Using the 3D-Model of the Vienna Hofburg to Store Written and Pictorial Historical Sources from Collections and Archives

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A 3D-model of the Vienna Hofburg consisting of twelve stages from the 13th century until 1835 was built to make the construction and planning process of this palace easily comprehensible. The basis for this reconstruction was formed by archaeological findings and by the analysis of handwritten and printed historical sources including pictorial sources like architectural drawings. Questions of sustainability of digital models and the responsibility of publicly funded research projects have lead us to believe that 3D-models and the large number of digitized data have the potential for future use. We are aiming at constructing an online-prototype which locates the written and the pictorial sources according to time and space within the 3D-model as a three dimensional archive which allows to analyse the building and the respective sources both synchronically and diachronically.

Our paper focusses on the challenges we face both on the side of IT-technology (e. g. the structure of storing and correlating data, the divergent quality of digitized objects) and on the side of the visualization of a big amount of heterogeneous data within a three-dimensional frame (e. g. the complex situation of written sources which can simultaneously contain a range of information on different topics and dates of diverse character or the problem of visualising uncertainties of text-based data for a spatial context). This new visualisation of data can offer new contextual visions of a built structure and new ways of looking at source materials for different scientific disciplines transcending architectural history towards other text-based disciplines to help interpreting written sources dealing with a spatial situation.

Key words:
Three-Dimensional Archive, Spatial Presentation of Digitized Historical Documents, Cross-Border Tool for the Humanities, Re-Use of 3D-Models.

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INTRODUCTION

From 2004 until 2015, the Austrian Academy of Sciences carried out a multi-disciplinary research project, located at its institute for history of art, on the Hofburg in Vienna, the main seat of the emperors and kings of the Habsburg dynasty [1]. The aim was to analyse the history of the construction and planning process of this palace (both the executed plans as well as those, which were never realised) and to investigate the intended functions and the complex change of use from its foundation around the middle of the 13th century until the present. During this research, it soon became apparent that a visual reconstruction of several construction phases would facilitate our understanding of the building process. Therefore, the decision was taken to use a digital 3D-model to illustrate the status of the palace complex in twelve stages, which were identified as crucial points in a building process lasting over more than 600 years. The last stage was set in 1835 after which date the Hofburg turned into the building complex still visible today. Thus, the 3D-model actually started just as a side product of a classic art historical research project.

