

# Knowledge representations of digital reconstruction in 3D models

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## 1 Introduction

Source-based 3D reconstruction is a field of the digital humanities dealing with the hypothetical recreation of lost heritage of architecture, cities and landscapes. The creation of visual messages in the form of illustrations or animations shows a hypothetical vision of an object or space at a specific time. However, from a scientific point of view, it is also important to show the process, appropriate documentation, used source materials and the level of the hypothesis (Pfarr-Harfst, 2016). It is difficult to determine how this information should be adapted in the projects. Researchers have a large variety of possible publication options in the form of articles, images, videos, or 3D models themselves and all of those forms require a different approach. This work will deal with the possibilities of knowledge representation in the 3D model and challenges associated with this approach of presentation of digital reconstructions.

## 2 Web-based 3D-viewers

Publication of 3D models on the web with the use of 3D viewers gives additional opportunities to enrich the model with additional knowledge. One of the options is adding annotations, in the form of comments or descriptions that are permanently associated with a specific place in the model (Fig. 1). One of the platforms that offer this type of solution is a free repository of 3D models, Sketchfab, which is quite popular in the scientific community (Champion, Rahaman, 2020).



Fig. 1: Annotation system performed in Sketchfab<sup>1</sup>

The other solution is the open-source framework for the creation of interactive Web presentations of high-resolution 3D models, oriented to the Cultural Heritage field called 3DHOP. It allows to extend the annotation system from single points to hotspots, which can take the form of a specific plane, sphere or fragment of the model (Potenziani, Callieri, Dellepiane, Corsini, Ponchio, Scopigno, 2015). It gives a possibility to recreate model

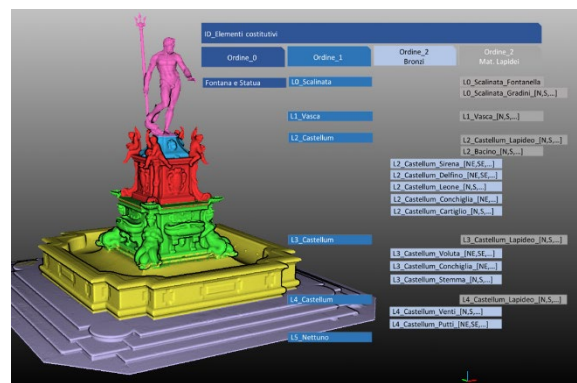


Fig. 2: Segmentation of the reconstruction model in 3DHOP<sup>2</sup>

<sup>1</sup><https://sketchfab.com/3d-models/bar-hill-fort-reconstruction-antonine-wall-6d04c19858b8421ebd034ba13abf4831>, last accessed 09.02.2022

<sup>2</sup> Apollonio F.I. (2019). Conceptual modelling and cognitive process in 3D virtual reconstruction In:

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41 segmentation, which was used during data creation  
 42 and apply it in the viewer (Fig. 2). In this case, the  
 43 included knowledge is not limited to texts only.  
 44 Hotspots could also contain images or other media.  
 45 However, a certain difficulty may be the  
 46 necessity to saturate the model with knowledge  
 47 during the publication process. The information  
 48 obtained during the creation must be documented  
 49 independently and manually added on the model.  
 50 This may result in the loss of some data that could  
 51 be retained by the knowledge application during  
 52 model production.

### 53 3 Modelling programs

54 One of the most important aspects of  
 55 reconstruction from a scientific point of view is the  
 56 level of uncertainty. General rules for graphical  
 57 representation of it have already been undertaken  
 58 by researchers (Grellert, Apollonio, Martens, and  
 59 Nußbaum, 2019). Even though these  
 60 considerations include online publication, there is  
 61 no explanation of how to apply this knowledge to  
 62 the model.<sup>3</sup> It seems important to prepare an  
 63 appropriate segmentation in advance, based on  
 64 architectural knowledge and available sources.  
 65 This would indicate that the object-oriented  
 66 approach seems to be the best in the case of  
 67 knowledge representations of digital  
 68 reconstruction models (Apollonio, 2019). This  
 69 approach allows the assignment of parameters with  
 70 different values to individual elements of the 3D  
 71 model. As default, the parameters are related  
 72 mainly to the technical aspects of the building  
 73 (Bruno, Roncella (2019).

74 Described methods can only be applied to the  
 75 3D models during the production process. It means  
 76 that to store all information it is necessary to save  
 77 the file in native format of the software. That makes  
 78 the data readable only for the users of the specific  
 79 software. Most 3D data exchange formats store  
 80 mainly information about the geometry and  
 81 textures. Data export may cause the loss of the all  
 82 collected knowledge may.

83 The project of reconstruction the New  
 84 Synagogue in Wrocław<sup>4</sup>, conducted by researchers  
 85 from Institute of Architecture at Mainz University  
 86 of Applied Sciences, has made an attempt to link  
 87 the model with the additional reconstruction data.

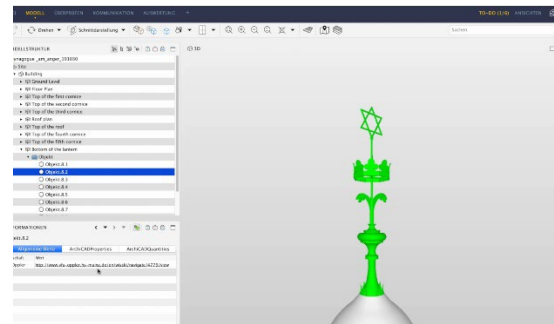


Fig. 3: Parameter with link to the VRE site with documentation of reconstruction of selected object in IFC viewer<sup>3</sup>

88 The division of the model into objects was carried  
 89 out with a modeling program supporting Historic  
 90 Building Information Modeling (HBIM) approach.  
 91 This made it possible to assign each object a  
 92 parameter with a link to an entry in an online  
 93 database containing data about that object. Then,  
 94 thanks to the export to Industry Foundation  
 95 Classes (IFC), which is a standard for the building  
 96 industry, it was possible to display the model in an  
 97 external viewer and preserve the link between the  
 98 objects and the database based on the CIDOC-  
 99 CRM ontology (Fig. 3) creating a network in the  
 100 Linked Data web.<sup>5</sup> However, lack of storage of  
 101 textures in this format makes it impossible to  
 102 capture the entire atmosphere of the building in a  
 103 single data exchange format (Kuroczyński, Bajena,  
 104 Große, Jara, Wnęk, 2020).

### 105 4 Conclusions

106 Knowledge representation in the case of digital  
 107 reconstitution aims at the possibility of applying  
 108 information directly to the specific elements of the  
 109 model. This would suggest an advantage of object-  
 110 oriented modeling techniques in this field.  
 111 Attempts to link the model to external sources of  
 112 knowledge bring new opportunities for the  
 113 integration of knowledge in the 3D model and its  
 114 publication. Author's further research focuses on  
 115 the knowledge implementation to the models,  
 116 information preservation in different data exchange  
 117 formats. The results will be presented during the  
 118 workshop to determine a possible loss of  
 119 information to determine further direction of the  
 120 work on knowledge representation in 3D models.

<sup>3</sup> <http://www.sciedoc.org/>, last accessed 07.02.2022

<sup>4</sup> <https://www.new-synagogue-breslau-3d.hs-mainz.de/>, last accessed 10.02.2022

<sup>5</sup> <https://www.w3.org/DesignIssues/LinkedData>, last accessed 10.02.2022

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