Research of Digital Cultural Heritage

Virtual Scientific Models

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Abstract: Digital reconstructions or 3D reconstructions are an important medium to open results of research to the public. The main potential of such reconstructions give an opportunity to present the research in different ways.
Besides this, digital reconstruction as a crossing point of various scientific disciplines, like architecture, history of architecture and archaeology, became more and more a tool for researches during the last five years.
Bringing the results of excavations into the third dimension they consolidate the knowledge of these disciplines. Serious questions or unclear situations of a building structure can be easier discussed and often be solved. This lecture shows the potential of digital reconstructions as a tool for research at different stations of the research process and provides an insight into the research in this special part of the cultural heritage.
There is a focus on the research with the digital reconstruction before, during and after the reconstruction process corresponding to its role in excavation process. The special potentials of this researching method are demonstrated on digital reconstruction projects done at the Technical University of Darmstadt over the last 20 years. One of these examples is the project „Ephesus during the Byzantine Period“ with the Austrian Archaeological Institute, Austrian Academy of Sciences, Romano-Germanic Central Museum, Mainz, Technical University Munich, Vienna University of Technology as project partners and its main goal to consolidate and visualize the results of excavation and research.
Besides this, the lecture takes a critical look into the future of the digital reconstruction as a researching tool, the chances and the risks of this method.

Keywords: researching tool; cultural heritage; 3d reconstruction

Research of digital Cultural Heritage

Introduction

Digital reconstructions are a special form of the digital Cultural Heritage and the New Memory. In consequence of the paradigm shift of information and communication technology these models are based on the principle of digitality. Coupled with the language of pictures as a universal language potentials result from the main characteristic traits of the 3D models at the point where architecture, archaeology and the history of art and architecture meet. These digital reconstructions become a tool for science. During the last decade the most terms have become inadequate to express the underlying potential. Rather, this type of scientific method should be called a “virtual scientific model”. A virtual scientific model is a digital three-dimensional model that can be employed in research in various ways.

Within the process of scientific research the spectrum reaches from simple pictures in scientific papers, to the use of models coupled with a data bank or to an open research model. In the meantime, a wide variety of technical possibilities has become available for the practical implementation of such models. Thus, this paper will not concentrate on a technical system, but rather will be a theoretical view related to methodology, potentials and fundamental structures. Further the characteristic traits and the resulting potentials of virtual models are placed in the context of the process of scientific research in general and transferred to reconstruction projects.
Virtual Scientific Models have two main characteristic traits resulting from the principles outlined above. The first one is the merging and consolidation of knowledge and the second one the three-dimensionality.
In the following the two properties are described coupled with the resulting potentials.

Property: Merging and consolidation of knowledge

Bringing together all of the data relevant to a research project in an interdisciplinary working process is one of the most important characteristic trait of Virtual Scientific Models. Today the most of the excavation data are collected digitally, archives and libraries are also digitalizing older sources. In this context the virtual model can serve as an orientation system, a sort of interactive stage upon which the current state of information and research can be presented in a visual manner. All research data can first be merged and consolidated into such a model, which employed at the beginning, during and after the research or excavation process.
At the beginning such a model can show the status quo of a research project and serve as the basis for further research and/or excavation campaigns. During a research process a virtual scientific model can serve as an open research model. There is already a wide variety of technical possibilities, such as self-generating models, the coupling with data bank systems, and the use of caves. After the research project, the virtual scientific model can make knowledge widely available in suitable documentation and archiving system.
Therefore the potentials of the merging and consolidation of knowledge are:

- Definition of the archaeological findings and sources – interactive stage
- Open research model
- Documentation und archiving

Property: Three-dimensionality

The first potential of the characteristic trait three-dimensionality is the Illustration of complex relationships in space and time. The digital model becomes a tool for the scientific process in order to investigate open questions concerning a spatial structure in a content-based or time-based context, also for large architectural structures or areas. The use of model structures at varying scales, and thus with differentiated information densities, facilitates this process.
Working within three-dimensionality makes it possible to observe three-dimensional ideas, which are reconstruction variants, side-by-side. Older ideas can be reappraised, new ones can be established, contradictions exposed and new directions sought through interdisciplinary discourse. In relation to the research process, three-dimensional theses or sketches can be applied prior to beginning an excavation

campaign or a research project in order to facilitate or complement the formulation of the scientific problem. During the research process, these three-dimensional theses can be used as a guide for structuring and orientation. By means of concrete formulation of questions, these theses can be reviewed, refuted or verified. After the research process, the three-dimensional theses can serve by themselves as a basis for further research.

