Working Experiences with the Reconstruction Argumentation Method (RAM) – Scientific Documentation for Virtual Reconstruction

MARC GRELLERT, TU Darmstadt, Germany
FABRIZIO IVAN APOLLONIO, University of Bologna, Italy
BOB MARTENS, TU Wien, Austria
NORBERT NUßBAUM, University of Cologne, Germany

Interest in the field of digital heritage has grown considerably over the last couple of decades, giving rise to a wide range of representations that aim to visualize the past. Although the visual results of these efforts are relatively accessible, the knowledge underpinning the majority of these reconstructions is not properly documented and will most likely get lost. It is hard to proceed at a later stage with a further iteration of a reconstruction, as the earlier argumentation and the reasons for the decisions that were taken to arrive at the acquired interpretation are no longer available. In order to bridge this gap and to preserve the accumulated meta-knowledge, a web-based tool – called "*sciedoc*" – was developed in 2017. This paper presents experiences with this documentation environment and outlines considerations towards further developments.

The experience of working with the tool led to the insight that it is not only useful for documentation but also as a communication tool between the academic and technical sides of the team carrying out the reconstruction. Moreover, further, different structures of documentation ("grammar") came to the fore which might be helpful in the future. Lastly, this paper also considers the use of colored models to present an overview of plausibility and used sources in reconstruction.

Key words:
Virtual Reconstructions, Scientific Documentation, Standards, Online Tool, Graphic Evaluation

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INTRODUCTION

This paper seeks to foster systematic documentation practices and, with it, the development of (visual) argumentation standards that will benefit the field of digital heritage. There is a definite need for preserving access to the comprehensive body of information and arguments underpinning any given virtual reconstruction to keep the decision-making process transparent, traceable and comprehensible. In other words, the intermediate steps of interpretation – based on a specific set of material collected in archives and in the field – are accessible and displayed and may thus give rise to alternative variants and interpretations. As the overall process of reconstruction tends to be very time-consuming, it is proposed to establish a "minimum" standard of documentation.

The ongoing development and implementation of a web-based platform – called *sciedoc*[1] – serves as the starting point for the discussion of how it might be possible to incorporate the traces of the underlying argumentation in

Authors' addresses: Marc Grellert, Fachgebiet Digitales Gestalten, TU Darmstadt, El-Lissitzky-Straße 1, D-64206 Darmstadt, Germany; email: grellert@dg.tu-darmstadt.de; Fabrizio Ivan Apollonio, Dept. of Architecture, University of Bologna, Viale Risorgimento, 2, I-40166 Bologna, Italy; email: fabrizio.apollonio@unibo.it; Bob Martens, Faculty of Architecture and Regional Planning, TU Wien, Karlsplatz 13, A-1040 Wien, Austria; email: b.martens@tuwien.ac.at; Norbert Nußbaum, Kunsthistorisches Institut, Universität zu Köln; Albertus-Magnus-Platz, D-50923 Cologne, Germany; email: norbert.nussbaum@uni-koeln.de

[1] www.sciedoc.org

order to make the preservation and transfer of knowledge through visual means in the field of virtual reconstruction more effective.

This paper presents a further development of the *sciedoc* interface along with experiences of already documented reconstruction projects in this platform. Furthermore, it sums up the outcome of discussions between the involved partners concerning some principal questions related to imaging the past:

- Which intellectual, technical and aesthetic approach should be adopted to ensure the transparency of hypothetical reconstructions processes?
- What should a reasonable categorization of plausibility concerning reconstructions consist of?
- What would be the best way of using the interface as a communication tool during the reconstruction process?
- What would be the appropriate way of presenting the level of plausibility in hypothetical reconstructions, while at the same time presenting the underlying sources? Are graphic overviews helpful and how should they be organized?
- What would be the best way to ensure transparency relating to evidence data, archival documents and conjectural interpretations?

Overall, the experiences with the interrelationship of documentation within the framework of reconstruction are depicted. The context of research-driven teaching and activities is partly narrowed by specific building typologies, destroyed synagogues (sacred buildings).

COMPREHENSIBLE DOCUMENTATION

The application of computer-based visualization in the field of virtual reconstruction is inherently characterized by “highs and lows”. It demonstrates not only the extraordinary potential of digital technologies but also its weaknesses and inconsistencies. This problem was first tackled in 2006, when the “The London Charter for the computer-based visualization of Cultural Heritage” [London Charter 2006] was drawn up, and again in 2011 with the “International Principles of Virtual Archaeology. The Seville Principles” [2011]. Geared towards the needs of research and communication of cultural heritage, the two charters defined guidelines for the use of computer-based visualization in relation to intellectual integrity, reliability, documentation, sustainability and access of heritage artefacts.

Despite some proposals in recent years [Demetrescu et al. 2016; Gonzalez-Perez et al. 2012; Kuroczyński et al. 2016], the scientific community has not yet succeeded in developing and establishing operational standards that would allow, for example, for the expression of the degree of hypothesis in the visualization of the data model, or what the data model behind the 3D visualization looks like, or how the process adopted could be mapped or referenced in the 3D model.

