Behind the data – preservation of the knowledge in CH Visualisations

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Structured Abstract

The basics of visualisations in the context of Cultural Heritage are not broadly defined. But this is the precondition to find out suitable and practical strategies to document and manage the knowledge contained therein. For this, the paper focusses the properties, potentials and typologies of Cultural Heritage visualisations related to application fields and possibilities as well as documentation strategies, creation process and methodology.

The paper starts with a theoretical overview of the properties and potential of visualisation related to the usability in the context of Cultural Heritage. On this basis the correlation between application possibilities and the three application fields - research, transfer of knowledge and preservation - will be discussed.

In a second part, the paper identifies the similarities and differences of typical working processes and methodologies by the study "Investigation of 3D modelling workflows in CH with the object of development of key concepts and definitions". This is a subproject of the project COSCH with the purpose to create a framework called COSCHKR as an international and interdisciplinary platform for state-of-the-art documentation of Cultural Heritage. For this, the main topic of the study was the analysis, evaluation and comparison of thirty different 3D projects of three institutes. It was possible to define different types of CH visualization and framework of a working process.

Third topic is the documentation and management of knowledge of such visualisation in the field of Cultural Heritage. The paper compares three current research projects and points out commons and differences of the different strategies.

At the end, a synthesis gives a first idea for common strategies and best practice guidelines of Cultural Heritage visualisation related to the process, methodology and documentation.

Purpose – Find out general strategies to document and manage knowledge

Design/methodology/approach – Based on investigation and evaluation of different projects.

Originality/value – Most of the projects are a special application for one research question, this methodology raises a common claim.

Practical implications – The outcomes of the investigation is a basis for further practical applications with a high range of usability.

Keywords – Best-practice-strategies, Documentation, Cultural Heritage, Knowledge

Paper type – Academic Research Paper

1 Introduction

Three-dimensional computer models as digital reconstructions have been at the interface of architecture, archaeology and the history of art and building for about 25 years. There they have been involved in the dissemination of knowledge of complex research topics to a broader audience (Frings, 2001). The history of the models lies primarily in their original application context - the dissemination of knowledge. The result is thus the hitherto existent understanding of 3D-models as a tool devoted purely to visualisation, often tinged with prejudices.

The prejudices – often even academic – are demonstrated in the trend toward "high-end" presentation and the question of findings, hypothesis and scientific verifiability of results within the context of Cultural Heritage (Münster et al., 2015).

Virtual 3D-models are often used in media presentations in museums, exhibitions or also in documentary films in order to produce a space-related context for exhibits or to visualise historical events and structures. During the last decade the use of these models has been expanded to other areas of application, such as research or the preservation of cultural heritage by means further development of technical applications (Pfarr-Harfst, 2014).

While in the humanities some methodological approaches and rudiments of standards have been established in various areas of digitality. They are largely lacking in the area of 3D- computer models. A reaction to rapid technological development and the accompanying necessary formulation and establishment of standards or guidelines for methodology and procedures had been urged even in the early years (Koob, 1995). However, to date there have been no comprehensive integration of the community nor incentives for the establishment of such basic principles and the general theoretical discussion of 3D-computer models with respect to methodology, terminology and organisation or even documentation (Münster et al., 2015, Pfarr, 2010).

2 Characteristics, Potentials and Possible Applications

2.1 Characteristics and Potentials

Firstly, comprehensive analysis and evaluation of the connections between the characteristics, potentials and possible applications of 3D-computer models in the area of CH are necessary for the development of basic principles. These specific characteristics are the starting point from which the potentials generate their use. These potentials, also on the basis of technological developments, in turn result in possibilities for use in three main fields of application – research, preservation and dissemination (Pfarr-Harfst, 2014).

Presently three properties - digitality, three-dimensionality and language of pictures - can be defined for these 3D-models.

Digitality means that the information lying behind the digital data sets is composed of strings of undamaged characters that can be disassembled or reassembled as needed. This is the basic requirement for the availability of a wide range of outputs.

Three-dimensionality constitutes space as a central theme in the culture of buildings and structural cultural heritage in its entire complexity. The interplay of space-creating elements, their ambience and the perception of space itself can become perceivable and understandable.

