientVis, which allows to generate sketch-like renditions of arbitrary 3D models. It is possible to specify certain illustrative features such as fading line styles that indicate uncertainty.

These techniques emerged from the work on the virtual reconstruction of the "Kaiserpfalz zu Magdeburg", a collaboration between the *Institut für Simulation und Graphik* and the *Kulturhistorisches Museum Magdeburg*. The reconstruction will be presented as part of the exhibition "Otto der Große, Magdeburg und Europa" in the year 2001 in the museum. Several different visualization techniques that were developed throughout the reconstruction process will be applied in this exhibition.

We conclude that a much richer selection of visualization and interaction techniques is ultimately needed for providing viewers a "fair" picture of a virtual reconstruction and the difficult process of arriving at it.

References

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