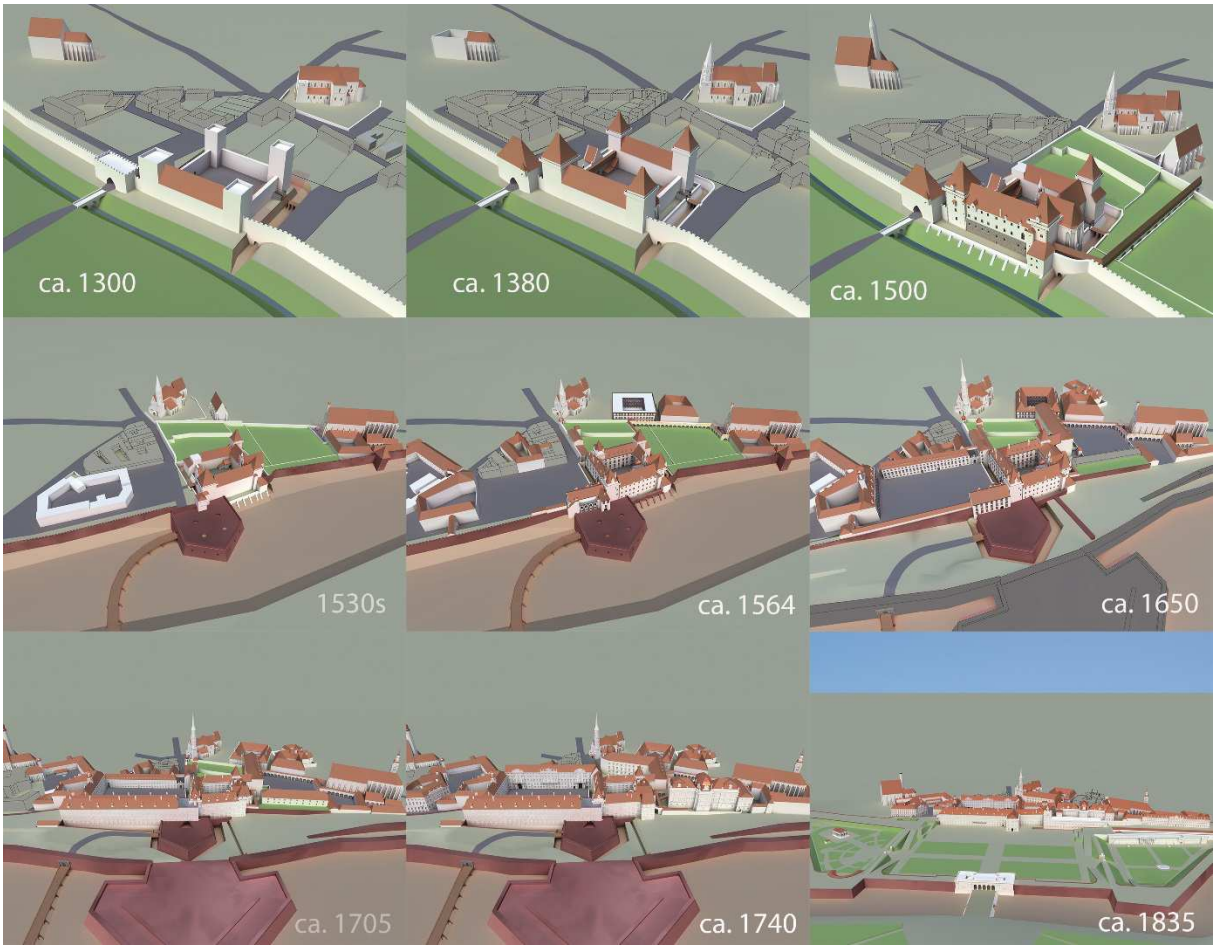

Fig. 1. Construction phases of the Hofburg between ca. 1300 and ca. 1835 (Austrian Academy of Sciences, Institute for History of Art and Musicology, Division for History of Art; Vienna University of Technology, Department for Spatial Planning; Christian Benedik, Günther Buchinger, Markus Jeitler, Petra Kalousek, Herbert Karner, Renate Leggatt-Hofer, Hellmut Lorenz, Anna Mader-Kratky, Jochen Martz, Paul Mitchell, Doris Schön, Mario Schwarz, Manuel Weinberger, Herbert Wittine; 2013–2015).

The building history of the Hofburg (Fig. 1) starts around 1300 when a fortress with four corner towers was built. Until 1500, the walls were replaced by proper wings and vast gardens separated the Hofburg from the surrounding city. When the fortification system of Vienna was modernized in the early 16th century, a bastion was added to protect the city gate next to the Hofburg. During the following decades, separate palace buildings for the use of the court (like the Stallburg) were erected on isolated sites. Only in the 17th century were these buildings united by halls and proper wings. By the mid-18th century all garden areas had been built over with additional structures. Hardly any traces of the medieval core of the Hofburg were left by the beginning of the 19th century when a new square was laid out in front of the Hofburg by moving the city walls some hundred meters westwards, creating what is today's Heldenplatz.

Archaeological findings and the analysis of handwritten and printed historical sources were the basis for the reconstructions of these building phases. Protocols of the court ceremonial for instance indirectly tell us about the spatial situation for ritual actions. Estimates of costs can also inform us about the iconography of the statuary decoration of the two court museums. These written sources were transcribed by our scientific team or they were sum up in regestae using common word documents. Especially important for the art-historical work were pictorial sources. Their variety of types ranged from vedutas and maps to architectural drawings like ground plans or cross sections and to interior views in watercolour or photography. As common in museum practice, these pictorial sources were stored in the relational database Adlib [2]. We shared the research results (concerning for instance the attribution of drawings to individual artists, the dating, etc.) with the cooperation partners like the Albertina Vienna, which keeps the most important inventory for the Hofburg complex. The respective stock of drawings can already be easily accessed via Albertina-online [3].

