PHOTOGRAMMETRY, REMOTE SENSING AND SPATIAL INFORMATION SCIENCE FOR HERITAGE DOCUMENTATION

K. Kraus
Institute of Photogrammetry and Remote Sensing, Vienna University of Technology, Gußhausstraße 27-29/E122, A-1040 Vienna, Austria, kk@ipf.tuwien.ac.at

KEYWORDS: Heritage Documentation, Cellini´s sculpture Saliera, Behaim Globe, Buddha statues of Bamiyan, National Park Neusiedler See, archaeological excavations in Ephesos, Schloss Schönbrunn, Historic Centre of Vienna

ABSTRACT:

The frame to this presentation is provided by the intermediatory role of CIPA with its RecorDIM initiative, between ICOMOS on the one side, and ISPRS on the other. Exemplified by seven relevant occasions and projects (see Keywords), ways and potentials of special contributions to precise and comprehensive heritage documentation will be described – applying methods and procedures as developed and provided by the ISPRS. Additionally, for each project, closing statements – in some cases just *keywords* – are given to concern potential financing, and the main technical points exemplified by the project.

1. PRELIMINARY REMARKS

International organizations such as ICOMOS (International Council of Monuments and Sites) and ISPRS (International Society for Photogrammetry and Remote Sensing) are energetically pursuing most of the aims as formulated by their respective statutes and bylaws. Issues connecting such organizations are not given sufficient attention, however. CIPA (International Scientific Committee for Documentation of Cultural Heritage) at the seam between ICOMOS and ISPRS provides the corresponding bridging function; with its RecorDIM initiative (Recording, Documentation and Information Management), CIPA has set ambitious goals for the coming four years, closely connected with ICOMOS and with ISPRS. Corresponding activities play an important role also in the CIPA Symposium Antalya 2003.

2. INTRODUCTION

This contribution to the CIPA Symposium is declared as ISPRS presentation. I am going to deal with points of ISPRS competence in Photogrammetry, Remote Sensing and Spatial Information Sciences in correspondence with §1 of its statutes. I am addressing in the first line the ICOMOS community; to do this via the CIPA seems to me appropriate and reasonable. – In the next half an hour the CIPA can be considered as some relay station connecting ISPRS and ICOMOS.

I am going to comment on several occasions indicating the necessity to intensify heritage documentation. To describe the very wide methodological and technological spectrum represented by ISPRS, I will use typical examples. I am asking for your understanding for presenting several projects with involvement of our institute, the Institute for Photogrammetry and Remote Sensing (I.P.F.). In the literature (e.g. Proceedings of the CIPA-Symposium in Potsdam 2001) one can find numerous descriptions of similar and comparable projects, and also of projects considerably more far-reaching than those at the I.P.F.

For each project, first a short general description is given, followed by a more detailed presentation of the special methods and techniques applied. Statements or just *keywords* concerning on potential financing and the relevant technical points is rounding up the description of each project.

3. ROBBERY OF A SCULPTURE FROM VIENNA'S ART HISTORY MUSEUM

There are numerous accounts of this robbery in the Internet. The following slightly modified citations are from (Fleishman/Yee, 2003): "Climbing, scaffolding and smashing a window, thieves slipped into Vienna's Art History Museum and – despite high-tech motion sensors and round-the-clock guards – disappeared with a 16th-century gold-plated masterpiece sculpted by Benvenuto Cellini. The sculpture, known as the Saliera, or salt cellar, is valued at about € 50 million."

Cellini wrote this about the Saliera: "In order to show how the sea is connected with the Earth, I made two figures … The sea, depicted as a man, holds a richly decorated ship which was intended to hold salt. The Earth, I depict as a woman, of such lovely form and as graceful as I knew how to create. Next to her I placed on the ground a richly decorated temple, which was intended to hold pepper."

Figure 1: The stolen sculpture called Saliera

The loss in such cases could be somewhat easier if the article stolen would have been thoroughly documented at an earlier date. The currently best method for such recording is close range laser scanning.