The language of images is universal, a language which requires no knowledge of its coding to understand it. It contrasts, for example, to technical drafts that are subject to normed coding and thus are not accessible to everyone.

The following potentials of 3D computer models result and are generated from these characteristics:

- diversity of forms of output
- illustration of complex content and spatial interrelationships
- representation of variations
- consolidation, generation, verification and dissemination of knowledge
- communication
- virtuality

These potentials manifest themselves in various application possibilities that can be transferred to the three mentioned application fields, the boundaries of which however are fluid. In the following, the potentials and examples for their application will be put into the context of intention and demand.

2.2 Potentials and applications possibilities

2.2.1 "Diversity of output forms":

The basis here is primarily the property of digitality that allows a digital data set to be displayed in any technically possible way. This ranges from dynamic or static formats of output such as film or rendering to interactive formats or augmented reality, virtual reality and 3D plots. Most have been available in the dissemination of knowledge for many years. If one transfers these application formats or potentials to the application field of research, the format of output must be adapted to the intention and adjusted to scholarly investigation. Indirectly, this implies that it is not possible to find an application for all such scholarly questions. In this case an exact analysis of the project intention and the formats of output (Sander 2014) is required to establish a best-practice strategy.

Thus, for example, simulations can place time-based events into context with the built-up environment and superimposition with real pictures can clarify spatial relationships, for instance, between hypothesis and finding. Accessible real time models can serve as virtual research environments and can be verified by means of immersive experience space concept; construction principles or construction details can be verified. The application/output as 3D Wiki can be understood as an open research model in Wikipedia format that can be enhanced and updated as a type of 3D archive system, also for the preservation of cultural heritage.

2.2.2 Clarifcation of complex spatial and/or temporal correlations.

This potential is based on three-dimensionality and the language of images. Here, as well, many application possibilities have been established.

By means of 3D-models non-visible structures are recorded, made visible and understandable and thus can contribute to finding their context, for example settlements and the development of cities. By means of integration of various original data, it could be possible to localise individual finds or objects in buildings and to draw conclusions as to position, construction or function. In virtual space it is possible to test and correct construction principles and constructive details 1:1. This also applies to the temporal components that can be directly superimposed by the spatial aspect. As a result, various construction phases and various states in the history of a building can be generated and conclusions drawn as to building history and structural changes. It is just this temporal and spatial contextualisation that offers great advantages for the dissemination and processing of research results in the museum.

2.2.3 Representation of variants

A further potential is opened up in immaterial space through digitality and the resulting research work: "representation of variants". It is possible to verify scholarly assumptions and to compare various approaches as three-dimensional propositions or outlines. 3D-models could be used as a medium of scholarly discussion and thus reveal discrepancies and contribute to new insights.

2.2.4 Consolidation, generation, verification and dissemination of knowledge

Academically founded 3D-models rest upon a basis of knowledge that is generated from sources of various types, origins and authors. From this arises the most important group of potentials. It focuses on knowledge within digital scholarly models and concerns the consolidation, fusion, verification, generation and dissemination of knowledge.

This is particularly relevant for the application field "research", as previous research results can be brought together and new knowledge generated. Consequently, these models reflect current scholarly discourse and constitute the basis and starting point for further research.

2.2.5 Communication, interaction and intuition coupled with virtual space

If digital scholarly models are to be understood as innovative future research methods, communication, interaction and intuition are important components. This is underscored by the great success of such technical devices as tablets and smartphones, directly based on these potentials. In industry, for example in the area of product development, such applications have already arrived and established themselves. For research application this could be a future vision of communication, the meeting of involved persons in virtual space in which problems and solutions can be discussed in three-dimensionality.

In future, this potential can, in the sense of citizen science, serve the dissemination of knowledge by enabling the participation of the public in the research process by means of virtual systems as virtual museums.

3 Challenges

This is a still very young research field that uses 3D-models in CH. It unites potentials and opportunities with numerous challenges.

In examining the challenges, one must first confront the question of the position of digital scholarly models within the scholarly landscape. Where do these models belong? To the digital humanities, architecture or computer science? Are they subordinate or do they stand for themselves.

