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IMG23

IMAGIN(G) HERITAGE

Atti del Convegno | Proceedings

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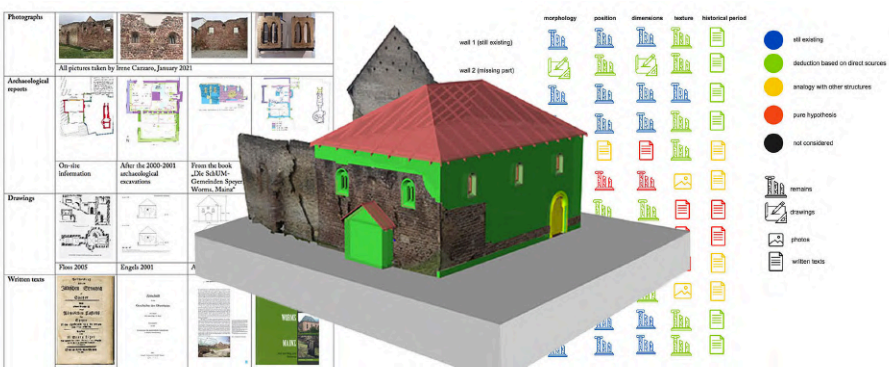
GRAPHICAL STUDIES
STUDI GRAFICI


Photographs
All pictures taken by Irene Cazzaro, January 2021
Archaeological reports
On-site information
After the 2000-2001 archaeological excavations
From the book „Die SchUM-Gemeinden Speyer Worms, Mainz"
Drawings
Floss 2005
Engels 2001
Written texts
morphology
position
dimensions
texture
historical period
wall 1 (still existing)
wall 2 (missing part)
still existing
deduction based on direct sources
analogy with other structures
pure hypothesis
not considered
remains
drawings
photos
written texts

IRENE CAZZARO

Hypothetical Cultural Heritage and its users:
challenges in the interpretation and communication through verbal and visual methods

Abstract

The documentation and visualisation of digital 3D models related to hypothetical artefacts can be useful to analyse our past and make new discoveries, but can also be informative in educational contexts and when dealing, more in general, with non-specialised users. The publication of these models in web-based and open platforms, which would be a good practice, especially raises some questions related to the audience we refer to. This paper analyses the issue of communication of digital reconstructions and tries to give some answers to it by presenting a methodology through a case study and by indicating future developments.

Keywords

Cultural heritage, Uncertainty, Perception, Communication, Documentation.

INTRODUCTION

Digital 3D models of hypothetical artefacts (i.e. objects or buildings that have been destroyed or have never been built) have been increasingly employed since the 1990s in a variety of fields ranging from history to archaeology and architecture (Barceló, 2001; Favro, 2006; Reilly, 1991). Their interdisciplinary nature also emerges in their creation process that combines historical and archaeological research with digital technologies such as 3D modelling software, virtual reality, and augmented reality. The significance of these hypothetical 3D models lies in their potential to provide researchers, scholars, students and the public with a more profound understanding of historical objects and buildings: for these reasons they should be shared online (Champion & Rahaman, 2020) as far as possible, avoiding the creation of digital cemeteries. The differentiation of the audience we refer to is indeed central in this context, since it generates differences in the way these models are constructed and presented. At a general level, we know that they may offer an immersive experience that goes beyond the limitations of traditional research methods. For this reason, they are sometimes thought to be more "realistic" than simply examining images or reading descriptions in a textbook, even though, especially from an academic perspective, it has often been observed that photorealism doesn't necessarily correspond to historical or archaeological certainty (Apollonio, 2016; Lengyel & Toulouse, 2015): especially in the case of hypothetical models, when we describe something that we cannot see in the real world and we can only imagine starting from archival sources, some uncertainty degree is always retained and, rather than of "reconstruction", we should speak of "construction" (Clark, 2010).
Having said this, well-documented digital 3D models of destroyed or never-built artefacts may be valuable educational tools in classrooms, museums and other educational settings (Di Blas & Poggi, 2006) as they help students and visitors comprehend the past more accurately. Interactive exhibits can be created through these models, providing individuals with an opportunity to engage in a multisensory exploration of historical objects and buildings.
Digital 3D models can also be employed in the preservation of cultural heritage, to document and conserve information that may have been lost (Pietroni & Ferdani, 2021). The data obtained from these models can inform restoration and conservation efforts, helping to ensure that cultural heritage sites are preserved for future generations.
In academic environments as well, the information carried by these models, that is, the data model conveyed together with the visual model (Kuroczyński, 2017), is extremely important in studies related to the past and may have a heuristic value, giving rise to new discoveries.
It is therefore clear that, according to our aim and to the audience we refer to, the models we produce should have particular (desirable) characteristics.
In the light of these considerations, the paper aims to analyse and apply a range of methods to describe and visualise hypothetical cultural heritage, recreated through 3D models and shared in a network involving not only scholars, but also the general public, aiming to understand what is expected and how this should be communicated following, as far as possible, a principle of scientific accuracy.

