UTILISATION OF HISTORICAL PLANS OF THE CASTLE OF HEIDELBERG FOR CHANGE DETECTION AND NEW CONSTRUCTION ACTIVITIES

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ABSTRACT:

Detailed data captures from past decades are available in some cases for very famous historical objects of cultural heritage. So a complete set of historical plans exists for the world famous Castle of Heidelberg (about 700 plans acquired 1883-1889) which offers a high quality in large scales (1:40, 1:5 and 1:1). The presented paper demonstrates that this precious historical data base is very useful for current conservation as well as for new construction activities inside the castle.

To be able to integrate this great amount of analog plans into modern data processing and management systems the original plans had been digitized by means of a scanner. Afterwards the ground plans were geometrically rectified on the base of control points which could be still identified. The measures of the actual status were done by tacheometry. The obtained accuracy after transformation lies between ±1cm and ±3cm which seems to be suitable for the required tasks mentioned above. To convert the information of the scanned and rectified ground plans from raster to vector format the graphical elements had been digitized manually. In the same way all sheer plans (upright projections) of vertical walls had been geometrically rectified, however, they were not manually digitized (due to the extensive amount of work) but overlaid with currently created orthophotos of these objects. The accuracy was slightly lower (between ±1cm and ±5cm), dependent on the number and spatial distribution of the still identifiable control points.

Now the first aim was to use the existing data capture for ongoing conservation tasks. Therefore, a preliminary investigation concerning the completeness and the level of detail of the historical data was necessary. This was realized by a visual inspection of the above mentioned overlays/superimpositions with digital orthophotos captured during the last years. In this paper examples are presented which demonstrate that all main structures of the buildings had been acquired completely and with a high level of detail and accuracy. However, relatively homogeneous bricking structures have been drawn not accurately but simply as a kind of "stone signature". One main application of these overlays was an extensive change detection which confirmed a lot of destructions and rebuilding activities like a missing chimney, shortened cross vaults or windows which had been closed and plastered during the last 100 years. Therefore, a great number of architectural changes could be detected and their dimensions could be measured from this digital image information. Some essential examples will be presented in this paper. Additionally, the new orthophotos as technique for obtaining geometric information provided a basis for mappings to preserve and restore the ruins of the Castle of Heidelberg. For instance – amongst others – a material mapping and a damage mapping have been produced.

A second aim of this approach is the usage of historical data as base for new construction activities. Since the high geometric quality of the historical plans (after digitizing and rectification) has been proved, the idea was to use main parts of it instead of a completely new data acquisition, e.g. as base for planning and construction of a new pavilion inside the Vitreous Hall Building ("Glaeserner Saalbau").

All data – (digital) historical plans and current photogrammetric and geodetic acquisitions as well as derived thematic maps etc. – are integrated in a common data base as part of the facility management system developed for organisation and support of the versatile activities concerning the Castle of Heidelberg.

ZUSAMMENFASSUNG:

In einigen Fällen existieren für sehr bekannte historische Bauwerke des Kulturerbes detaillierte Datenerhebungen aus der Vergangenheit. So ist ein kompletter Satz an historischen Plänen für das weltberühmte Heidelberger Schloss verfügbar (ca. 700 Pläne, zwischen 1883 und 1889 erfasst), die eine hohe Qualität in großen Maßstäben besitzen (1:40, 1:5 und 1:1). Der hier präsentierte Beitrag zeigt, dass diese wertvolle historische Datenbasis sehr nützlich für die laufenden Konservierungsarbeiten sowie zur Unterstützung neuer Baumaßnahmen innerhalb des Schlosses ist.
Um diese große Anzahl an analogen Plänen in ein modernes Datenverarbeitungs- und -management-System integrieren zu können, mussten die Originalpläne mit Hilfe eines Scanners digitalisiert werden. Danach wurden die Grundrisse auf der Basis von identischen Punkten (Paßpunkten) entzerrt, die noch identifiziert werden konnten. Die Messungen des aktuellen Zustandes wurden mittels Tachymetrie durchgeführt. Die erreichte Genauigkeit nach der Transformation lag zwischen ±1cm und ±3cm, was geeignet für die geforderten Aufgaben erscheint. Zur Raster-/Vektor-Konvertierung der gescannten und entzerrten Grundrisse wurden die grafischen Elemente manuell digitalisiert. In ähnlicher Weise wurden auch die Aufrisse und Ansichten der vertikalen Wände entzerrt, jedoch wurden diese auf Grund des extremen Arbeitsaufwandes nicht manuell digitalisiert, sondern den aktuellen Orthophotos dieser Objekte überlagert. Die Genauigkeit war hier geringfügig niedriger (zwischen ±1cm und ±5cm), abhängig von der
Anzahl und räumlichen Verteilung der noch identifizierbaren Paßpunkte.
Das erste Ziel des Projektes war es, die existierende Datenerfassung für die laufenden Erhaltungsaufgaben zu nutzen. Daher war eine Voruntersuchung bezüglich der Vollständigkeit und des Detaillierungsgrades der historischen Daten notwendig. Diese wurde mit Hilfe einer visuellen Inspektion der oben erwähnten Überlagerungen mit den digitalen Orthophotos realisiert, die in den letzten zwei Jahren aufgenommen wurden. In diesem Artikel werden Beispiele präsentiert, die zeigen, dass alle wesentlichen Strukturen der Gebäude vollständig und mit einem hohen Grad an Detaillierung und Genauigkeit durch Koch/Seitz erfasst worden sind. Jedoch wurde relativ homogenes, einheitliches Mauerwerk nicht korrekt wiedergegeben, sondern nur als eine Art "Steinsignatur". Eine wesentliche Anwendung dieser Überlagerungen war eine ausführliche Änderungserkennung, die eine große Anzahl an Zerstörungen und Umbaumaßnahmen bestätigte, wie z. B. ein fehlender Kamin, gekürzte Kreuzbögen oder ein Fenster, das während der letzten 100 Jahre zugemauert und verputzt worden ist. Auf diese Weise konnte ein große Anzahl architektonischer Veränderungen aufgedeckt und deren Dimension mit Hilfe der digitalen Bildinformation gemessen werden. Einige wesentliche Beispiele werden in diesem Beitrag präsentiert. Zusätzlich dienen die aktuellen Orthophotos - eine Technik zur Erfassung geometrischer Informationen - als Grundlage für weiterführende Kartierungen zur Erhaltung und Restaurierung der Ruine des Heidelberger Schlosses. So wurde damit beispielsweise - unter anderen Anwendungen - eine Zustands- und eine Schadenskartierung durchgeführt.
Ein zweites Ziel dieses Ansatzes ist die Nutzung der historischen Daten als Basis für neue Baumaßnahmen. Nachdem die hohe geometrische Qualität der historischen Pläne - nach der Digitalisierung und Entzerrung - nachgewiesen werden konnte, bestand die Idee darin, wesentliche Teile daraus zu verwenden an Stelle einer kompletten Neuaufnahme, z.B. als Grundlage für die Planung eines neuen Pavillions innerhalb des sog. "Gläsernen Saalbaus".
Alle Daten - die (digitalen) historischen Pläne, die aktuellen photogrammetrischen und geodätischen Erfassungen sowie die abgeleiteten thematischen Kartierungen etc. - werden in eine gemeinsame Datenbank als Teil des Facility-Management-Systems integriert, das zur Organisation und Unterstützung der verschiedenen Aktivitäten am Heidelberger Schloss entwickelt wurde.

1. INTRODUCTION

In some cases detailed data captures from past decades are available for famous historical objects of cultural heritage. Fortunately a complete set of historical plans exists for the world-famous Castle of Heidelberg. The aim of this paper is to demonstrate that this precious data base is very useful for current conservation as well as new construction activities inside the castle. The support of conservation tasks concerns mainly a change detection to recover many destruction and rebuilding activities during the last 100 years. The integration of the historical data into the current digital database of the facility management system for new construction activities aims to an avoidance of extensive new data captures inside the castle. If a sufficient data accuracy and completeness can be verified, these data may serve for planning purposes.