If these 3D-models are deemed an independent typology, then it is necessary to generate an epistemology and construct a scholarly structure.
The difficulty in applying for appropriate funding is a result of the lack of positioning and theoretical substantiation, since most sponsors still regard these models as a tool exclusively for visualisation. As yet there is no common understanding in the sense of UNESCO to regard them as a disseminator of knowledge.

Certainly the complexity of the issue as a whole is one of the next challenges. Many issues have arisen from a recent survey within the current community from which topics of concentration indicating need for action were initially filtered (Münster et all, 2015).

In addition to basic research and the typification of 3D-models orientated to the type of application and intention, the topic of sustainability is currently of great interest. Preservation of knowledge, documentation, long-term accessibility or long-term archiving and publication can be classified under the concept of sustainability.

The preservation of knowledge should take place by means of suitably practicable documentation methodology similar to a drag-and-drop solution, far removed from complicated data bank systems. In addition the accessibility of data must be ensured by a suitable archiving method. Thus it is not only the archiving of digital data and the attendant guarantee of accessibility to them decades later that challenges us, but also the availability of knowledge.

That means the availability of results, that is, the models for subsequent generations of researchers. In addition the topic of resource preservation plays a large role. This, too, is a challenge. Here the focus lies on the availability and editibilty of models. However, thus far the questions are unsettled as to the missing basis with regard to methodology and the accompanying question as to verifiability of a scholarly approach to a digital academic model. Guidelines must be found that imply a sort of quality assurance that, in the so-called brave new world, models without scholarly basis can be distinguished from the academically-based so that the dissemination of false knowledge to the broad public can be prevented.

A challenge in technology certainly involves rapid development of technical systems. This holds opportunities as well as dangers. A problem of current research is that technology is more important than content. This applies to the area of dissemination, where content and didactics often lag behind technical applications. The question of additional value offered by the applied technology is always paramount.

Virtual environments certainly represent a special case in the area of challenges. Here, as well, the question of additional value must be posed. Do these research methods in virtual space really have a use and which advantage do they have as opposed to other methods? The networking of the community is also a great challenge at the national as well as international level. It must be recognised that networking advances the entire field and does not stand in the way of one's own research. Interdisciplinary discussion must be encouraged, just as the various requirements for 3D-models on the part of research must be elaborated in order to aim selectively at strategies. Subject-oriented, institutional and national boundaries must be surmounted.

4 Challenges

With all of the mentioned challenges, knowledge is the focus of digital scholarly models and its scholarly basis. This problem must be effectively solved (Mahr, 2004). Currently there is a wide range of different typologies of 3D-models in the context of cultural heritage.

All of these typologies can be summarised as a contribution to a uniform terminology under the concept "Digital Knowledge Models" and can be defined as follows.

Digital knowledge models are computer-based models of buildings, building structures or structural elements in which object-based knowledge is gathered, consolidated, compacted and visualised. The consequence of this process is the regeneration of knowledge. Thus these models effectively reflect current research and the object of future research. As such they are an innovative and future-orientated tool in the research, dissemination and preservation of building culture.

Most of these knowledge models are also to be understood as repositories of knowledge and Digitally Born Objects. They are a fusion of various types of knowledge that can be termed primary and secondary sources.

Primary sources are the results of excavations, knowledge gained from research, extracts from literature, surveys, plans etc.

Secondary sources are sketches, comparable structures and, above all, personal knowledge.

This personal knowledge is often essential for the construction and, in turn, is the result of a complex process of creation.

In the ideal case knowledge is generated during such a process. Consequently, there are three categories of knowledge:

- Knowledge within the model stored from the various sources that is transferred into three-dimensionality
- Knowledge concerning the models containing the context of the models, important background information on the project, project partners, technical systems, intention and objectives, that is, all factors directly influencing the model and the end result.
- Knowledge from the model that is regenerated from the transfer into three-dimensionality and fusing of the sources

5 Process

The existence of these various forms of knowledge follows from the process in which knowledge is fused and knowledge is newly generated. Thus they are not only bearers of knowledge, but also sources of culture and science. They are a synthesis of sources, historic and cultural context, project backgrounds and reconstruction process. Within them information is gathered, consolidated, filtered and compiled in a digital data set.

This information can then be further processed for various areas of application, which in itself illustrates the great complexity with regard to the creation process of these digital knowledge models. In the case of digital reconstruction, they are usually subject to a non-automatic modelling process, which means that such models depend upon the person processing them and his or her technical and specialist expertise.