Based on the absence of standards for the scholarly documentation of virtual reconstructions and the lack of such underlying documentations themselves, the goal defined in 2016 was to develop a user-friendly and easily understandable online tool that can be used without any prior knowledge or specific software know-how [Grellert et al. 2018; Pfarr-Harfst and Grellert 2016]. The tool should not only serve most architectural reconstruction projects, it should also be affordable. A further goal was to keep obstacles small. In other words, the interface should not require highly specialized IT or visualization skills. Moreover, the transformation of an existing model into another software environment was ruled out.

Basically, the structure of *sciedoc* consists of a documentation of the sources relevant to the reconstruction along with a (short) written statement (=argument) underpinning the graphic representation of the reconstruction.

In the course of recording the reconstruction process, the outcome (model) is divided into several different *areas*. For each of these *areas* one or more alternative solutions (*variants*) can be documented in order to explain how the model has been set up. This acknowledges a new conceptualization of reconstruction methods that accepts that a single solution cannot be the goal and that allows for lacunae and for thinking in variants.

Each *variant* of the reconstructive hypotheses is represented by a set of images showing the reconstruction and by the related documentary sources. Images and source information are accompanied by the verbal argumentation. This documentation method is called “Reconstruction Argumentation Method” (RAM) and can be displayed on just a single web page.

Depending on the availability, completeness and quality of the archival material, the grade of plausibility of the reconstruction may differ dramatically. To account for the difference in quality of the source material, a rating system was developed with the following scaling:

1) Substantiated
2) Very probable
3) Probable
4) Possible
5) Not probable

COMMUNICATION TOOL

Based on the experience gained from several completed and ongoing projects (for example, the reconstructions of the Gothic cathedral of Paderborn, the Klenow Palace and the Praetorium and Jewish quarter in Cologne), the *sciedoc* platform is very useful as a communication tool. A common experience in other projects was that, for example, during a telephone conversation it was not immediately clear which image was under discussion. In the *sciedoc* tool, each image, each source, each text etc. has its own unique reference (Fig. 1). Using the tool right from the start as a communication tool ultimately made the documentation much quicker and the process of reconstruction more transparent. Another advantage is that all the copyright information for the used sources can be requested in advance. Open Access is a serious challenge for any documentation and can be time-consuming. The advantages of using *sciedoc* as a communication tool were immediately convincing in the day-to-day exchanges between the academics and the people carrying out the reconstruction.

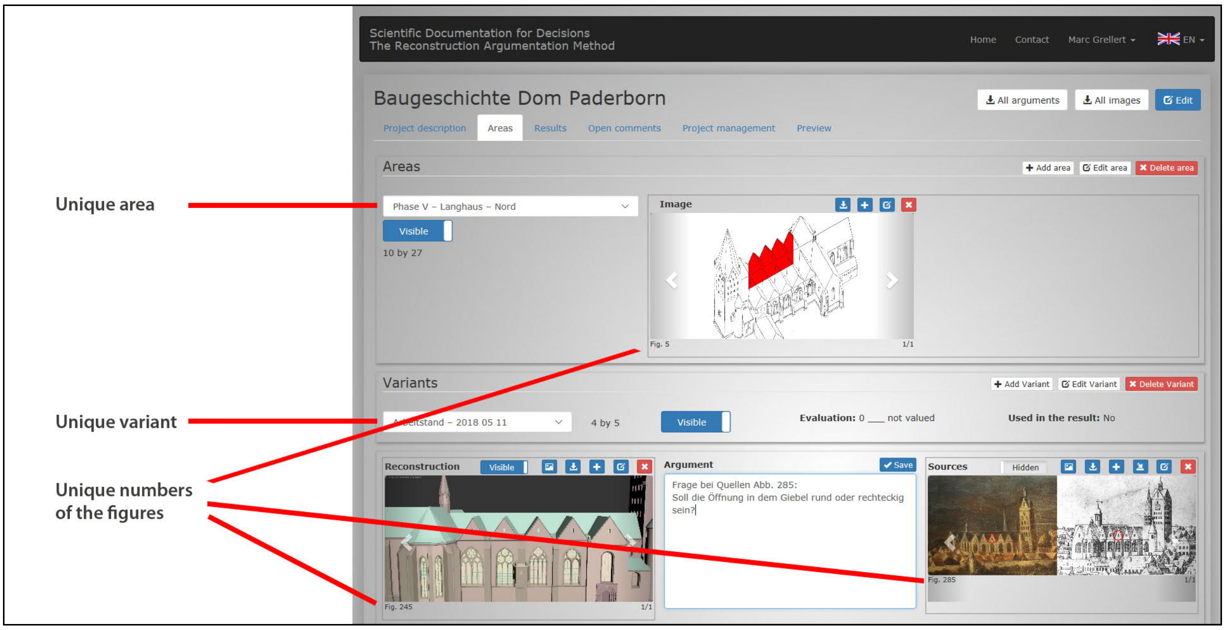

Fig. 1. Screenshot of the sciedoc interface, project Cathedral of Paderborn (© Marc Grellert)

In the reconstruction of the Praetorium in Cologne, a key objective was to bring together a group of about 20 academics to reflect on the ongoing process. As it turned out, even the easily understandable structure of the *sciedoc* tool was too challenging for people looking up the work status just once in a month. An email to this group with images of the reconstruction and the answers to their questions worked better. These answers were then integrated into the platform to make that input traceable online.

