Zukunft Bau

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FÖRDERN FORSCHEN ENTWICKELN

ABRIDGED REPORT

Title

"Archaeological refurbishement of destroyed valuable cultural monuments with the goal of an anastylosis"

Occasion/starting situation

Syria has an immeasurable wealth of archaeological sites and architectural, civilisation and art history monuments. Many of these monuments were destroyed as a result of the civil war or were targeted during the fighting. The damage thus suffered by the world community is hence enormous. Returning these destroyed treasures back to mankind is an archaeological challenge, a challenge of monument conservation and a matter of Syrians' national identity.
The rescue of the monuments that have been destroyed is currently being prepared under the auspices of UNESCOA lot of documentation and virtual reconstruction work has been performed. All available materials will be compiled in order to be able to commence the reconstruction work once a sufficiently safe situation has been established. Thus, an anastylosis (also known as anastilosis) for a number of buildings becomes a possibility.
A considerable gap that currently exists became apparent at the conference of the Federal Foreign Office of the Federal Republic of Germany and UNESCO in June 2016 for the preparation of the reconstruction phase [1]:
The handling of the finds from the time they are found until they are reinserted into the original building. The research project is intended to provide an appropriate technology for this purpose.

The applicant/project manager Prof. Jäger was responsible for the planning and execution of the archaeological rubble clearance work for the Frauenkirche Dresden from 1991 to 1994 as well as for its evaluation and integration within the reconstruction process [2] [3] [4]. The technology developed at that time was based on the application of information technology that was the state of the art at that time with which a maximum level of information acquisition with simultaneous acceleration of the rubble removal process could and had to be achieved [2]. In principle, the methodology is still up-to-date today, but the possibilities have potentially increased on the basis of a technical basis that has been almost completely revolutionised.
Findings and results obtained: The sequence of work steps developed at that time can still be employed to this day. They correspond to the basic archaeological working methods for the handling of finds [5]. The experience gained is available in its entirety, as the entire process of rubble removal has been meticulously documented and archived. The documentation can be found in the researcher's archive.
Literature research: Extensive research was performed in the preparation of the application, which also covered peripheral areas. No significant new publications have been added since then ([6] [7] [8] [9] [10]). The Syria conference at the start of June 2016 [1] provided an overview of the current state of preparation, which, however, mainly focuses on the documentation and virtual reconstruction process using old documents.

Object of the research project

Decisive information in order to assign a find to its original location can be obtained based on the location of the find and the cause of the collapse. 3D bodies are required for the assembly.
To this end the findings and experience gained from the archaeological rubble clearance of the Frauenkirche in Dresden were used [2] [3] [4], which should serve as a basis and be brought up to date through the employment of new technologies and techniques:

0. Design of a general database and storage system using a software basis that can be generally used
1. Electronic recording of the finding in the location of the finding (scan and digital photo) - recording of the finding situation
2. Initial contact with the find and creation of the corresponding data record
3. Numbering of the find and first data recording and entry into the database
4. Recording/scanning of the find
5. Storage of the find in the special find storage area
6. Storage management via the find number, which is also an index in the database
7. Evaluation of the recordings / the scans - production of a 3D model
8. Manual /automatic assignment of the finds
9. Documentation of the result
10. Representation of the results
11. Description of the technology for comprehensive continued use

The Federal Republic of Germany plans to take on a not insignificant share of the war damage repair work in Syria. The research project serves to provide a technology that begins with the inspection of the site and ends with the reconstruction of the building from the finds.

Necessity: The in-house analysis in the follow-up to the Syria conference of the Federal Foreign Office together with UNESCO in Berlin in June 2016 demonstrated that there is currently a considerable gap for the described chain during the anastylosis of collapsed historical buildings and archaeological remains.
Urgency: Since essential information will be lost without further preparation when the clearance work begins, it is necessary to take precautions now so that the correct, up-to-date technology is available for immediate use at the required time.
Promotion of innovation: The innovative aspect of the project is demonstrated by the use of state-of-the-art information technology.
Contribution towards the strengthening of competitiveness: The project contributes towards an increase in competitiveness of German teams in such cases.