2. DATA

The complete set of historical (analog) data comprises about 700 plans, which were captured by the architects Koch and Seitz in the years 1883-1889 (Krimm, Ganz, 2005; LDA, 2005; Goetze, Fischer, 1988). This set can be subdevided into ground plans (Figure 1), sheer plans (upright projections) and vertical sections (Figure 2) as well as a lot of detailed mappings. The accordant scales are 1:40 for approx. 250 ground and sheer plans and 1:5 to 1:1 for the remaining detailed plans. Most of the original measurement lines could be reconstructed which enable the transformation of the historical data into the modern (digital) facility management system. For comparison and supplement current photogrammetric images of main facades were taken during the last years by a large format camera (LINHOF METRICA 45) and rectified as orthophotos based on control points.

3. PREPROCESSING

3.1 Digitizing

To be able to integrate this great amount of analog plans into a modern (digital) data processing and management system the original plans had to be digitized by means of a scanner. For lack of a large format scanner (the dimension of the plans is up to 1.0m x 0.8m !) and due to the thickness of the drawing cartons the analog originals where captured by a large format camera (LINHOF with APO-SYMMAR 300mm focal lens) by F.

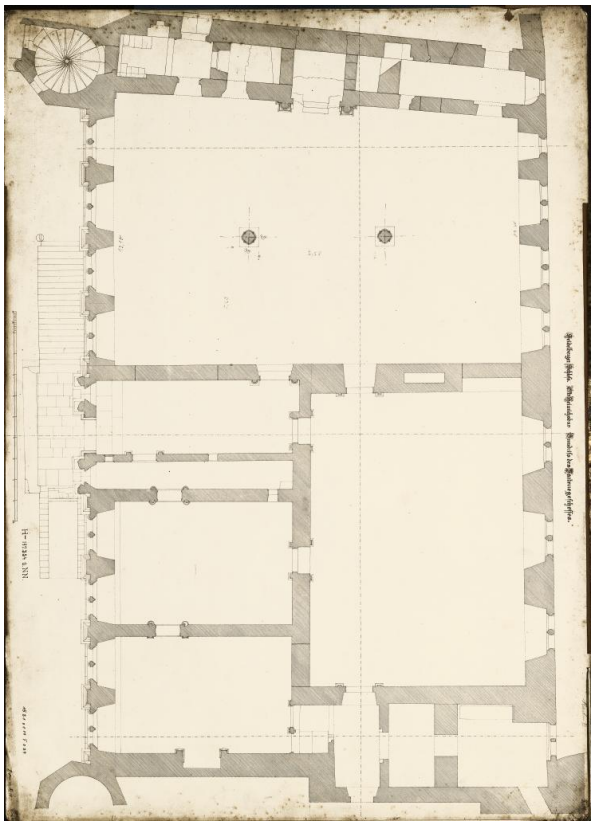

Figure 1. Example of an original ground plan of Koch/Seitz (1883-1889)

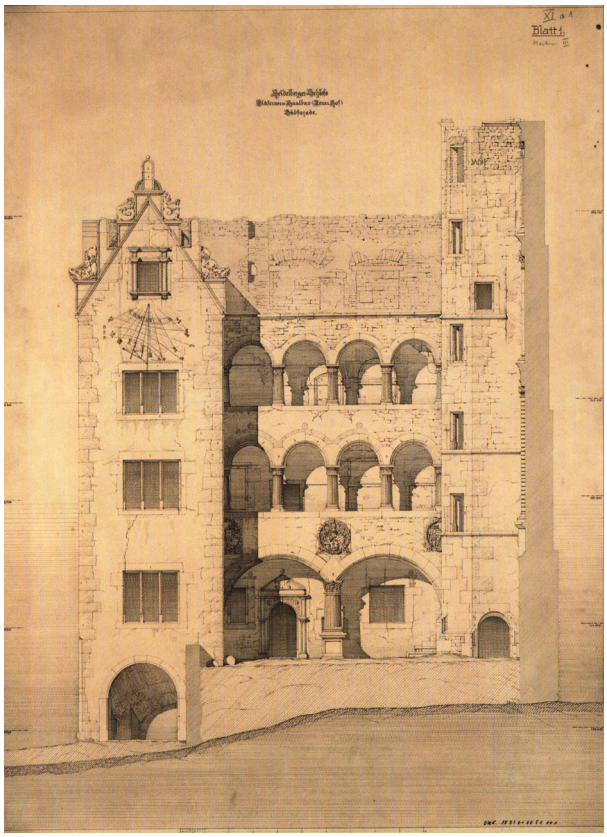

Figure 2. Example of an original sheer plan of Koch/Seitz (1883-1889)

Gross (Karlsruhe). The camera is equipped with a digital scan-back PHASEONE which contains a line scanning array of 10.000 Pixel. This results in an image area of about 100mm x 84 mm. These additional influences (camera, scanback) on the geometric accuracy has to be taken into account during the subsequent rectification process. Afterwards these geometrically rectified raster data were transferred to vector data by manual digitisation.