Today, projects in a scholarly context include a number of disciplines, whose participation in a model is dependent upon other influential factors such as the idea, occasion, aim of the project, project partner and so on (Münster, 2011). There are two basic types of participation:

- Content-related participation - archaeology and the history of culture, art and architecture, building research, and at times also architecture
- Technical participation (model creation) - IT, architecture, earth and engineering sciences.

However, the boundaries here are often somewhat blurred.
The consequence of the participation of various disciplines is the use and integration of various initial data or typologies in the three-dimensional data set and the further processing of the same. Laser scanned data or results from SFM procedures are often integrated.
In a study within the context of COSCH - Action the processes of various projects were compared in order to examine the question of commonalities within the process and, in association, the definition of guidelines and strategies for quality assurance. These studies were carried out at the University of Sarajevo and King‘s College London (Pfarr-Harfst, 2015a, 2015b).

As an initial result it was possible to generate a scheme consisting of four main stages: preparation, data collection, data processing and completion
This scheme is based on a linear project sequence among the individual work packages. However, it is already evident that various typologies of 3D-models flowed into the end product.
In a second step, this scheme could be verified and supplemented through the investigation of projects at King’s College. These projects were far more complex, a combination of various typologies and methods and approaches. Here, the work

packages were no longer a linear process, but were seen as linked into a cross-over process, or were a combination of various links. However, the results of these processes, both in London and in Sarajevo, were always a digital data set.

This enabled us to filter out and recognise the commonalities. On the one hand, it was possible to confirm the project phases after my stay in London and on the other, the input-output principle. At the end of this process a digital data set is generated that decides the input for the end phase of the project, the type of presentation or the output formats. The phases are anchored in a project framework. The definition of the background of the project, the intention, underlying technology, the disciplines involved, should be made at the beginning and provide the framework for the remainder of the project. This is absolutely crucial. There must always be a milestone, a quality check at important points in the process where the output from one phase generates the input of the next one. This needs to be considered, and any necessary adjustments made.

6 Documentation

6.1 In General

The necessity for documentation is demonstrated by the highly complex process of the consolidation of heterogeneous information, data and knowledge into a digital three-dimensional data set as the basis for subsequent processing for various applications. However, the idea and the posing of the problem are not new. This is shown in four publications that deal with general challenges and in particular with the knowledge stored in these models. They call for action.
As early as 1995 in his paper "Architectura Virtualis" Prof. M. Koob drew attention to the absence of a suitable archiving system as follows:
"We research and work on the new technology, we document our knowledge with an old technology". "We are entering a new territory and do not yet have rules." At the time, this was an extremely visionary way of thinking (Koob, 1995).
The next publication is from the year 2001, "The Virtue of Models – CAD and New Space in Art History". It deals with a subject that was most controversial at the time, the question as to what these models can and should achieve (Frings, 2001).

For the first time, the London Charter of the year 2006 put the aspect of an independent typology into an international context and transferred the demands of the UNESCO Charter into the area of three-dimensional computer models in cultural heritage (Denard, 2009).
The initial ideas for courses of action are shown here in the background In five guidelines. In addition to the normal use in dissemination, research and conservation

have also been included and defined as further topics.
The Seville Charter from 2011 is based on the London Charter, but substantiates the application areas as well as current challenges and adapts them to further developments (International Forum of Virtual Archaeology, 2012). These publications are theoretical essays with a marginal practical relevance that as yet has not been established.
What could this sort of documentation look like, and what is the least it must contain in order to present the knowledge in, of and from the models?