The transfer of constructions, assembly principles for construction element and architectural styles into virtual three-dimensionality is quite comparable to building in reality, a further potential of three-dimensionality. Within the scientific context, the transfer of sources into a 3D-model requires wider knowledge of the basis of architecture and construction as well as of the historic parameters.

Here one can simulate construction processes, environmental influences, cultural particularities and constructional-technical procedures. In particular, this potential can be applied during the research process and can support scientific experimentation.

The potentials of three-dimensionality are:

- Illustration of complex relationships in space and time
- Designing three-dimensional theses und variations
- Building in three-dimensions
- Understanding structures that are not visible

Potentials, projects and methodology

In the following the potentials mentioned above using examples from research projects carried out at the Department of Information and Communication Technology of the TU Darmstadt (IKA) are demonstrated. First of all the methodology and the working principles of the Department IKA which leave all doors open and which allow the models to be used in various situations, are described.

These principles are:

- Determination of model structures at the beginning of a project and classification in macrostructures and microstructures.
- Determination of a binding glossary for the 3D-model as well as for the scientific sources.
- Classification and structuring of sources and the establishment of source catalogues for all elements
- Establishment of referencing models in the fixed model structures so that everything remains editable.
- Archiving of the status of all models with dates in a specially designated file.
- Documentation of the working steps within a consistent system.
- Combining everything in a file system – subfiles: model data, sources, documentation.

These potentials as well as the chronological positioning within the entire scientific process now are connected to the following examples from research projects; Benedictine Monastery Plan, the Architectural History of St. Peter in Rome, Crystal Palace in London, the Imperial Tombs of Xi´an, Ephesus – Byzantine Heritage of the Western World, the Virtual Synagogues.

The resulting potentials of the Property "Merging and consolidation of knowledge"

Definition of the archaeological findings and sources – interactive stage

In the Ephesus model it was the intention to bring together the findings of 100 years of excavation work, a classic case of the merging of knowledge. First of all three large-scale structural models (macrostructure I) were designed: a Greek, a Roman and a Byzantine model. Each was then referenced according to a city district (macro II) and individual building (microstructure I). Individual objects that can then be found in the buildings were allocated to the Microlevel II.

An incredible amount of findings was available for each building, district and objects. The sources were digitalized in the event that they had not yet been available in digital form. Moreover, 3D-models or 3D-scan data of objects and building elements that had been prepared as a basis for modeling by other scientists were also worked into the model. Thus a meshwork of data was created that demonstrates the complexity of the excavations at Ephesus and emphasizes the potential for knowledge consolidation.

