Scientific Reference Model

A methodological approach in hypothetical 3D reconstruction of architecture

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Introduction

The documentation of the procedures, the applied method as well as the resulting outcomes is one of the cornerstones of scientific practice. Over the centuries, scientific publication established itself with set basic principles, such as verification of methods, objectivity, disclosure of sources, comprehensibility of reasoning, accessibility of results, accuracy and reliability, uniformity (Brink, A. 2013). In the field of computer-based hypothetical 3D reconstruction, the application of the above basic principles faces a yet unsolved challenge related to the new nature of research data and their derivation. Considering 3D modeling and the 3D model as a scientific interpretation, reasoning and hypothesis, it is found that due to manifold and rapidly developing software applications, modeling methods and types, no application-related documentation and publication of 3D models has been established. In consequence, the results of the work are not traceable, cannot be found, are not accessible and are not sustainable.

Scientific Reference Model

Three decades after the spread of computer-aided 3D-visualization in the research and dissemination of cultural heritage, we observe an intensified examination of the question of what and how should be documented. Web-based documentation and publication requires technical infrastructures and services as well as the definition of scientific methods in terms of a comprehensible model creation and sustainable accessibility to the research data (re-)presented in form of 3D models. The *Scientific Reference Model* aims at establishing an academic working method with a low barrier for a broad application in digital hypothetical 3D reconstruction. As a result, it should ensure a comprehensible and accessible (on the web) 3D model which can serve as a source reference for further research and dissemination of knowledge. The method is based on seven work packages developed and tested within research projects (Kuroczyński, P. et al., 2021) and educational courses.

(1) Object identification clarifies the name, location, and historical context of the building. Special attention will be given to permanent identifiers associated with the object. A special field of interest is the analysis of object-oriented information in Wikidata and Wikipedia, encouraging the participation in the content edition and creation on established knowledge platforms (Citizens Science). (2) Source collection includes the compilation, classification, and analysis of historical sources related to the object and includes all possible formats. A special feature is (if possible) the involvement of expert consultants regarding the historical context of the object. (3) The structuring of the project emphasizes the importance of normative organization, storing of sources, argumentations and hypotheses in terms of traceability and reuse. A template for the normative structuring is provided for usage. (4) The object hierarchy follows the approach of object-oriented research and sets a semantic segmentation of the object to be reconstructed into individual elements according to scientific questions and project requirements. The division enables a classification of the elements with the inclusion of controlled vocabularies/thesauri and the object-oriented assignment of argumentation and hypotheses. (5) The 3D reconstruction is done in a free choice of 3D modeling software, depending on personal knowledge and/or on the requirements of the project. (6) The documentation of the reconstruction takes place in given form regarding the divided elements. The reconstructed element has to be presented visually, the sources used (also own supplementary sketches) have to be named according to the normative structuring of the project and an argumentation regarding the derivation has to be provided.

Among the good practices to adopt in the light of a scientific methodology for hypothetical 3D reconstructions, we should also mention the definition of their level of uncertainty. There have been several proposals concerning uncertainty scales, based not only on different visualization techniques (Kensek, 2007), but also on different parameters, such as quality, coherence, type of source (Favre-Brun, 2013; Grellert et al., 2019; Apollonio et al., 2021). The proposal of a simplified scale based on four levels corresponding to the methods used to reconstruct an object (survey of still existing elements, deduction based on direct sources, analogy with similar objects, pure hypothesis) helps us focus on the challenges that inevitably arise when dealing with this topic.

On the one hand, the scale should be easily understandable by users with different backgrounds; on the other hand, uncertainty data should be shareable and, hopefully, both human- and machine-readable. For these reasons, each category of the proposed scale is associated with a highly recognizable color (to facilitate visualization) and a progressive value (represented by number 1-4 to be integrated to documentation). These features can be applied to the entire model or each element, according to its level of detail and semantic segmentation. In order to allow interoperability, these data should be integrated in the 3D data set and shared through standard exchange formats such as IFC for models based on Constructive Solid Geometry or City GML for models based on Boundary Representation.

A key element is indeed the dissemination of the research results in a way that ensure their traceability, accessibility and reusability. In the light of the Semantic Web (Berners-Lee et al., 2001) publication of the knowledge for 3D models takes place in online 3D repositories. Published files need to be accompanied by an appropriate set of metadata which will increase their findability on the web (Wilkinson et al., 2016).

The proposed metadata schemas have to meet the requirements for the documentation of digital 3D reconstruction (London Charter, 2011; Principles of Seville, 2017). Currently, there is an ongoing discussion between the communities associated with the German research projects developing infrastructures for the documentation and publication of 3D models, such as DFG 3D-Viewer[1], IDOVIR[2] or NDFI4Culture/Kompakkt[3], with the aim of developing the basis for a shared standard for the exchange of metadata. The quality of provided metadata is also depended on the way how data is shared. Record in RDF format with use of an ontology-based data model can improve machine readability of the data. In addition, the dissemination of data can be enriched by the network effect obtained by combining our data with external data (Berners-Lee, 2012).