DIFFERENT PERCEPTION OF CULTURAL HERITAGE

First of all, it is important to understand how cultural heritage is perceived, since it is connected to topics such as identity formation, impact of globalisation, relationships with tourism and use for political and economic purposes (Caciora et al., 2021; Poux et al., 2020; Toukola & Ahola, 2022; Trizio, Demetrescu & Ferdani, 2021). In order

to ensure the preservation and protection of cultural heritage, it is essential to engage with and involve local communities and stakeholders in the decision-making process.
Cultural heritage refers indeed to the tangible and intangible aspects of a society's past that are considered to have cultural, historical, and/or archaeological significance, but this can be communicated in different ways: some stakeholders may prioritise the economic benefits of cultural heritage, while others may prioritise its educational and cultural value or its potential to foster a sense of community and national identity. The perception of cultural heritage is also influenced by a person's level of education, exposing individuals to a wider or narrower range of cultural experiences and perspectives. This is also reflected in the way in which different people use hypothetical digital reconstructions: as an example, we can simply consider the difference between students, researchers and general public (by generalising the three categories, which nonetheless admit exceptions and a certain variety of approaches).
Students primarily use hypothetical 3D models as educational tools. These models allow indeed the visualisation of historical objects and buildings, providing them with a more engaging and immersive learning experience (Di Blas & Poggi, 2006; Grissom, McNally & Naps, 2003; Naps et al., 2002; Ott & Pozzi, 2011). They can interact with the models and explore them from different perspectives, gaining a better understanding of the object or building's form, function, and historical context. Additionally, they can use these models as research tools in a digital environment.
Researchers use hypothetical 3D models to study historical artefacts and structures with detailed and accurate representation of the objects or buildings, allowing the analysis of their features, construction, and historical significance. The models can be used to generate new hypotheses and test the existing ones, providing researchers with a deeper understanding of the past. Furthermore, hypothetical 3D models can be used to document and preserve information (Kuroczyński, 2017) about artefacts and structures that may be lost to time.
As far as the general public is concerned, hypothetical 3D models are used to gain a better understanding of historical objects and buildings especially in museums, exhibitions, and other public spaces (Gambin et al., 2021; Stanczak, 2007) where interactive displays may be created. Visitors can explore the models with immersive technologies (Kargas, Loumos & Varoutas, 2019) and learn about the object or building's historical significance. In addition, the models can be used to create virtual tours of historical sites, also providing access to people who are unable to visit the physical location (Poux et al., 2020).
Therefore, when we present digital models, we should know our audience and/or retain the possibility of adjusting the way of communicating our reconstructions according to different goals.

VISUALISATION AND DOCUMENTATION ACCORDING TO DIFFERENT AUDIENCES

Depending on the various levels of perception of cultural heritage, therefore on the public and the aim of our work, we should adopt different verbal and visual tools to interpret and communicate our reconstructions (Günay, 2022).
For the general public, it appears that neither the geometry nor the accuracy in shape and material is the most important. On the contrary, it is the overall visual effect that appeals (or not) the audience (Kepczynska-Walczak & Walczak, 2015). Photorealistic presentations are preferred to technical drawings and in-depth analyses: in a contemporary culture based more on the senses than on the intellect, atmosphere, as a quasi-object (Böhme, 2013), should consequently be indicated in a balance between objectivity of forms and subjectivity of