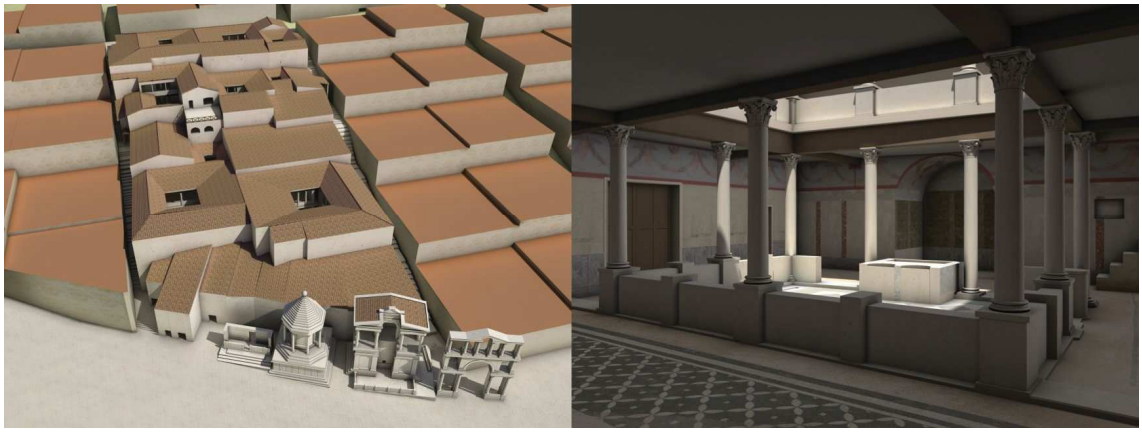

Fig. 1– Digital reconstruction of the Terrace House 2 in Ephesus (Copyright TU Darmstadt, FG IKA, 2009)

Fig. 2 – Digital reconstruction of the masonry saw in Ephesus (Copyright TU Darmstadt, FG IKA, 2012)

Open Research Model

The 3D-model of Ephesus became a sort of open research model that, since the completion of the original model, is undergoing a few extensions.

One extension included new findings concerning mill wheels and the masonry saw. This area was extensively revised.

Documentation, publication and the availability of knowledge

Within the context of digital cultural heritage and the new memory, all projects must include extensive documentation. The merging of knowledge must be a goal of each project. Last year I presented a system designed specifically for this purpose and it is currently being further developed.

The resulting potentials of the Property "three-dimensionality"

3D Theses, variants or 3D-Sketches

The starting point of the EU research project "Benedictine Monastery Plan" was to understand the plan of the St. Gallen monastery as a master plan which included construction instructions with the necessary information for building and space organization. "If one understands the monastery plan as a master plan, it must be applicable as a construction plan in northern, middle and southern Europe." In this case three 3D theses were set up with respect to the transfer of monastery design into one typical of each of the three regions together with Barbara Schedl. The characteristic features of the regions were taken into consideration with respect to building construction, materials and design. You see the three models in the back.

With the reconstruction of the Imperial Tombs of Xi'an two problems were developed as three-dimensional theses, on the one hand, the three-dimensional thesis of the South Palace of the burial site Zhaoling and on the other, the thesis with regard to the entrance to the burial site. The tomb of the first Tang-Emporer and its reconstruction consists of a northern section, a southern gate and a southern palace and the actual burial site within the mountain. The excavations of the southern palace were just beginning when the reconstruction was in its inception. The reconstruction is based on a few excavation findings and on geomagnetic investigations. The basic structure of the site was altered several times during the research process. The final result now serves as a basis for further research by the expert Prof. Zhang. The entrance to the burial chamber had not been found at the beginning of the reconstruction work. There was only a single written source from a grave robber and an excavation finding with respect to a wooden bridge. The direct transfer of the written source, the locating of the sites of discovery as well as the comparison with other buildings led to a three-dimensional thesis for a possible location of the entrance that, up to then, had been assumed to be at another location. The individual steps can be seen here in the background.

After an on-site inspection, Prof. Zhang verified the presumed site of the entrance.

The potential "Building in three-dimensions"

Construction in three-dimensional space as a direct transfer of active building in reality can be illustrated very well with the examples of the reconstruction of the Crystal Palace. The working plans for all of the building

components were available for this “space without limits”. Up to the present it has not been possible to reassess the assembly methods of this modular construction. As yet, it has not been possible to verify the construction methods of this ingenious feat of engineering. The transfer of each individual type of element into three-dimensionality and step-by-step assembly not only made the impression of space visible, but also this incredible engineering achievement is important for today’s method of high-rise construction.

Fig. 3 – Construction elements of the Crystal Palace London, (Copyright TU Darmstadt, FG IKA, 2011)

The potential: Illustration of complex relationships in space and time

To illustrate the potential of complex relationships in space and time two examples of project are used.

The project “The Reconstruction of the Design and Construction History of St. Peter’s Basilica in Rome” as an example for the time components shows the layers of time in the context of the history and theory of architecture. A three-dimensional representation of the 500-year history of the construction of the building was realized in the computer.
Thus each individual concept – model and sources - was provided with a suitable glossary and registered with its own data set. The referencing of the data did not take place until the end of the process. Thus the construction phases or plans of the architects and master builders can be superimposed as a whole by the data and an overview of the complex history of construction and spatial development is possible.