3.2 Rectification

A geometric rectification of the digitized ground plans (raster format) had been performed by means of (natural) control points (Ringle et al., 2005). The measures of the actual status were done by tacheometry. A comparison of some distances was used to determine systematic deformations of the plans (e.g. shrinkage of the drawing cartons)). The differences in longitudinal as well as in transversal direction lay between 0.00m and 0.05m (in object space). The obtained accuracy after transformation by means of control points is shown in Table 1.

Minimum	Average	Maximum
± 1.0 cm	± 1.5 cm	± 3.0 cm

Table 1. Accuracy of the rectification of scanned ground plans based on control points

Because one single ground plan is only a subset of the castle area – and even of most buildings – the single rectified data sets had to be merged by a registration process based on a affine transformation. Figure 3 shows two single original plans which were registered to one unified data set (Figure 4 and 5). In Table 2 the residuals after transformation are assembled.

Minimum	Average	Maximum
± 0.5 cm	± 1.5 cm	± 3 cm

Table 2. Accuracy of registration process

To convert the information of the scanned and rectified plans from raster to vector format the graphical elements had been digitised manually (Figure 5).

In a similar way the sheer plans had been geometrically rectified, but based on current photogrammetric orthophotos (Nutto, Ringle, 2000; 2001), because not enough natural control point could be identified. However, it was also quite difficult to detect and identify corresponding points and structures resp. in these rather different representations of the same objects: on one hand historical plans and on the other hand current photogrammetric images.

But in a direct comparison between the plans and orthophotos more identical points could be found than by tacheometry. The resulting accuracy was slightly lower, dependent on the number and spatial distribution of these control points (Table 3).

Minimum	Average	Maximum
± 1.0 cm	± 2.0 cm	± 5.0 cm

Table 3. Accuracy of rectification of digitised sheer plans based on (natural) identical points in orthophotos

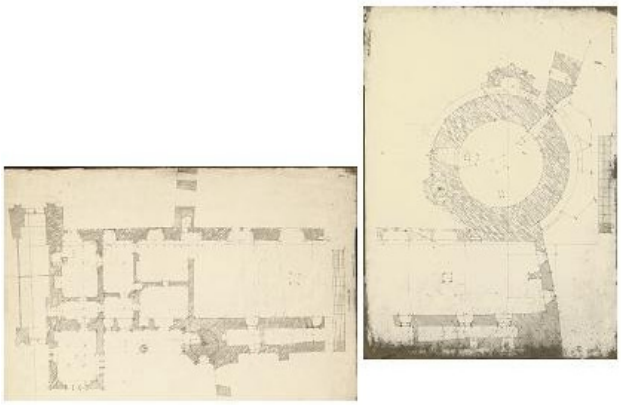

Figure 3. Two single original ground plans of Koch/Seitz

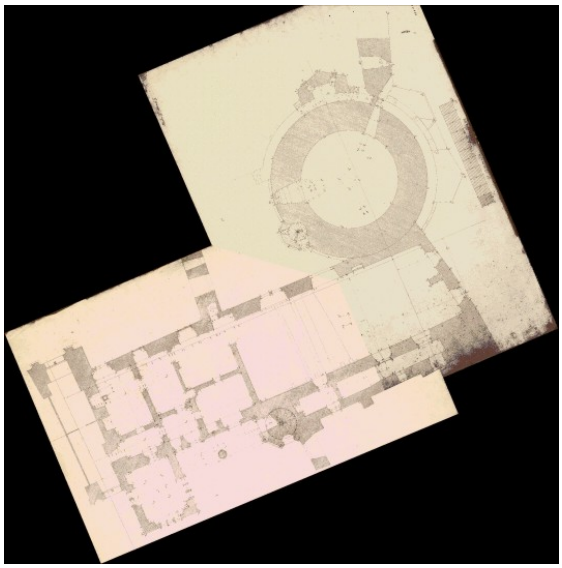

Figure 4. Unified (transformed) data set of two plans (cf. Fig.3)