STRUCTURE OF DOCUMENTATION

At the time of going to press, 20 projects are online. Four projects are completed and awaiting copyright clearance for the sources. Further 28 projects (17 synagogue reconstructions and 11 other buildings) are currently using *sciedoc*. In terms of date, these projects range from ancient history (11th-century BC Tell Halaf), Roman antiquity (the Praetorium in Cologne) to the middle ages (the monastery at Altenberg) and modern times (St. Johannis, Mainz). It was also extremely helpful to be able to define the structure for the *areas* – the “grammar” in advance. Summing up the experience gained from the various projects, it seems to make sense to allow for a wider range of structural approaches:

- Structured by architectural building types, e.g. churches, palaces, synagogues, basilicas, halls
- Structured by spaces
- Structured by architectural elements
- Structured by specific research questions
- Structured by specific research methods
- Structured by a limited number of sources
- Structured by the new insights

The question is: Once a meaningful structure of documentation for a certain type of building is developed, could this serve as a guide for the structure of the 3D models at the same time? After carrying out quite a number of projects, the authors believe that there will be different useful structures of “grammar” which could act as a pattern for new projects and reconstructions. For the typology of synagogues as a building type – a shared field of research – the universities of Darmstadt and Vienna have developed such a “grammar”.

DESTROYED SYNAGOGUES – EXAMPLES OF DOCUMENTED BUILDINGS

TU Wien has been conducting virtual reconstruction work since 1998 with a particular focus on the virtual reconstruction of destroyed synagogues in Austria and the former crown lands of the Danube monarchy. The principal platform of these efforts is the academic framework of the final thesis (2018: 60+ completed theses). The output does not only consist of written documentations (incl. context, background, etc.), it also encompasses detailed 3D models and visualizations [Martens and Peter 2014]. To facilitate the MA students’ reconstructions, the graduands are linked up with art historians and building history experts who have a vested interest in raising the validity and plausibility of the considerations. The results of the research work are published to reach the widest possible audience.

These buildings, constructed for the most part in the late 19th and early 20th century, follow an overall architectural pattern. As a matter of fact, it is possible to distinguish several useful structures of a kind of “grammar” that can – as suggested above – serve as a typology for future projects and reconstructions. For this reason, the following structure (Table 1) was set up to establish a catalogue of meaningful *areas* (in line with the “grammar”):

Table 1. Principal structure of the areas related to synagogues (19th and 20th century)

Exterior 01 - West façade	Interior 08 - Details – floor
Exterior 02 - North façade	Interior 09 - Details – ceiling
Exterior 03 - East façade	Interior 10 - Details – chandelier
Exterior 04 - South façade	Interior 11 - Details – organ
Exterior 05 - Roof	Interior 12 - Details – pulpit
Exterior 06 - Land borders	Interior 13 - Details – furniture
	Interior 14 - Doors
Interior 01 - East face with ark	Interior 30 - Pillars ground floor
Interior 02 - South face	Interior 31 - Women’s gallery – Pillars upstairs
Interior 03 - West face	Interior 32 - Women’s gallery – balustrade
Interior 04 - North face	Interior 50 - Anteroom
Interior 05 - Details – aron kodesh	Interior 60 - Staircase
Interior 06 - Details –bimah	
Interior 07 - Details – benches	Urban context

This allows to document significant *areas* (Fig. 2) independent of the amount of archival material considered. As the period in question (late 19th century) is roughly a century ago, the probability of finding hitherto unseen archival material is relatively high. A structured documentation also allows for a comparison between the same kind of *areas* in different buildings, for example the “Pillars ground floor” in different synagogues (Fig. 3).