The actual use that was made of the 3D-model was rather conservative: it served to get two-dimensional illustrations for the analogue volumes, which were published to present the results of the research on the Hofburg [4].

However, questions of sustainability of digital models have led us to believe that the 3D-model and the large number of digitized data have the potential for future use. So how could we combine the information of the collected sources, our digital reconstruction and external databases like Albertina-online? Especially regarding the general theme of the CHNT-conference 2018 to enhance the collaboration between historical disciplines and disciplines developing digital methods, how can we turn the existing digital model into a tool offering useful applications for research questions of the humanities? The discussion how to establish standards to document the process of a digital reconstruction [on the Charters of London and Seville: Beacham et al., 2006; Denard 2009; Lopez-Menchero and Grande 2011; Bendicho 2011] is already highly advanced [Münster et al. 2015 (with references to: Kiouss et al. 2011; Pfarr 2009; Sürül et al. 2003; Kuroczyński et al. 2014; Münster and Köhler 2012; Felicetti and Lorenzini 2011; Ronzino et al. 2011; Ronzino et al. 2013; Niccolucci 2012, Pfarr-Harfst 2011); Kuroczyński 2017]. However, it focusses on the reconstructed model and lacks an important question – which is at least essential for the humanities: How can we make use of a digital reconstruction for *further* historical research beyond the digital reconstruction itself? The answer we want to offer is very close to the method of documentation: by turning the digital reconstruction into a container for storing historical sources.

CURRENT RESEARCH PROJECTS

There are currently a number of projects dealing with equipping 3D-models with historical data. In most cases, the aim is to document the decision making and construction process of the very models. A significant example, which can exemplarily already be accessed online – which unfortunately is not yet common practice – is patrimonium.net [5] which is based on an ontology following CIDOC-CRM. For art historical research it offers valuable information on the written primary and secondary and on the pictorial sources which were used for the reconstruction. However, the concept of information storage of this project does not cover historical information beyond the reconstruction process, e. g. on the decision making process during the historical course of construction or on the historical creators of the reconstructed parts of the building. Information of this kind usually forms an important basis for art historical research into specific buildings and can be deducted from for instance bills or estimates of costs. With our project idea we are trying to integrate this kind of archival information which needs not necessarily be integrated in the decisions of a reconstruction process, into our three-dimensional model. Other projects like the Venice Time Machine [6] promise to offer archival content in quite the way our project aims at, too – however, there is yet no public open access to these data. Another similar project is 4D-Stadtmodell "Bamberg um 1300" [7] which aims at presenting a wide range of historical information connected to the 3D-model on the city of Bamberg via historical documents, the presentation of scientific research results and building archaeology. However, the focus lies on one

period of time (around 1300) while our aim is to link historical sources to our 3D-model which covers the whole period of existence of a building (until the present) and therefore allows connections between far distant periods of time. Other important issues of the Bamberg-Project like the visualization of uncertainties [Lengyel et al. 2016; Grellert et al. 2016] will not be in the focus of our project, but concerning this special topic we will rather resort back to the before mentioned projects for issues like the last named. Other projects (like MonArch or DokuVis) which deal with similar or even equal questions will be discussed later in this paper.

CONSTRUCTING A THREE-DIMENSIONAL ARCHIVE

We are aiming at constructing an online prototype which locates the written and the pictorial sources according to space and time within the 3D-model. Thus, it will be turned into a three – and actually – four dimensional archive which allows to analyse the building and the respective sources both topographically as well as synchronically and diachronically.

The application should enable two directions or modes of discovery: On the one hand, the navigable 3D-model shall provide a mean to spatially browse the documents linked to the model's various parts (spatial or immersive discovery). On the other hand, the classical search over the document metadata shall give the opportunity to retrieve data in a more traditional sense together with a supported navigation which links the data to its spatial context. At the heart of linking the assets (the written and the pictorial sources) in their various databases (AdLib [2], eXist [15] etc.) with their respective positions in the 3D model lies an ontology modelling the structure of the building throughout its various construction phases. The annotations of the 3D model along this ontology are stored and queried in the backing database, whilst the actual assets linked are retrieved directly from their respective source databases. This distributed setup allows for the continuous integration of other data sources into the model.