Financing such projects could be solved in my opinion via sponsorship. Related information should be accessible at the corresponding museum.

Technical keyword: *'Close Range Laser Scanning'*
Financial keyword: *'Sponsorship for Valuable Pieces of Art'*

4. THE 500 YEARS OLD BEHAIM GLOBE

The oldest Earth Globe preserved has been created in 1492, immediately before the discovery of America by Christopher Columbus. This globe is at the German National Museum in Nuremberg, and it may not be accessed by the public for reasons of safety. On the occasion of the globe's 500th anniversary, the museum directorate sought some suitable method of documenting it; another important aim of this documentation was also to provide this way an access to the globe for the general public, and in the first line for historians and geographers.

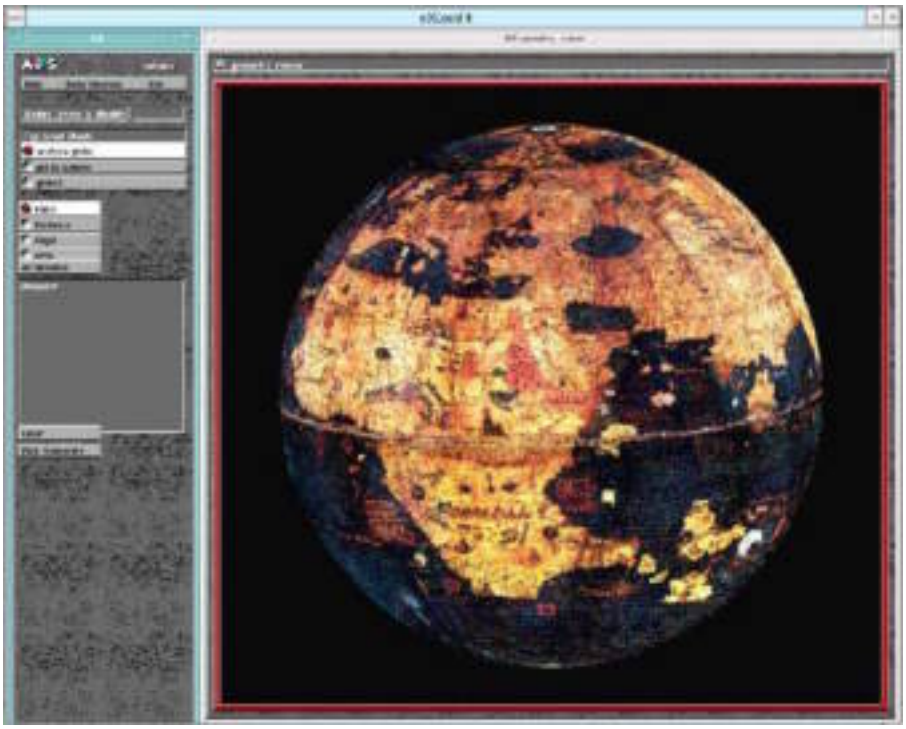

Figure 2: The Digital Behaim Globe

The I.P.F. (Dorffner, 1996) has taken 34 photographs using a large format glass plate camera. These photographs have been scanned, and applying these digitized images a surface model of the globe has been derived. Given these prerequisites, the digital Behaim Globe was computed (Figure 2). The digital Behaim Globe allows for interactively rotation, shifting, zooming, and prospecting it in three-dimensions. It also allows for measuring 3D co-ordinates of points on its surface – with no need to access the original. These capabilities are valuable for teaching geography in the schools. Historians and geographers, but also private amateurs, can choose of different resolution levels fitting best their individual purposes – e.g. of analysis. Of special interest has been – and still is – the integration of current geographical information with the historical contents of the Behaim Globe.

Based on those parts of the original painting with the colors conserved best, colors for the rest of the globe's surface have been restored – and archived for the future.

Financial Statement: This is a prominent example of presenting and thus documenting valuable pieces of Art and of History on their major anniversaries. Such occasions often allow for special public or private financing.