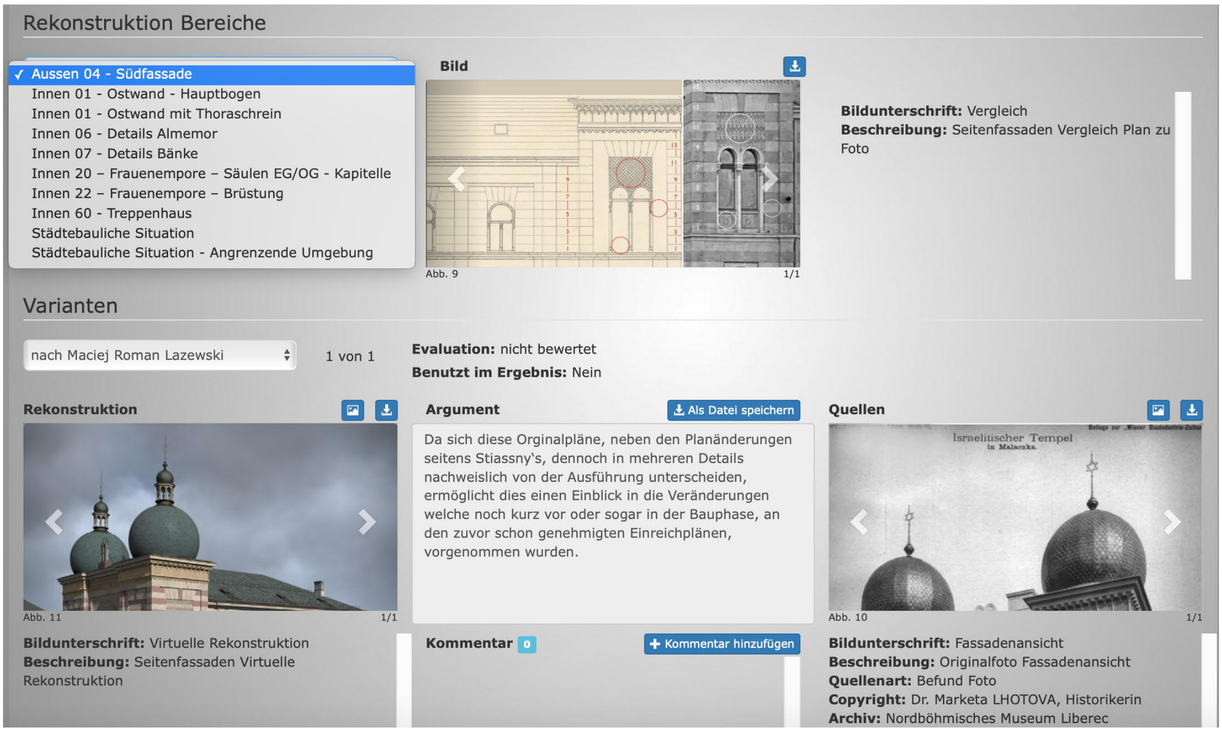

Fig. 2. Screenshot of sciedoc interface, areas of one of the synagogue projects (© Bob Martens)

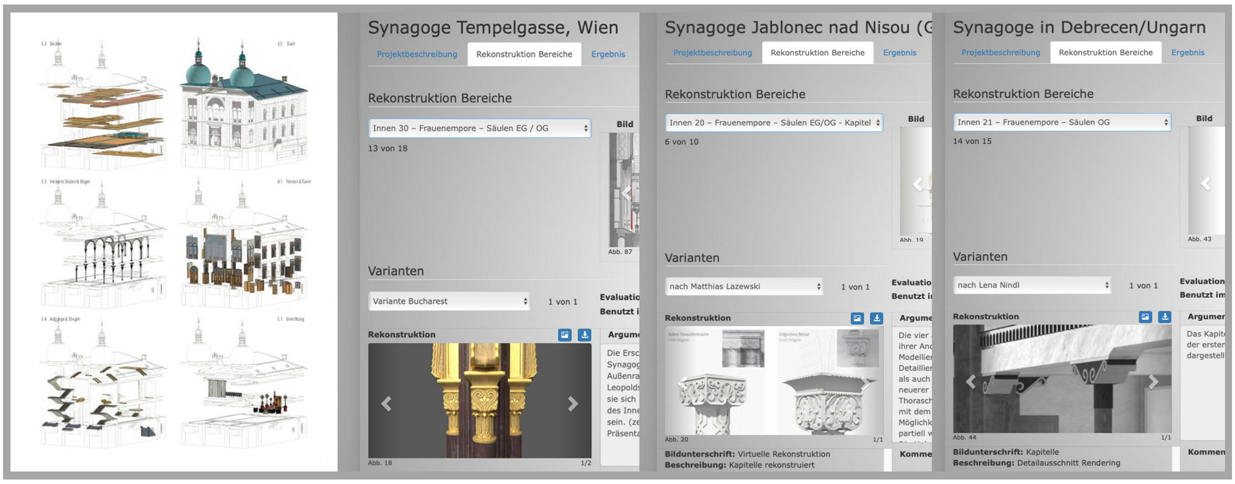

Fig. 3. Left: Structure of the project "Synagogue of Jablonec", right: Screen-shots of the sciedoc interface with the Area "Interior 30 - Pillars ground floor" of different synagogues. (© Bob Martens)

GRAPHIC DOCUMENTATION

In the field of architectural representation, the advances of digital technologies go hand in hand with the development of new tools and methods for 3D data acquisition, documentation and dissemination of information related to architectural-archaeological heritage. This gives rise to a drastic transformation in the way data and information related to any kind of artifact are collected, processed, represented and communicated.