experiences, also considering that certain spaces are meant to evoke the same feelings. Anyway, photorealism imposes a solution, without giving a chance to own reflection, while more "abstract" representations should encourage people to think. The most accurate image may not recall the unique atmosphere of the place; moreover, in the case of no longer existing structures, even the most photorealistic representation is an illustration of some assumptions and author's imagination rather than of a real building. In this case, less quality and precision, as well as less literal representations are usually required: this should be hopefully considered – to some extent – also when dealing with the general public, in order not to deceive the users. However, there is no better or worse method: it should be evaluated case by case.
Let's see, for instance, which features may be included in the presentation of a hypothetical digital model, in a differentiation of approaches, starting from the more "experiential" ones, related to the generation of an atmosphere, up to the more "abstract" ones, related to research, traceability and scientific accuracy (Apollonio, Fallavollita & Foschi, 2021; Kensek, 2007).

1. Virtual/Augmented/Mixed Reality: they allow users to interact with digital models in a fully immersive way, providing a sense of presence (Champion, 2011; Pujol & Champion, 2012) and engagement. They can be particularly effective for presenting hypothetical models of historical buildings or environments, as they allow users to explore these spaces (and provide additional information) in a way that would not be possible with other tools, but they remain a particular interpretation of a past that is not known and this should be indicated;
2. Animation and interactive features: animated sequences and multiple points of view can be used to explore, manipulate and showcase different features of the digital model, such as how it may have been constructed or how it may have looked during different time periods, to better understand the object and its historical context;
3. Visualisation techniques: these include using lighting, textures, and materials to create a "realistic", or at least as "accurate" as possible, representation of the object or building, but they are not limited to this aspect: non-photorealistic renderings can be used to present a more abstract model, where the use of false colours or different visualisation styles can correspond to the variation of a parameter, such as the historical period or the level of uncertainty of different parts of the reconstruction;
4. Documentation: this concerns providing detailed descriptions of the object or building being modelled, as well as the sources used to create the model. Documentation should also include any assumptions or interpretations made during the modelling process;
5. Comparison with the available sources: when presenting a hypothetical digital model, it is important to compare it with historical documents or archaeological findings. This can help researchers evaluate the accuracy and validity of the digital model.

These features can be communicated through the use of immersive technology, mobile apps, web-based platforms or 3D printing; they can be applied individually or in combination to provide an engaging and informative experience for the general public, but also useful material for researchers.
In both cases, however, the process should be based on a scientific approach, in which the limits of interpretation, when dealing with hypothetical reconstructions, should be declared.
In the next paragraph, we can see how some of these techniques, sometimes more adapt to researchers and sometimes to a wider public, have been applied to a specific case study, dealing in particular with points 3, 4, 5 listed above (visualisation techniques, documentation and comparison with the sources).

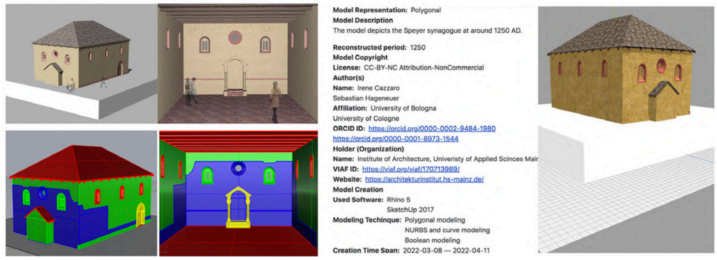


Fig. 1 - Digital 3D reconstruction of the Speyer synagogue in its second Romanesque phase. On the left: internal and external views of the model as a rendering showing how it may have been in the past and as a false-colour visualisation showing the level of uncertainty of each element. On the right: the model with its metadata uploaded to the DFG Repository: https://3d-repository.hs-mainz.de/ (accessed 12.03.2023). Author's visualisations and elaboration..