Conclusion

On the basis of the Syria conference at the Federal Foreign Office in June 2016, it became clear that there is a considerable gap in the process of clearing the rubble in preparation for the anastylosis. In order to close this gap, the process chain, which was performed by Professor Jäger's team during the clearance of the rubble of the Frauenkirche Dresden 1991-94, should be reformed through the application of modern technologies. The experience gained and problems that emerged during the work on the Frauenkirche provided an important basis for the pilot project due to the excellent documentation of the entire process. It was not only possible to view the documents used at that time, but also to interview the employees involved at that time.
The research project started with thorough research of the methods and technologies used then in addition to modern ones. It emerged here that the methods and working sequences used in the rubble clearance of the Frauenkirche are still used in today's (building) archaeology, but are now better supported using the available technologies. In the further sequence, both technology-based methods and also technologies that are supported by methods were designed. The choice of the development of a new way of working is based on this mutual influencing of matters and the findings gained from it.
In the area of source research, the options were extended to include the use of Internet research and resources available on the World Wide Web were exhausted. The documentation options where site inspections and stocktaking were employed were supplemented by the use of 3D laser scanning, drone photography and satellite images. A newly added method is represented by the timely construction of a 3D model before the start of the rubble clearance work based on the data collated from the source research and site inspection. The recording of the discovery site and the finds themselves was further revolutionised with the aid of drones, laser scanners and hand-held (laser) scanners.
The primary innovation to be highlighted is the information collection and management that accompanies the processes and management using the hermine software. Compared to previous methods, this guarantees the continuous, seamless and parallel documentation of all the working steps and not simply a selective status report of the sequence. Virtually all the work can be performed after the brief initiation of the operators, without the any need for special expertise in the performance of this work.
A not inconsiderable amount of time was required to design the requirements to be met and the desired user-friendliness in order to create a tool using hermine that can be used not only within the framework of this research project, but also in real scenarios and for any documentation of rubble clearance work. In order to further enhance its usability, hermine was additionally licensed as freely accessible and free open source software. A licence model was selected here where a so-called copyleft application is used, which does not protect the app from being distributed under a different name, but guarantees that any changes to the source code must also be made publicly available. Not only the application itself, but also all elements used in it or which are necessary for its operation have been implemented by means of open source solutions. It is thus completely independent of opt-in effects as caused by proprietary software. In general, the use of open source software proves to be possible in all steps of the rubble clearance and documentation processes. However, the performance of proprietary software was higher in the usage area, which was partly due to the manufacturer's ability to optimally equip hardware with its own software. The processing of the point clouds can, for instance, be performed consistently using CloudCompare or the recording of finds can be performed using photogrammetric methods and thus COLMAP or VisualSfM.
The performance of all the components was verified in a practical environment. The continuous recording of the discovery site and all the working steps in hermine proved to be extremely useful, due to the fact conclusions could be drawn at any time about the working sequence and current status. Due to the fact the expanse of ruins was recorded layer by layer as a point cloud, this offered manifold options for its subsequent evaluation. The recording of the finds using hand scanners went smoothly and models that were subsequently created proved to be extremely helpful during the reconstruction and find mapping processes. However, there is also still potential to optimise this process here in order to avoid the intermediate step of taking several images and the resulting compilation of the raw scans. The use of a vantablack material (https://de.wikipedia.org/wiki/Vantablack) as a scanning background could be considered for this purposes due to the fact the object to be scanned can thus be captured in its entirety and on all sides and no structures surrounding the scanning object are captured in this process.
Even in the event of unforeseen events, which require flexible action, it was still possible to demonstrate the efficiency and flexibility of the working method in the pilot project. With the exception of restrictions (weather, temperature) stipulated by the manufacturer for the technical aids, no problematic factors arose which would have negatively influenced the removal of rubble in accordance with the research.
It is conceivable that the processing of all recorded data records (merging the scans, mapping of finds, 3D modelling) that has until now been performed manually could be automated with the aid of a sufficient computing capacity and artificial intelligence. It is hoped that the guideline developed in the pilot project will find acceptance in international committees and become the standard work on rubble clearance. The acceptance and updating of hermine as an international database for rubble clearance work that has

already been performed or will be performed in the future is desirable. The associated archive notion and the function of the application as a knowledge and information store with regard to important world cultural heritage sites underline the globalisation concept.