Moreover, the use of virtual reconstruction in archaeology and architecture [Reily 1990] opened the debate, within a multidisciplinary approach, of a wide range of theoretical problems related to documentation [Pfarr 2010], analysis and interpretation of hypothetical reconstruction [Dell'Unto et al. 2013], about the subject of transparency in the reconstruction process [Hermon et al. 2007], and about the definition of new protocols for processing spatial data (acquisition, manipulation and management) [Münster 2013; Grellert and Pfarr-Harfst 2014]. Within this wide context, in order to validate the entire 3D modeling reconstruction process and to facilitate the exchange and reuse of information as well as collaboration between experts in various disciplines, new standards are necessary, due to the reusability and accessibility of knowledge linked to 3D digital models [Apollonio and Giovannini 2015; Apollonio 2016a]. For a better interpretation of a digital heritage artifact, a comprehensive interpretive method is needed. Because many hypothetical reconstructions are the result of a highly complex decision-making process [Kőller et al. 2009], we have to focus attention on the cognitive-reconstructive process and its ability to transfer knowledge and communicate information related to a source-based reconstructive process [Apollonio et al. 2017; Apollonio 2018].

The source-based reconstructive process is a reverse process which starts (a) with the collection of documentary sources or the collection of reality-based data, defines (b) the semantic structure of a case study, interprets (c) its shapes (dimensional, geometric and morphological consistency), and produces (d) a semantically enriched 3D digital model. From its starting point, the data upon which the hypothetical reconstruction model is built, accumulates an unknown, thus unpredictable and unquantifiable, degree of uncertainty and/or reliability [Apollonio 2016b]. Without a degree of confidence, expressed by the uncertainty/reliability of the incorporated data, the final model cannot be critiqued or properly evaluated from a scholarly point of view. The information necessary for completing the hypothetical virtual model is not always obtainable in a single and unambiguous way from data sources or drawings that we have at our disposal. All information collected may be conveyed by using different technologies of visualization, defining a structured modeling process based on different levels of interpretation, characterized by a progressively increasing ordinal scale of uncertainty.

The hypothetical reconstruction process is influenced by various factors, each of which plays its own role and carries its own weight in arriving at the final outcome. Therefore, a structured modeling process is based on different levels of interpretation, characterized by a progressively increasing level of uncertainty: different type of information (deduced or induced) may be conveyed through different solutions, adopting (i) new 3D symbology (e.g. a series of glyphs 3D), (ii) animation techniques display, (iii) rendering techniques and (iv) a combination of text metadata and 3D visualization.

In [Apollonio et al. 2013] a method using color to depict uncertainty was proposed, based on the definition of a structured modeling process and on different levels of interpretation. The degree of uncertainty of a reconstruction is visualized by a sliding pseudo color scale that divides the rendered objects into a few color bands to express the separate level of interpretation/uncertainty.

This first proposal was only able to represent the different levels of uncertainty related to the coherence/pertinence of data sources used. Any hypothetical reconstruction, in fact, is not a black/white or yes/no process, but a more complex and interconnected analysis and interpretation of documentary sources affected and/or characterized by different degrees of (a) coherence/consistency, (b) accuracy/metric quality and (c) subjectivity/perceptiveness. A diagrammatic representation of the inter-reference and interconnection among these three aspects is in Fig. 4, where the single nodes of the mesh represent the different levels of interrelation between coherence, accuracy and subjectivity in the definition of each of the constituting elements of the reconstructed artifact.

Fig. 4. Diagram representing the interrelation between coherence, accuracy and subjectivity (© Fabrizio Apollonio)

Coherence/consistency could be related to: the reference to contradictory sources; the entirety/integrity of original sources (e.g. a fragment of a document); the consistency of information recorded in sources; filiation, i.e. sources derived from other sources and the relevance or currency of the source. Accuracy/precision/metric quality could be related to: faithfulness/error arising from the device used for the survey (i.e. manual survey vs laser scanner); precision due to different graphic qualities of the source. Objectivity/subjectivity/perceptiveness could be related to: different abilities to interpret the sources; the credibility/reliability of the data source; level of objectivity/subjectivity, i.e. elements conjectured/deduced through knowledge (e.g. conjecture of a capital from an architectural treatise); interdependence/relationship, when we refer to sources based on other sources.

In order to overcome the limitations of previous methods – at least in part – the authors put forward a new proposal that could be developed in relation to subjects on *sciedoc*: the scaling of the plausibility of variants and a categorization of the used sources (Fig. 5). The idea was to give an overview of a reconstruction by presenting two images side by side (Figs. 6, 8).

1. - Rendering of the reconstructed building
   - Same perspective of the building - parts are colored to reflect plausibility
2. - Rendering of the reconstructed building
   - Same perspective of the building - parts are colored to reflect the used sources
3. - Perspective of the building - parts are colored to reflect plausibility
   - Same perspective of the building - parts are colored to reflect the used sources

Working together, the authors developed the already mentioned scaling of the plausibility of the *variants* into “Substantiated”, “Very probable”, “Probable”, “Possible”, “Not probable” and, at the same time, a categorization of the used sources. Different types of used sources were defined, but their positions in the listing and in the diagram do not represent any graduation value. They are structured into two hierarchical levels: the first related to the different uses / origins of those documents, the second to the different types of document:

- Building survey
  - Laser scan of architectural remains
  - Building survey drawings
  - Photographs of the building
- Designs
  - Drawings carried out
  - Drawings
  - Maquette
- Interpretations
  - Maquette
  - Contemporary drawings / sketches
  - Reliefs, seals, coins
  - Written and oral descriptions
- Analogies
  - to constructive systems
  - to buildings, ideas, etc.
- Derived from sources used
- Failing references