An important part of the publication of the 3D model is to make it accessible to a broad public. This can be achieved by making the exported file available in a data exchange format like .obj/.mtl, .fbx, .ifc, .gml/.xml, etc., which will allow the model to be used in various 3D software. It is also good practice to use of a web-based 3D viewer integrated with the 3D repository. This will also provide access to the model for those without special 3D software skills.

Conclusion

The introduced *Scientific Reference Model* is a methodological approach dealing with the whole range of a 3D model creation. Revealing the need of documentation and web-based publication of the findings and results by offering templates, forms and services ready to use (Fig. 1). It is a starting point for further discussion on methodology and standardization in the field of the computer-based hypothetical 3D reconstruction considered inter alia in the EU project "CoVHer – Computer-based Visualisation of Architectural Cultural Heritage"[4].

[1] DFG 3D-Viewer website,https://dfg-viewer.de/en/dfg-3d-viewer (Accessed 05 October 2022).

[2] IDOVIR website, https://www.dg.architektur.tu-darmstadt.de/forschung_ddu/digitale_rekonstruktion_ddu/idovir/idovir.de.jsp (Accessed 05 October, 2022).

[3] Kompakkt website, https://kompakkt.de/home (Accessed 05 October, 2022).

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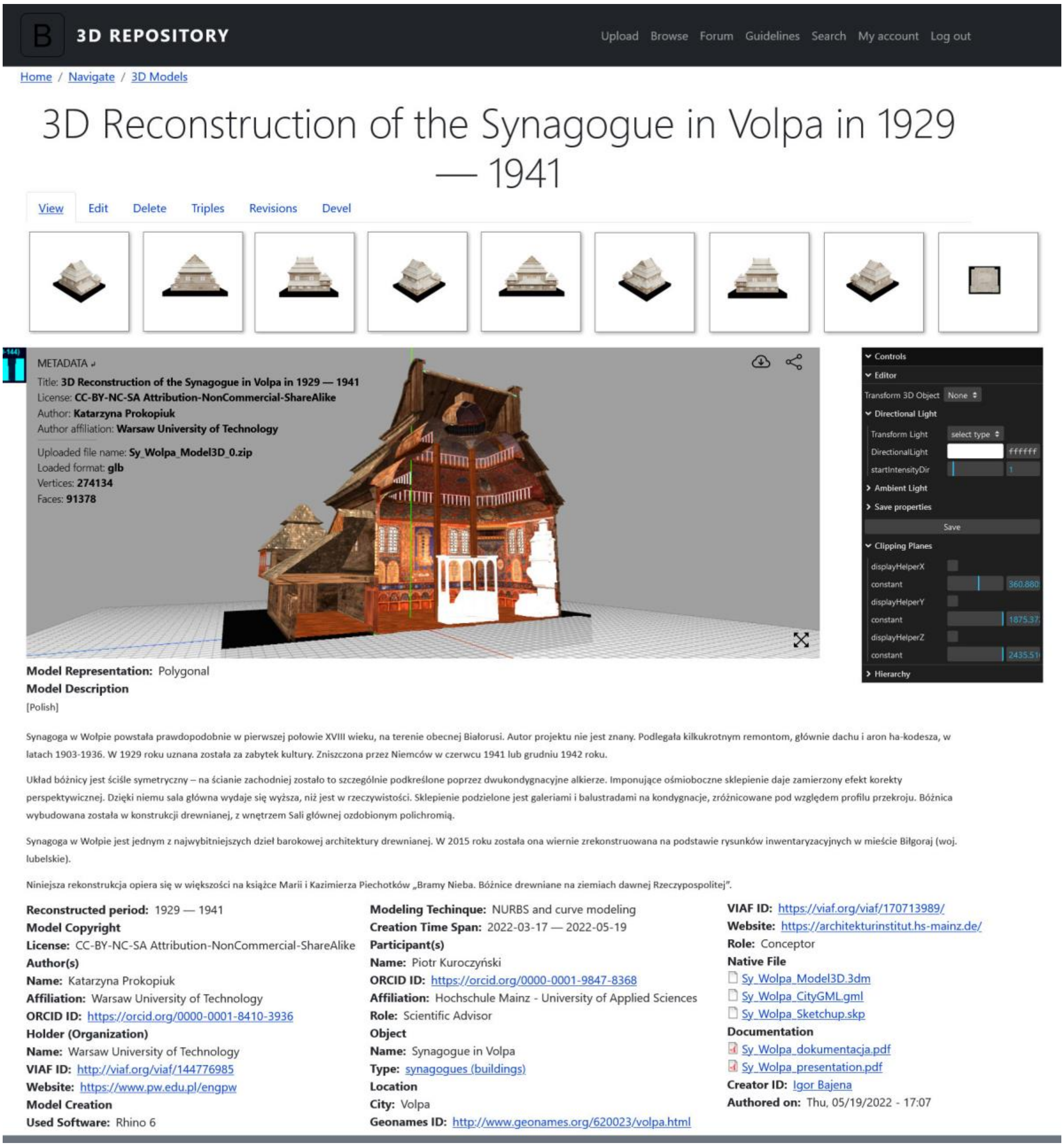

Fig. 1. Documentation and Publication of the Synagogue in Volpa in the 3D repository developed in the "DFG 3D-Viewer" project (© AI MAINZ, 2022)

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