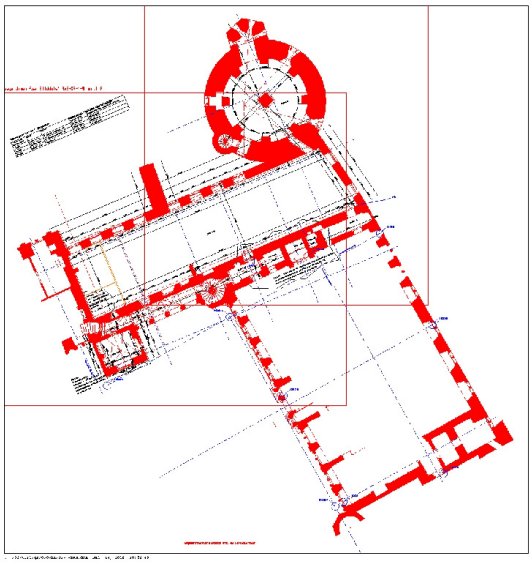

Figure 5. Unified and digitised data set (cf. Fig. 4)

However - in contrast to the ground plans - the geometrically rectified sheer plans were not manually digitized due to the extensive amount of work (cf. Figure 2 and 6) but overlaid with the orthophotos mentioned above (cf. Section 4).

4. SUPPORT OF CURRENT CONSERVATION ACTIVITIES

The first aim of this project was to use the existing historical data capture for ongoing conservation tasks (Mohn et al., 2004). Therefore, a preliminary investigation concerning the completeness and the level of detail of these data was necessary. For this, an overlay of the rectified sheer plans and the orthophotos was carried out. The subsequent quality assessment was realised by a visual inspection of these overlays (Figure 6). The assessment proved that all main features and structures of the facades had been acquired completely with a high level of detail and accuracy. However, relatively homogeneous bricking structures are drawn not accurately but simply as a kind of "stone signature" or a general "bricking pattern".

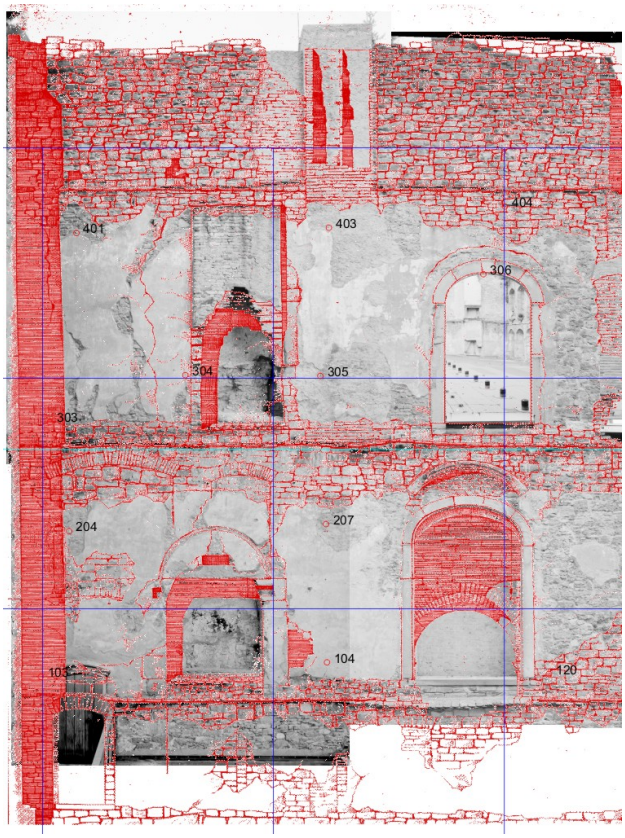

Figure 6. Overlay of a rectified historical plan and an orthophoto

One main application of these overlays was an extensive change detection which confirmed a lot of destructions and rebuilding activities during the last 100 years. For instance a chimney is missing now which is mapped in the corresponding plan of Koch/Seitz. In another part of the castle windows appear in the historical data which had been closed and plastered meanwhile; cross vaults had been shortened or a door had been displaced (Figure 7). Therefore, a great number of architectural changes could be detected. One of the advantages of this method is that