The two categorizations and the use of colors: The level of plausibility should be just one color with different degrees of saturation. This one color should not be part of the palette used for the sources. The following table shows the proposed color scheme:

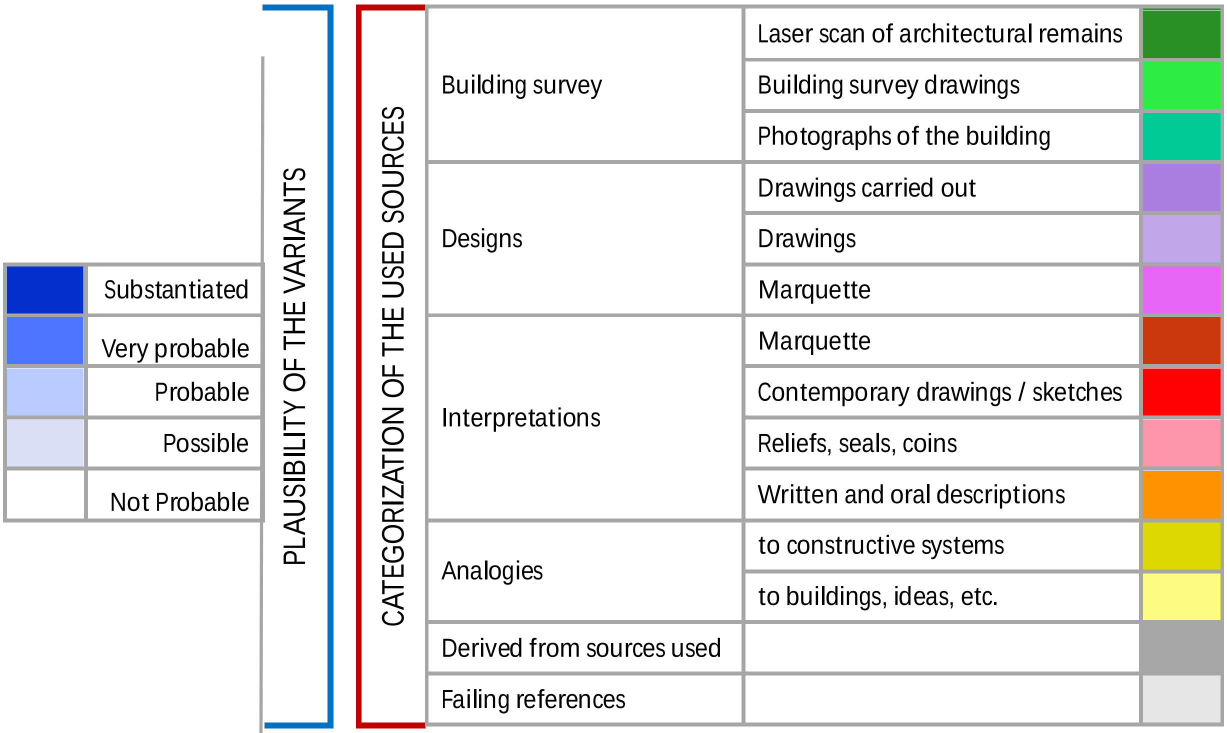

Fig. 5. The scale of the plausibility of variants and the categorization of the used sources

The proposed method was applied to some case studies. The first is the Church of Santa Margherita (Bologna, 1736). The design by V. Barelli shows the hypothetical reconstruction of the external church of the Benedictine cloistered monastery of Santa Margherita in the period between the end of the 16th century and the middle of the next. During that period, the church, which no longer exists, was the subject of a series of renovation and/or reconstruction projects [Costarelli 2015; Caprara 2002], documented by various drawings, plans and some sections, none of them are dated and not all of them easy to attribute to a specific author or to fit into a chronological sequence (Figs. 6 and 7). The second is the western cloister of the Cistercian monastery in Altenberg, founded in 1183 and fallen into ruin at the beginning of the 19th century. The reconstruction concerned the configuration of the monastery in the period between 1200 and 1400 AD (Fig. 8).