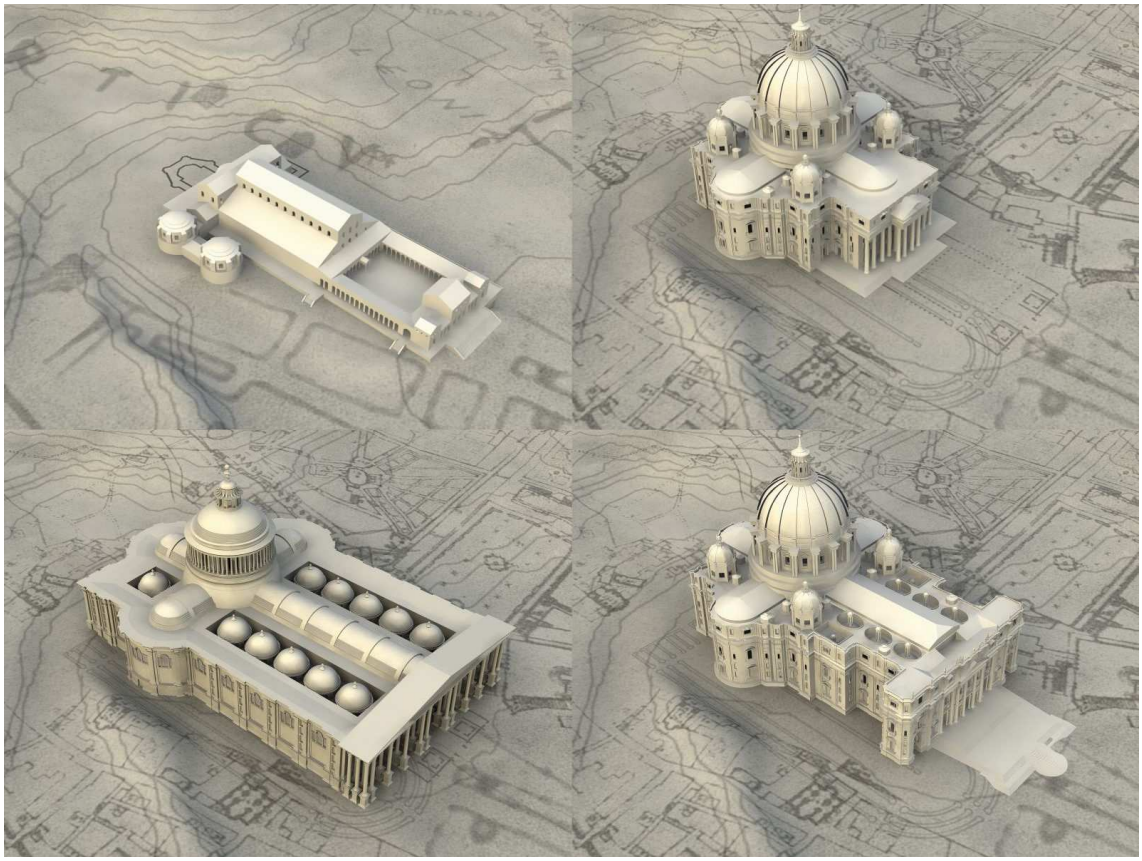

Fig. 4 – History of St. Peter’s Basilica in Rome (Copyright TU Darmstadt, FG IKA, 2005)

The excavation of the Cemetery of the Seven Sleepers in Ephesus can be utilized as an example of complex spatial structures. The Cemetery of the Seven Sleepers was a part of the general project Ephesus and thus incorporated in the data structure described above. Initially, all of the section and the outline were loaded. Together with Norbert Zimmermann systematically the entire complex was transformed three-dimensionally according to a certain system. First of all the basic structure and the external walls as well as the ceilings and floors were brought into the third dimension. After that the separating elements and the construction elements were gradually added. This systematic approach helped in the understanding of the complexity of three-dimensionality. This 3D-Modell showed that the old interpretations of this complex are not logical at all, new questions are posed. At the moment the 3D model is only a three-dimensional thesis too. In the next step Norbert Zimmermann will try to answer these new questions inside the virtual scientific model.