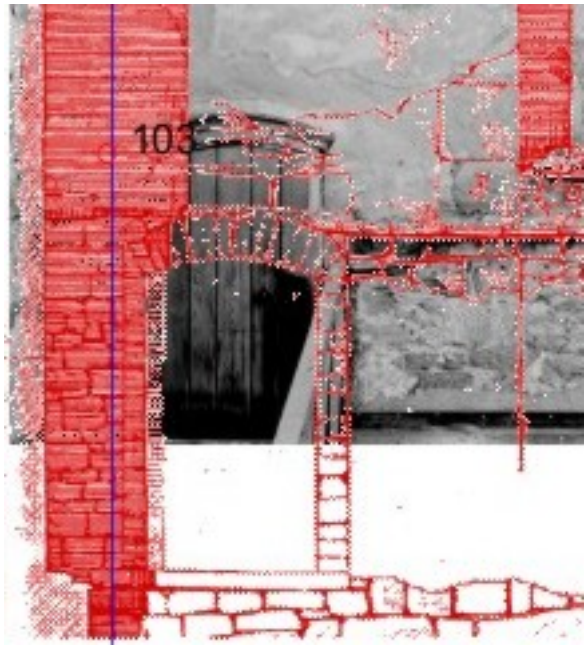

Figure 7. Overlay for change detection, e.g. displaced door

additionally the dimensions of these changes can be measured from the digital image information.

Another advantage is that digital orthophotos - as technique for obtaining geometric information - may serve as basis for mappings to preserve and restore the ruins of the Castle of Heidelberg. Two examples - among others - will be a material mapping or a damage mapping (Figure 8).

Figure 8. Damage mapping based on current orthophoto by H. Schaefer

5. SUPPORT OF NEW CONSTRUCTION ACTIVITIES

A second aim of this approach is the usage of the historical data base also for new construction activities to avoid extensive new data captures inside the castle. Because a sufficient geometric quality (accuracy, completeness, level of detail etc.) of the historical data could be verified, these digitised plans can also be integrated in the planning process of new constructions. For instance, the concept and design of a new pavilion inside the Vitreous Hall Building ("Gläserner Saalbau") was partially based on the data of Koch/Seitz. Figure 9 shows an upright projection of the planned building, using the historical data base.

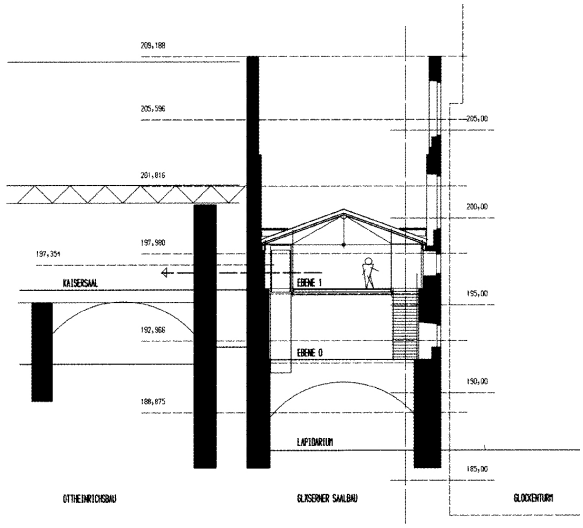

Figure 9. Upright projection of the planned pavilion inside the Vitreous Hall Building, based on the rectified historical data (Koch/Seitz).

6. CONCLUSION

This project has shown that historical data captures – if available – may provide a significant contribution to main conservation and new construction activities. For the famous Castle of Heidelberg some substantial examples could be demonstrated how these precious data can be integrated in a modern, digital facility management system.

All data – historical plans, current photogrammetric and geodetic data acquisitions as well as derived thematic maps (e.g. damage maps) – have to be related to a uniform coordinate system and included in a common data base. This is an important precondition to coordinate the versatile activities in such a complex building.

Acknowledgement:

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