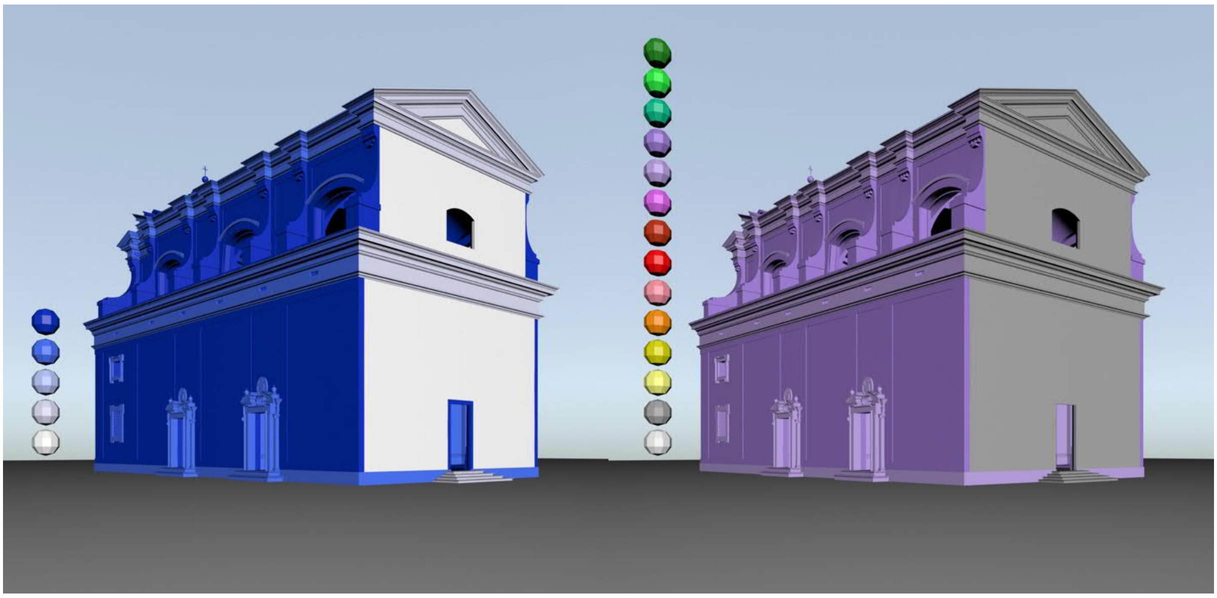

Fig. 6. Santa Margherita (exterior): representation of the scale of plausibility (l.) of variants and the categorization of the used sources (r.) of the hypothetical reconstruction based on V. Barelli's design (© Fabrizio Apollonio)

Fig. 7. Santa Margherita (interior): used sources of the hypothetical reconstruction based on V. Barelli's design (© Fabrizio Apollonio)

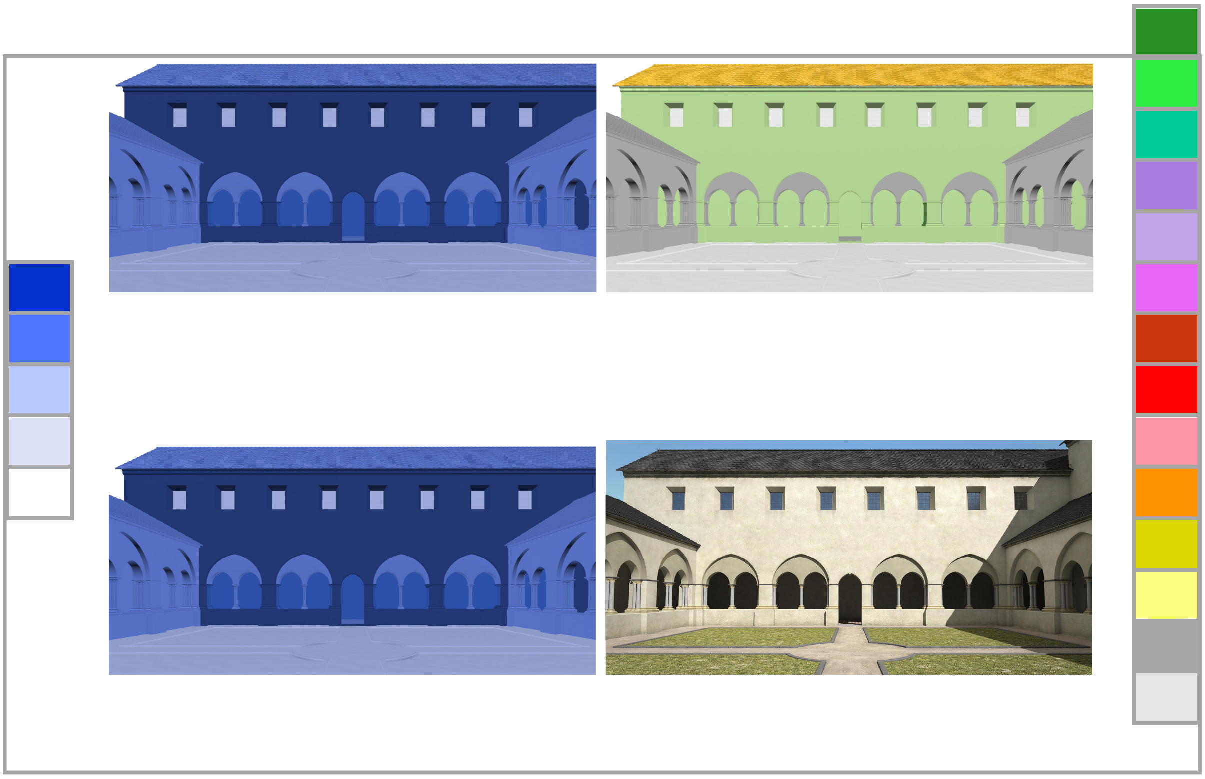

Fig. 8. Monastery of Altenberg, western cloister. The reconstruction was carried out for an exhibition at the Rheinisches LandesMuseum Bonn and shows the monastery as it might have looked from about 1200 to 1400 AD. Above: level of plausibility and used sources, bottom: level of plausibility and rendering (© Marc Grellert, Norbert Nußbaum)

CONCLUSIONS AND OUTLOOK

This paper outlines the need for scholarly documentation in the field of digital heritage. Ongoing developments with the online tool *sciedoc* have been described and its practical handling demonstrated. Its use as a communication tool is very convincing in the day-to-day work between the academic and the technical sides of the teams involved in the reconstruction.