6.2 Documentation Strategy – Four Level System

In 2010 a four-level-system had already been developed as a documentation strategy. It attempted to represent the complexity of the process (Pfarr, 2010).
Level 1 is the background for the project – that is, the knowledge of the models, project partners, intention, technology, results, etc.
Level 2 includes the project context – the knowledge that demonstrates the knowledge in the models. This involves cultural, historic and architectural backgrounds. One needs this background knowledge in order to reconstruct a building, a town.
Level 3 defines the classification of the documentation. This should be done individually, since every project has its own structure of rules.
The main focus is what is known as the level of proof – level 4 -, where both the origins and the creation process, the milestones are depicted. The starting point is the text-based construction description, an overview of the key data on the building with cross references to the so-called source and methods catalogues. In a building's source catalogue, the source is assigned directly to the project, and in the methods catalogue the project is assigned to the sources and the process.
This strategy was transferred to a particular 3D-model, the digital reconstruction of Xi´an.
The tomb installation consists of the entire installation and four main sections with a total of 29 individual buildings. The documentation for all of these buildings was provided at the level of proof. The buildings in each section were summarised in a building catalogue, a sort of table of contents. The catalogue contains the reference number of the building, as well as further information such as the shape of the roof and the number of floors.

The document is clearly assigned to the project in the sources catalogues. You will find the source here, along with the nomenclature and designation, information on its meaning, use and origins. The process is illustrated in the method catalogues. Input-output presentations are used to illustrate clearly the sources, the steps in the procedure and the results.

You can see how complex this type of scholarly documentation can be, and the question arises as to the absolute minimum required for the dissemination of knowledge in a museum.
The four-level-system presented here corresponds to a type of documentation strategy for the preservation of knowledge but also for the process and its confirmability.

6.3 Dohna-Schlodien – a virtual exhibition catalogue

The Dohna-Schlodien project at the TU Darmstadt ties in with an on-going project at the Herder-Institut Marburg in which the digital infrastructure WissKI SOUR was developed as a documentation tool (Kuroczynski et all, 2014). The goal of the project at the TUD is, on the one hand, the digital reconstruction of the architectural structure of the palace in East Prussia and, on the other hand, the linking of this 3D-Model and its basis to WissKI-SOUR. The digital reconstruction will be presented in the Internet as a virtual museum that, in addition to linkage with knowledge, also offers the opportunity for immersion into content as well as verification.

A further goal is the evaluation of the platform WissKI-SOUR with respect to usability in a concrete international and interdisciplinary project. The platform is based on the principles of semantic annotation and WebGL-technology. The user can annotate information according to object, person, source and process by means of four input fields. Thus the system complies with the requirements for scholarly documentation of editability, confirmability and the direct linkage of object to document. Notice that the four levels of the documentation strategy from 2010 can also be seen here.

During the course of the project it became apparent that the extensive and complex input possibilities in practice require a maximum of discipline from those involved. The information must be updated regularly. This involves additional staff including the accompanying expense. The question arises directly here as to what extent such a complex documentation system can be pegged on a long-term basis to the real practice of model creation. The establishment of such a system requires rethinking in project planning and by the sponsors; additional resources for staffing must be taken into consideration.

6.4 TOPORAZ

The current project TOPORAZ presents a further strategy in terms of linkage of knowledge and virtual research environments (VRE). Here geo-referenced 2D-data und 3D-models serve as a navigation platform to which heterogeneous research data are annotated by means of hotspots. The platform is based on open-access and accommodates the requirements of editability. Since it is a matter of VRE and not of a documentation system for 3D-models per se, verification functions indirectly through overall linking. A direct allocation of the 3D-objekt, source and process is as yet not provided for. It remains to be seen to what extent this approach is still functional with respect to preservation, linking and verification of knowledge in the sense of usability. This must be evaluated at the end of the project.

6.5 Not yet another platform

The on-going research projects attempt to connect topics such as open access, linked data, big data, semantics and ontologies with each other. For the most part the generation of a new platform, aligned with the given project, is the result. Hence in research one speaks today of the phenomena "yet another platform", the sustainable use of which is often, due to various factors, not comprehensively secured and the editability in other projects is difficult to achieve. As already mentioned, usability plays an important role.

A fundamental and structured analysis is necessary for requirements, practical suitability, processes, participation in comparison with available technologies.

7 Conclusions

Guidelines on the basis of the process framework from the COSCH-project and the insights of the documentation strategy can contribute the first step to a practicable approach to the preservation of knowledge in CH.

Minimal guidelines to achieve knowledge preservation, quality assurance and sustainability might be:

- Determination of a project framework at the onset of a project with the definition of binding model structures, nomenclatures for model structures, nomenclatures for sources and 3D-data as well as milestones within the process.
- Inspection of output data with regard to scientific and technical quality.
- Systematisation of sources and buildings as well as generation of source catalogues.
- Archiving of the most important model state points along the defined milestones of the project framework.
- Documentation of the processes by means of documentation forms (source, work, questions, result) and storing in a simple databank system.