To achieve this, we identified the following essential means: first, since we intend to construct our application as a browser-based online-tool allowing to investigate the model in real time (if possible without any download), we need to reduce the amount of data-flow. We will therefore structure our digital model into several levels of detail. The geometry of the first Level of Detail will only contain rough information and the deeper you go into the 3D-model additional data will be loaded.

Secondly, we need to develop a topographical structure of the Hofburg's construction process according to the structure of our digital model. We therefore decided to establish a hierarchically structured partonomy. At the same time, this partonomy uniquely defines different parts of the Hofburg model. The individual elements of this partonomy can therefore serve as Uniform Resource Identifiers for the annotations in the databases and for the tags in the text documents (to which I will refer to later). For these unique identifiers we decided not to use GIS-data (by the way, all parts of the digital model are georeferenced according to the official survey of the city of Vienna [8]), but to use units which are semantically and verbally defined – considering traditional art-historical research methods which in general do not make use of abstract numbers. Additionally, our partonomy can of course easily serve as a part of an overall ontology.

We are not the first to use such a partonomy as the basic structure. The tool MonArch (developed at the University of Passau [9]) for instance uses the different hierarchical levels to store data like images, plans etc. according to the respective unit of the building. For instance, for the city quarter in question the map of the centre of Nuremburg is shown. For the clerestory of the nave at St. Lorenz, plans and documentation photography is stored. All these results can additionally be filtered by a number of categories. The dimension of time, however, is not considered in the case of this very partonomy.

Therefore, and thirdly, we have to provide the elements of our partonomy with mark-ups indicating the valid timespan since the digital reconstruction of the Hofburg consists of parts which existed only for certain periods of time (i. e. buildings which were either demolished or added later or which replaced former buildings). Thus, access to different chronological versions of the respective parts of the 3D-model is granted.

A main component of our browser-based tool will be a time-slider allowing to choose the state of the Hofburg at a certain date in time. The time-slider needs to be subdivided into units per year (at least in a first step) to allow to present the changing state of the Hofburg as precise as possible. Additionally, when it comes to investigating the development of objects, the method of comparing is crucial. That is why we plan a feature like the double presentation which may be familiar from the mirador viewer [11] which allows to move images synchronically – a

good impression of which can be gained with the mapire-project, a collaboration between the Austrian state and the Hungarian national archives and several additional partners [12].

Apart from these technical functionalities, it is most important to note that the historical sources are in the focus of our project, thus turning the digital model into an auxiliary container for historical information. The sources we want to store within the digital model do not only serve to document the process of constructing this very model, but they serve to inform about the quantity and quality of written or pictorial sources for certain topographical areas. If these sources were only used to document the digital reconstruction than the use of this very model would be restricted to the modelling process and the reconstruction itself. However, if you added additional information data to the model it may turn into a useful tool for future research on a wide range of topics and for a larger number of disciplines. If we chose the Schweizerhof's North-western wing for instance, we retrieve a certain number of entries from written and pictorial sources. By filtering these results according to a certain period of time (in our example we are looking for pictorial sources between the year 1550 and 1875) the following three objects will be displayed which themselves stored in separate databases including relational databases (Fig. 2).