When entering a reconstruction project into *sciedoc*, the pre-structuring of *areas* (interior/exterior) is of importance to speed up the data entry and in future hopefully also for structuring the reconstruction itself. Although the current interface is to a certain degree self-explanatory, tutorials and guidance would be useful. Now that the number of recorded projects in *sciedoc* is growing steadily, a comparative analysis of the different decision-making processes involved has proven beneficial. Data entry at the TU Wien currently tends to take place after completion of the thesis work. However, in the future, this is expected to happen at an earlier stage in order to enrich the level of discussion and interpretation.

Further implementation could concern, for instance, the use of graphic visualization of the level of plausibility as proposed above. If we assume that each constituent *area*/element of a model is characterized by its own level of plausibility (ranging from Substantiated = 1 to Not probable = 0), the results of modeling processes can be represented by a unit vector described by a set of components that add up to the given vector. Each vector representing the plausibility value of each *area* is graphically defined in Cartesian space by a line segment connecting the initial point (0.0) with the terminal point which could range from (1.1) to (1.0). The overall plausibility value of the reconstructed model as a whole is represented by the sum of each unit vector representing each *area*. The process of creating a hypothetical reconstruction, in fact, may be modeled as a “construction” set of parts that need to be assembled in order to generate the final complete model. It is an incremental process in which one starts from an initial model *M0*, placed at position *x0*, adding the model of a new element.

At step *n* a new model *Mn+1* is built from *Mn* adding a new detail *mn + 1* in an absolute position *xn + 1*. The *n* unit vectors represent the plausibility of each *n* element hypothetically reconstructed. The plausibility of the *area X*, composed by *n* elements, is represented by the summation of each new detail added with its own value of plausibility. And, similarly, the plausibility of the final model *M* - composed of *n areas* - may be computed (step by step) as the summation of each *area* added with its own value of plausibility (Fig. 9).

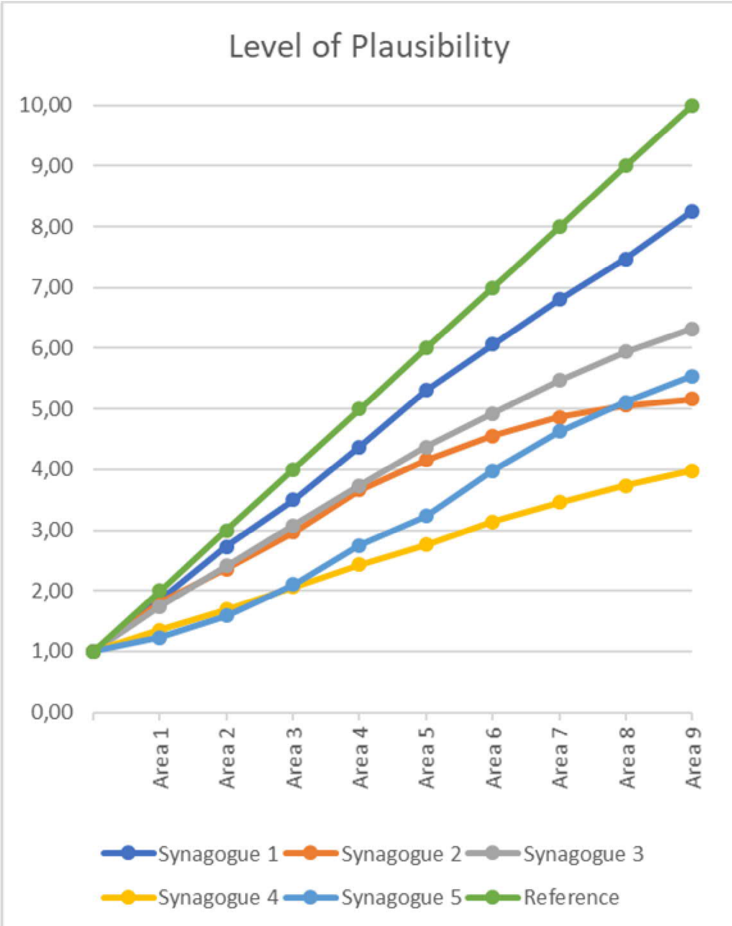

Fig. 9. Example of diagram representing different levels of plausibility of different reconstructive hypotheses concerning five synagogues composed of nine areas (© F. Apollonio, M. Grellert, B, Martens, N. Nußbaum)

At this stage, an evaluation of user behavior regarding the interaction with the interface does not seem feasible. However, this needs to be considered for future work by way of structured interviews and/or questionnaires. Overall, this is scheduled in the framework of a recently submitted research grant application.

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