CASE STUDY: ANALYSIS AND RESULTS

The digital reconstructions of some examples of partially destroyed buildings, such as the case here presented related to the medieval synagogue of Speyer (fig. 1), were used to apply and prove the effectiveness of a multi-step process that involved a combination of archaeological analysis, historical research, digital modelling aiming at scientific accuracy and publication on a web-based repository with an integrated 3D viewer. We can see a combination of approaches addressed to different potential users, from researchers to the general public. Here are some of the key steps, which have been collected in a handout shared within the participants in the reconstruction process:

1. Research and documentation: the first step in the reconstruction process involved researching and documenting the historical and archaeological evidence (Heberer, 2012) related to the synagogue. This included examining historical records, archaeological surveys, and physical remains of the building (fig. 2);
2. Semantic segmentation and digital modelling: once the historical and archaeological evidence had been collected and analysed, the next step was to create a digital model of the synagogue based on the definition of its elements and the relationships between them, according to the available sources. Every phase of the reconstruction process has been documented so that every choice that has been made remains traceable;
3. Analysis and refinement: the initial digital model was then analysed and refined based on additional research and input from experts in the various fields involved. This step, an ongoing process that may continue in the future, consists in making adjustments to the model based on new information or insights, and ensuring that the model is as accurate and updated as possible;
4. Visualisation and interpretation: the obtained model was used to create multiple visualisations based on different parameters. Images were created to show what the synagogue might have looked like in its "original" state, as well as to develop interpretive materials that helped explain the reconstruction process and its relationships with the sources, documenting, first of all, the level of uncertainty of the reconstructed elements;
5. Dissemination and engagement: the final step in the process involved disseminating the reconstructed model by creating online resources and engaging with a variety of users. This was allowed by means of the publication of the model on an online repository (the DFG repository being developed by Hochschule Mainz [1]), with both an integrated 3D viewer and some features to store metadata and paradata about the reconstruction, which helped share the model with a wider and differentiated audience (Bajena et al., 2022).

The classification and visualisation of uncertainty is a particularly challenging step that has required further studies and a series of visual variants. The uncertainty scale itself can be more or less complex (Apollonio, Fallavollita & Foschi, 2021): it can simply indicate a

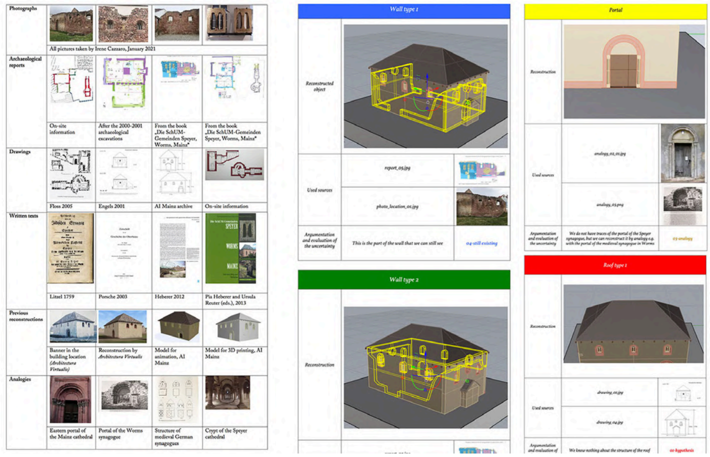


Fig. 2 - On the left: collection of the sources and classification of them according to their type (photographs, drawings, written texts, etc.); on the right: documentation tables where the reconstruction process for each element is explained. The used sources are included, as well as the argumentation related to the uncertainty assessment. Author's visualisation.