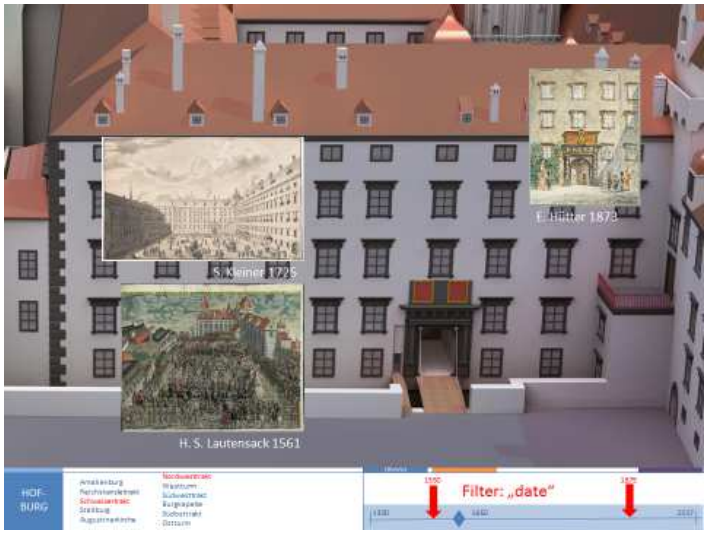

Fig. 2. Presentation of pictorial sources.

As these proposed functionalities require a lot of interactivity on the user end and should, at the same time, be browser based, the implementation of a decoupled JavaScript frontend application interacting with both the viewer as well as the interfaces of the various data sources seems inevitable. The application DokuVis (developed at the University of Applied Sciences in Dresden [13]) which is based on a JS/NodeJS backend serving a graph database through a REST interface and an Angular JS frontend, already brings along most of the required MVC-features. Despite being custom made for a different purpose, namely the documentation of cooperative modelling of historic sites, it is easy to customize and adapt to our purposes because of its modular decoupled structure. DokuVis offers a solution how to document the digital reconstruction process by applying commentaries to the digital model as well as by overlaying for instance ground plans or sections into the digital reconstruction. By doing so, the two-dimensional sources are related with the space of which they represent an abbreviated projection.

However, we also aim to offer a semantic search in the text-based documents stored in our 3D-model. If you were interested for instance in the phenomenon of naming of buildings (why the core building of the Hofburg is called Schweizerhof), you need to select the respective part of the Hofburg model and use the filter for "naming". You will get four objects where those sections of the text are highlighted which concern the naming of the Schweizerhof (Fig. 3).

Fig. 3. Presentation of written sources.

You can learn that already in 1730, a Swiss guard was mentioned as watchmen [I], that in 1745, the Swiss guard seems to have been renewed [II] while it was obviously abolished in 1767 [III], but was still remembered (in 1823 [IV]) as the reason for the naming of the Schweizerhof. Our word documents of the written sources therefore need to be transformed into xml-documents and they need to be tagged following the principles of the Text Encoding Initiative [14], a digital method applied by text-based disciplines such as literary and linguistic studies, since we can only tackle the challenges of a four-dimensional virtual archive which should be useful for the humanities in general if we include digital methods of other disciplines. These xml-files will be stored in eXist [15] as a separate database.

I would like to give another example where our 4D-archive can offer information exceeding the limits of just a documentation. I have chosen the destruction of the medieval Western tower of the Schweizerhof which still existed around 1740, but had been demolished by the 1790ies. If we just wanted to document the construction process and the decisions we have made which led to the shape of our digital model, one single source would have been sufficient: In a publication from 1770 it is said that in the month of April 1753 the ancient Western tower had been demolished [V]. However, the architectural collection of the Albertina, Vienna keeps the plan Albertina, Vienna, Az. 6394, which unfortunately is undated.

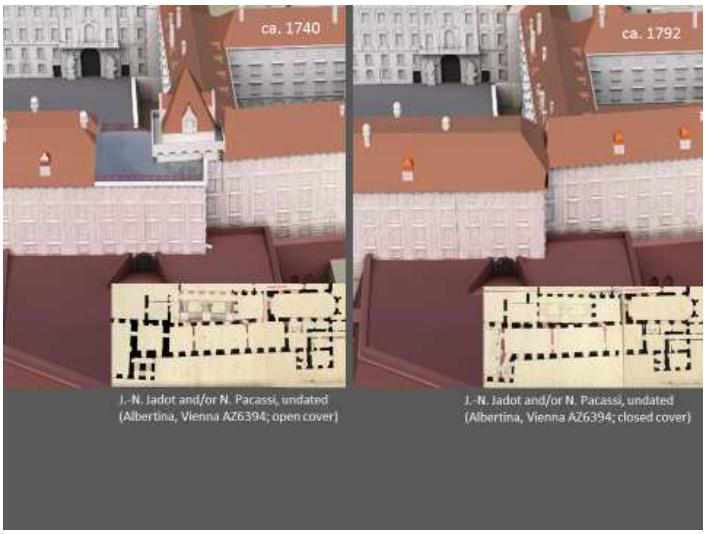

Fig. 4. Pictorial sources for the destruction of the Western tower of the Schweizerhof which took place in 1749.