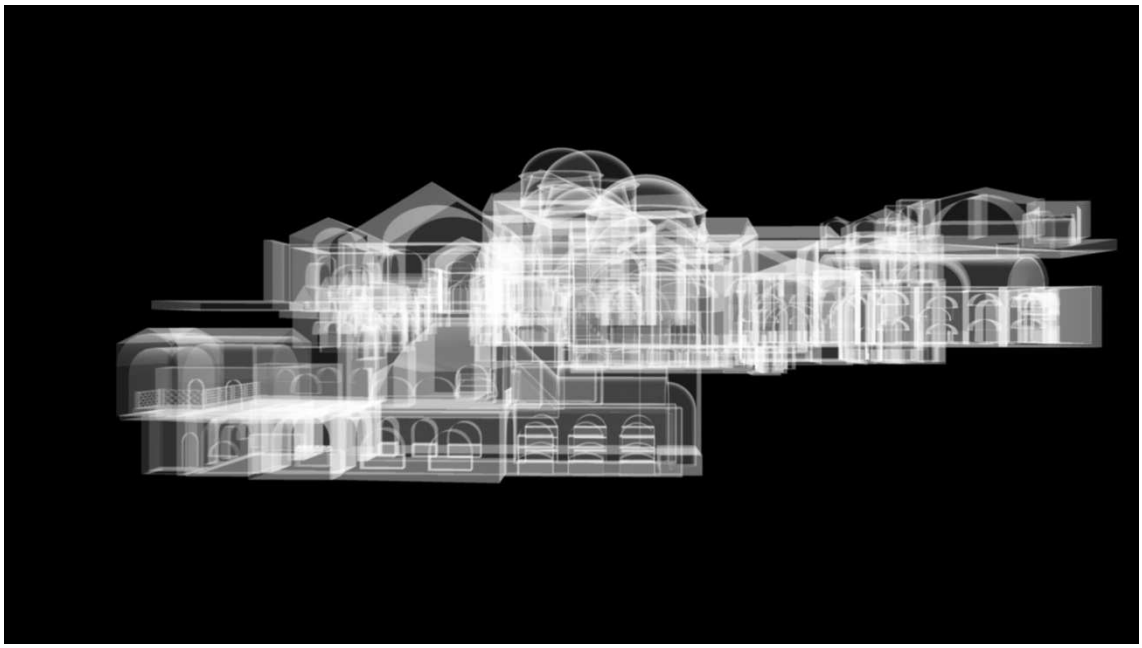

Fig. 5 – Cemetery of the Seven Sleepers in Ephesus (Copyright TU Darmstadt, FG IKA, 2009)

Potential: Understanding non-visible structures

At last the potential “Invisible Structures” is described using the current project “Virtual Mathildenhöhe” as an example. The all-round work of art, the Mathildenhöhe, in Darmstadt, a center of Art Nouveau, was decisively influenced by the architect Josef Maria Olbrich. In a series of four exhibition phases he displayed his concept and that of other participating artists. The four exhibition phases showed different focal points. Today, however, not very much is discernible or tangible. The project will deal with all four exhibition phases and the attendant individual buildings. At the beginning of the project all sources like plans and fotos are loaded into the special data structures mentioned above. The four exhibition phases are to be found at the macrostructure level II, which in turn is divisible into individual sectors – macrostructure level II. Individual houses, such as the Olbrich House, which was unfortunately destroyed, are part of the microstructure level I. The microstructure level II, rooms in the buildings, and the microstructure level III with objects complete the structure. The first goal of this project is to make the non-visible structures of the original complex “Mathildenhöhe Darmstadt” visible. Furthermore the second goal is to generate a prototype for an open, virtual scientific model as a basis for further research, in which existing technologies in this area will be examined and incorporated. The intention is to contribute to the preservation of digital cultural heritage and the new intangible memory and the general availability of knowledge. The bridge to the communication of knowledge is also built.