general evaluation based on a single parameter (a linear variation from less to more uncertain), but also on the combination of more parameters (a matrix indicating the features to which uncertainty is referred: the shape, the position, the material, the period of creation of an element). Moreover, even if we solve the classification problem, we have to choose a method to visualise information (Bertin, 1967; Tufte, 1990). Multiple versions of the same hypothetical model can be created and presented side by side, so that the viewers can see the range of possibilities; annotation can highlight areas of uncertainty with notes on assumptions or alternative interpretations; interactive features such as sliders and buttons allow users to adjust different parameters as well (Kensek, 2007; Wacker & Bruschke, 2019). These techniques can help viewers understand the uncertainties involved in hypothetical models and the limitations of these models in representing the past.
Particularly when dealing with a non-specialised audience, simpler and more intuitive representations are required. These might include using colour-coded maps, simplified graphics, or interactive features that allow viewers to explore the uncertainties involved in a model. Additionally, it may be important to provide clear explanations or annotations to help the general public understand the evaluation process. Researchers and educators should therefore consider the needs and expectations of their audience when selecting the visualisation techniques, and may need to adapt their approach depending on the level of technical expertise of their viewers.
In the case of our reconstruction (fig. 3), we have adopted a simplified scale based on four colours (the simplest ones: red, yellow, green, blue) to indicate the variation of a single parameter related to the average uncertainty for each element. The argumentation process is described in documentation tables, together with the reconstruction process. In this way, through a combination of visual and verbal techniques, the elements have been documented in a simple, but also effective way, understandable by a wide audience, but at the same time useful also for a more specialised one. Variations have been considered in order to address the visualisation problems (the scale can be adjusted to respond to the needs of people with vision deficiencies, such as colour-blindness, by changing the colours or transforming the colour scale into a texture scale, always supported by verbal documentation) and the complexity issue (the scale can be transformed into a matrix in which the parameters concurring to uncertainty assessment are related: this may be useful for a more expert audience).

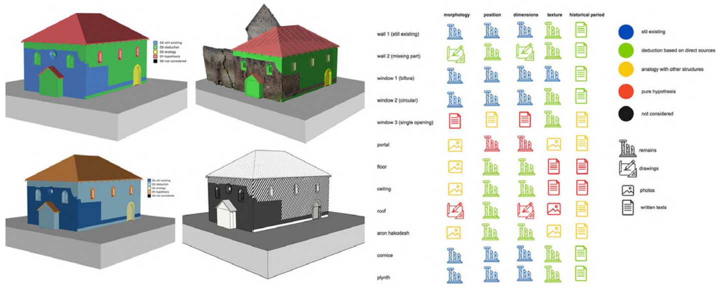


Fig. 3 - On the left: different visualisation styles to graphically represent uncertainty for each element in which the model is segmented. The four visualisations apply a simple scale distinguishing elements that are still existing (and that can also be represented with their actual mesh), that are obtained by deduction (because they are thought to be similar to the still existing part), by analogy (based on similar buildings of the same historical period) or by pure hypothesis, not confirmed by sources. The ground on which the model is situated is not considered in the uncertainty assessment. The two variants presented above are based on a well-recognisable colour scale, even though this can be tricky for people with problems in the perception of colours. For this reason, the variants presented below consider a colourblind-safe scale and a scale based on textures rather than colours. On the right: a more complex uncertainty matrix, where, for each element, uncertainty is assessed according to five parameters: morphology, position, dimensions, texture and historical period. The colour indicates the uncertainty level, the icon represents the main source type used for each assessment. Author's visualisation.

CONCLUSIONS

Cultural Heritage presupposes a participatory activity, in which interpretation and presentation play a vital role according to the audience we refer to. This becomes especially important when we deal with (re-) construction and visualisation of hypothetical heritage, which should hopefully be shared through online platforms in order not to lose information that may be useful for researchers to test new assumptions about the past, but also for students and for the general public, who can benefit from their educational and informative potential.
Moreover, the collected data may constitute a sort of visual (and verbal) heritage: a huge database may be created. This can be used to imagine other possibilities and variants or to create an "image heritage" that shapes our way of describing the past, always allowing its reconfiguration according to new discoveries.
We have seen how the visual and data model can be shared on the web, becoming potentially accessible by every interested user; still, there are some technical problems that should be solved in order to communicate uncertainty in an easier way. By now, the documentation tables can be downloaded together with an IFC or CityGML file where uncertainty is mapped; in the future, it is probable that uncertainty will be directly visualised through online 3D viewers and added to the data model in the form of a CIDOC CRM entry (Niccolucci & Hermon, 2017), allowing, on the one hand, a more direct and accessible visualisation of it and, on the other hand, its communication according to the most widespread standards, making the data both human- and machine-readable.

NOTES

[1] The DFG repository is available at this link: https://3d-repository.hs-mainz.de/ (accessed 12.03.2023).

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Immagine di copertina/Cover figure - The process of documentation and visualisation of uncertainty for source-based digital 3D reconstructions.