This plan (shown in Fig. 4) presents a prominent staircase with three flights of stairs next to a massive four-sided wall structure (which is our Western tower). The walls of this staircase are marked in red, thus indicating a new construction. From the protocols of the ceremonial we learn that in 1748, the former staircase next to the chapel (which is shown on the right of the ground plan) had already been torn down [VI]. Hardly a year later, we learn from an analogous source that the "great stairs next to the chapel" could already be used again by people on their way to their audience with the emperor in the state rooms [VII]. We now have a date for this ground plan which is the year 1748 when the planning process must have started. However, this ground plan has a cover. If you close it, you discover a further change: the massive walls of our Western tower have disappeared and there is a new wall, marked in red, separating the Great Antechamber on the left of this new wall from the First Antechamber on the right, an enlarged room which obviously replaces the former Western tower. Again, we must refer to written sources, this time to a diary entry by Johann Joseph prince Khevenhüller-Metsch who as Obersthofmeister of Maria Theresa was the highest ranking court agent. In the beginning of November 1749, he records re-decoration works in those rooms which the public court conduct (the "publique corteggio") used to traverse to reach the court chapel [VIII]. By mid-November of the same year, works in the Great Antechamber had been completed and the whole apartment used for the evening gathering of the court society [IX]. Therefore, the medieval Western tower must have been demolished in the autumn of 1749, at the latest, since at that time, the Great and the First Antechamber were enlarged using the space the Western tower had once occupied. If we just wanted to document the construction of our digital model it would have only been necessary to annotate one source which indicates that by the late 18th century the Western tower had disappeared.

CONCLUSION

Our understanding of the digital model as a four-dimensional archive offers to document historical processes like the constructional development, but it also provides the opportunity to present functions of rooms, to realize the spatial qualities of the information of a written source or to visualize the sequences of actions performed by humans within these spaces. This visualization of data can offer new contextual visions of a built structure and new ways of looking at source material for different scientific disciplines. The use of a digital model as a virtual archive thus creates a link for an interdisciplinary approach towards and a transdisciplinary use of digital technologies. Our aim is to construct a prototypical concept of how to realise such a four-dimensional archive technically. And to get an idea of the amount of work which is necessary and to gain experience how the sources at hand need to be edited and related with each other to achieve something like a new publication format for historical research connected to architecture.

In contrast to other current research projects focussing on using 3D-models as scientific tools for art historical research, we are not aiming at solely documenting the process of reconstruction. We rather want to equip the 3D-model with information and data, which can be used for future research projects beyond building archaeology or construction history of a building (including other disciplines than architecture or art history). Why should a 3D-model not be useful for research on functions of rooms or certain spaces in general, for bio- and prosopographic research, for history of administrations etc.? Another important issue, for which we want to present a feasible solution, is the question of access. To strengthen 3D-models as useful tools of future research in the humanities, they need to be easily accessible, without any download or long waiting times, and especially: they need to be openly and publicly accessible in all parts – including schemes used in the background like ontologies or the xml-versions of text-documents following TEI. Otherwise, we cannot honestly contribute to Linked Open Data. How we can in this respect consider and respect for instance questions of individual copyright (of museums, collections etc.) is another issue our prototype wants to offer solutions for. The future challenge of our prototype, however, will be how the scientific community in the historical disciplines will and can make use of information and data presented in their three-dimensional context, which new questions can be raised via this special visualization of data and how the 3D-model can serve to get adequate answer to new research questions. To extend the data-content of our prototype based on an ontology following CIDOC-CRM [Bruseker et al. 2015; Ronzino et al. 2016; Guillem et al. 2017] should be a next step further.

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