Basic data

Abbreviation: Archäologische Aufarbeitung zerstörter Baudenkmale (Archaeological work on destroyed monuments) (ArchAuf)

Researcher/Project manager:
Prof. Dr.-Ing. Wolfram Jäger
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Total expenses: € 212,285.00

Proportion of this in the form of a subsidy from the German federal government:
€ 148,455.00

Project duration: 24 months

Bibliography

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[11] own representation/archive photo

ILLUSTRATIONS:

Figure 1 **Design of the arched section [11]**

Figure 2 **Collapse sequence [11]**

Figure 3 Finds with attached finding marks [11]

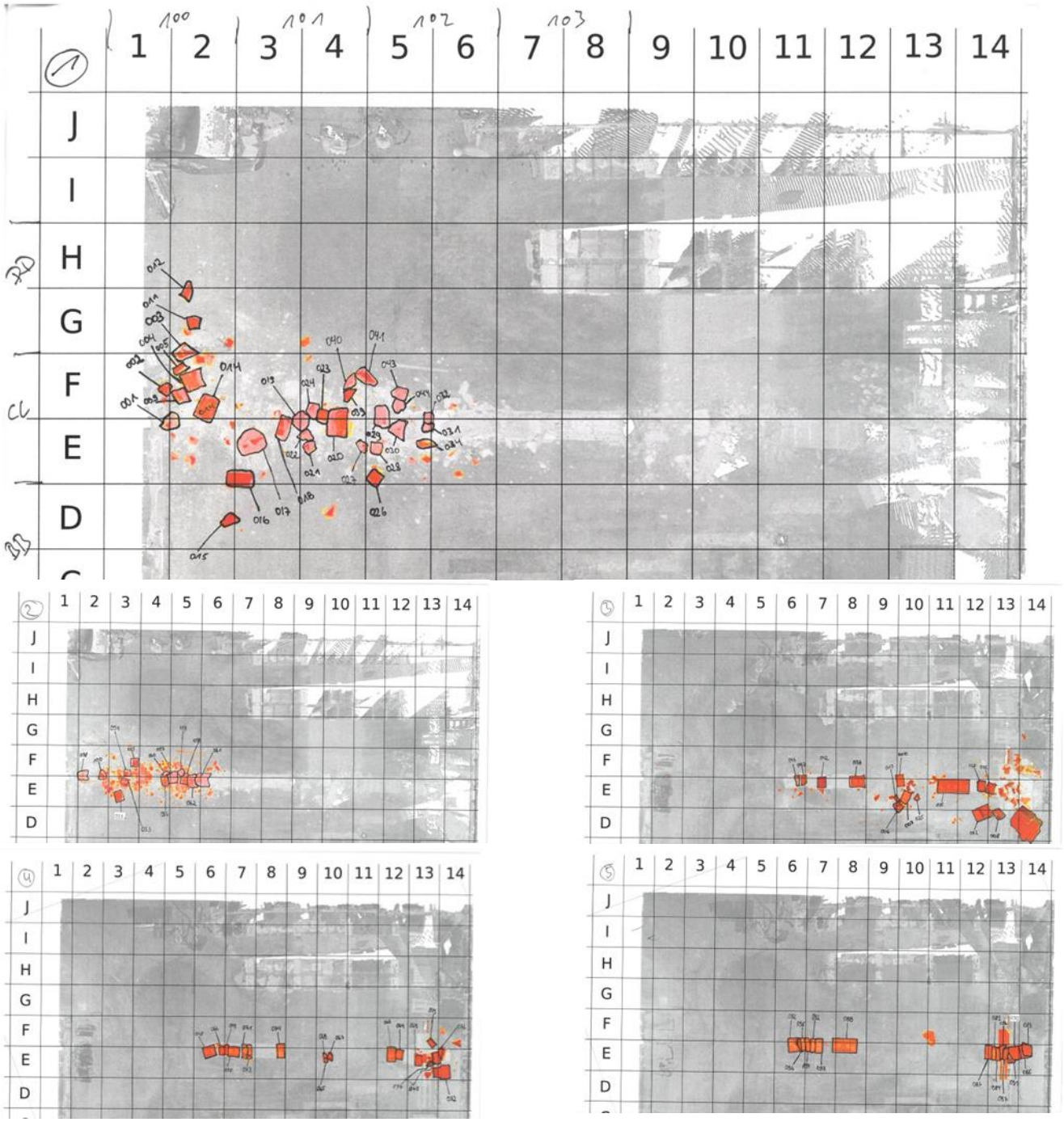

Figure 4 **Layer and step sequence of the rubble removal process [11]**

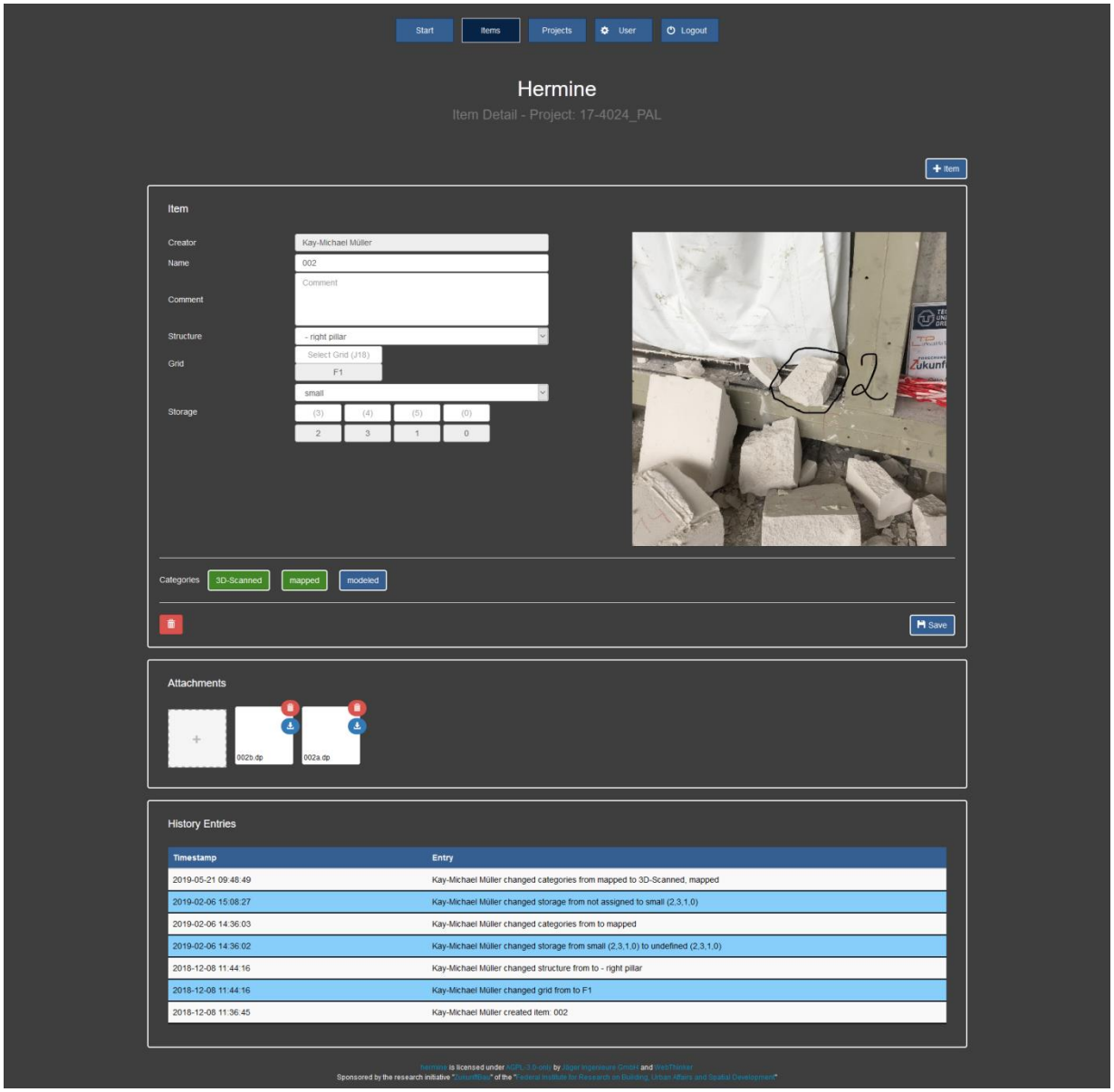

Figure 5 “hermine” rubble removal app [11]