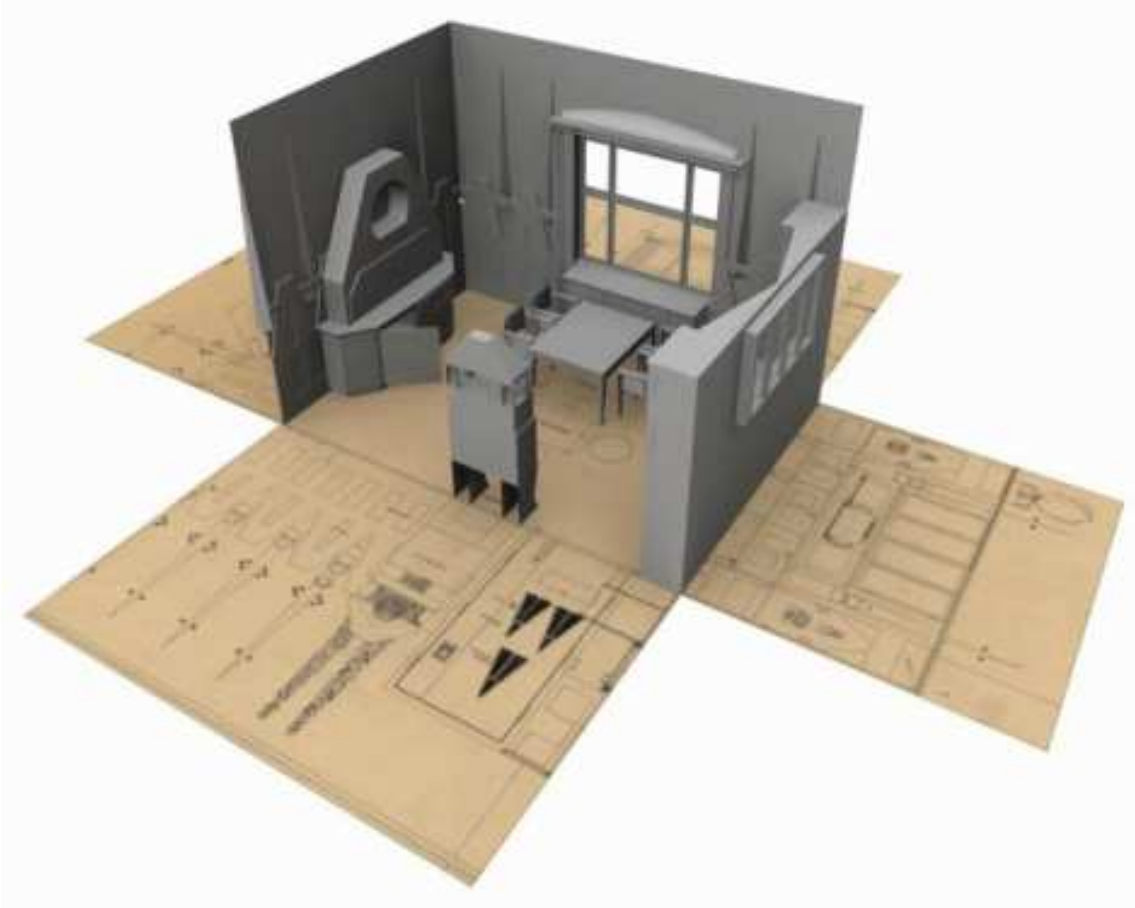

Fig. 6 – Virtual Scientific Model, Mathildenhöhe Darmstadt, House of J.M. Olbrich, dining room (Copyright TU Darmstadt, FG IKA, 2010)

Conclusion and challenge

The theoretical overview of characteristic traits and methodology combined with examples of real research projects showed the immense potentials of the virtual Scientific Models as a tool for research.
At last a short critical look at the virtual scientific models as a part of the digital cultural heritage and new memories. At the moment in this part we are focused on the technical system, not on the basics like common principles. Therefore a great research project is planned, bringing institutions and experts together to find a new way for the further research with virtual scientific models. The intention is to contribute to the preservation of digital cultural heritage and the new intangible memory and the general availability of knowledge. Perhaps that will be a new vision for research in digital cultural heritage.

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