The necessity for the securing of knowledge, information and data in 3D-models is uncontested, as well as the achievement of long-term availability of 3D-data sets.

However, a simple way of data storage and knowledge linking must be developed that requires no great outlay for staff and other funding. A comprehensive analysis and basic scholarly groundwork, including such factors as usability and universal applicability, must be of primary importance. Only in this way is it possible to meet the expectations of London and Seville as well as those of the UNESCO Charta.

References

Bentkowska-Kafel, A., Denard, H., Baker, D. (2012) "Paradata and Transparency in Virtual Heritage", Routledge, Burlington.

Denard, H. (Hg.) (2009) "The London Charter for the Computer-based Visualisation for Cultural Heritage", King´s College London, London. http://www.londoncharter.org (online)

Frings, M. (Hg.) (2001) „Der Modelle Tugend. CAD und die neuen Räume der Kunstgeschichte", VDG-Verlag, Weimar

International Forum of Virtual Archaeology (2012) "The Seville Principles - International Principles of Virtual Archaeology", Sevilla. http://www.arqueologiavirtual.com/carta/?page_id=437 (online)

Koob, M. (1995) "Architectura Virtualis. Projekt Weltkulturerbe", Bensheim.

Kuroczyński, P., Hauck; O., Dworak, D. (2014) "Digital Reconstruction of Cultural Heritage – Questions of documentation and visualisation standards for 3D content". http://www.academia.edu/9189049/ (online).

Mahr, B. (2004) „Das Wissen im Modell", KIT-Report Nr. 150, KIT, Berlin. http://www.tu-berlin.de/fileadmin/fg53/KIT-Reports/r150.pdf (online)

Münster, S. (2011) „Entstehungs- und Verwendungskontexte von 3D-CAD-Modellen in den Geschichtswissenschaften", in Virtual Enterprises, Communities & Social Networks, ed. K. Meissner, TUD Press, Dresden

Münster, S., Kuroczynski, P., Pfarr-Harfst, M., Lengyel, D. (2015) "Future Research Challenges for a Computer-Based Interpretative 3D Reconstruction of Cultural Heritage - A German Community's View", SPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume II-5/W3, 2015, 25th International CIPA Symposium 2015, 31 August – 04 September 2015, Taipei, Taiwan. http://www.isprs-ann-photogramm-remote-sens-spatial-inf-sci.net/II-5-W3/207/2015/isprsannals-II-5-W3-207-2015.html (online)

Pfarr, M. (2010) „Dokumentationssystem für digitale Rekonstruktionen am Beispiel der Grabanlage Zhaoling, Provinz Shaanxi, China", TU print, Darmstadt. http://tuprints.ulb.tu-darmstadt.de/2302/ (online)

Pfarr-Harfst, M. (2014) "25 Years of Experience in Virtual Reconstructions - Research Projects, Status Quo of Current Research and Visions for the Future", in Across Space and Time. Proceedings of the 42th International Conference on Computer Applications and Quantitative Methods in Archaeology (CAA), ed. P. Verhagen, Archaeopress, Oxford.

Pfarr-Harfst, M. (2015a) “Analysis, evaluation and comparison of 3D modelling workflows as basis for guidelines and vocabulary”, Final report of Short Time Scientific Mission (STSM) at Faculty of Electrical Engineering, University of Sarajevo, Bosnia-Herzegovina, 09.02 - 13.02.2015. Online:http://cosch.info/documents/10179/150264/Pfarr-Harfst_STSM+graphical+abstract_sarajevo_TD1201.pdf/79498c3b-c0c3-4367-b38d-cd366eac118b

Pfarr-Harfst, M. (2015b), “Investigation of 3D modelling workflows in CH with the object of development of key concepts and definition”, Final report of Short Time Scientific Mission (STSM) at King´s College London, United Kongdom, 02.03 - 06.03.2015. Online: http://cosch.info/documents/10179/150264/Pfarr-Harfst_STSM+graphical+abstract_london_TD1201.pdf/d0218869-c10a-4b9c-a2aa-dc371c5c8d57