Technical Statement and Keywords: A special feature is the application of a non-Cartesian reference co-ordinate system, often necessary for documenting curved surfaces – in this case the surface of a sphere. *'Presentation in Internet', 'Digital color conservation'.*

Similar techniques have been applied in another project to the frescos of the cupola in the Hagia Sofia (Dorffner et al., 2000).

Figure 3: : The largest statue of the Buddha in Bamiyan, 55 m high

5. DESTROYING THE BUDDHA STATUES OF BAMIYAN

From the point of view of photogrammetry, the homepage of the ETH Zürich (the Federal University of Technology, Zurich) is of special interest; (Gruen/Remondino, 2002). It is the main source of the following slightly modified citations:

"Strategically situated in a central location for travelers from North and South and East and West, Bamiyan was a common meeting place for many ancient cultures. And for 500 years, Bamiyan valley was one of the major Buddhist centers from the second century up to the time that Islam entered the valley in the ninth century. All along the valley, three big statues and many caves were carved out from the hill. The caves are full of paintings and were carved in the same period as the statues; see Figure 3.

On Monday, March 12, 2001, the Director General of UNESCO (United Nations Educational and Cultural Organization), Koichiro Matsuura said in a statement released at the UN Cultural Organization's Paris headquarters that the UN Envoy to Afghanistan has confirmed that the ancient Buddha statues at Bamiyan have been destroyed by the ruling Taliban militia. This cultural heritage goes back over two thousand years and was protected by UNESCO."

The Afghanistan Institute & Museum, Bubendorf (Switzerland), and the New7Wonders Society & Foundation, Zürich (Switzerland), have launched a campaign to reconstruct the Buddha statues at original shape, size and place. Armin Grün´s group (ETH Zürich) has volunteered to perform the required computer reconstruction, which serves as a basis for the physical one. The 3D reconstruction of the original Buddha will be in particular using metric photographs taken in 1970 by Prof. Robert Kostka, Technical University of Graz, Austria.

The reconstruction process consists of

- scanning the high resolution photographs;
- manual measurements on the metric images;
- image matching to extract a 3D point cloud;
- point cloud editing and surface triangulation;
- texture mapping and visualization.

Technical Statement: The manual measurement on metric stereo images for physical reconstruction of statues and of similar objects is still the adequate method of image compilation. Image matching is a valuable additional method in cases with flat surfaces and rich image texture.

Financial Statement: To take good metric photographs is very cheap[1], and the expensive restitution of them can be done on demand. For highly valuable pieces of art and historical monuments destroyed, fundraising for the compilation needed to restore them is usually successful.

[1] For simple photogrammetric documentation the CIPA 3x3 rules (Waldhäusl et al., 1994) are useful.

6. PARTIAL RE-NATURALIZATION OF THE NATIONAL PARK NEUSIEDLER SEE-SEEWINKEL / FERTÖ-HANSAG

In the previous example, photogrammetric compilation was based on images taken more or less by chance: professor Kostka has taken metric photographs at the time he spent in the region with an expedition. Historical aerial photographs are present in most countries since the 1950s. For country-wide mapping, regular aerial photography is carried out periodically every couple of years, and stored in archives. In addition to aerial photographs, historical country-wide or regional maps can be useful.

Similar historical maps and photographs have been of great benefit to re-naturalization of the national park Neusiedler See (Lake Neusiedler). Neusiedler See is situated in a basin without outlet. Of special interest in the National Park are the meadowlands created through use for traditional haymaking, the remaining pastureland, and the unique, frequently evaporating saltwater pants with their varying salinity levels. These biotopes are internationally famous and important for their many nesting or migrating wading bird species. However, from the beginning of the 20th century wide spread artificial draining took place, withdrawing the surface waters from that area very effectively and also lowering the water table in waterlogged soils. The water surface has been reduced by 75%.

As mentioned above, historical maps and photographs have been greatly beneficial to re-naturalization; nevertheless, they do not provide sufficient information on terrain elevations. Therefore a high-quality digital terrain model (DTM) has been generated in applying the new technology of airborne laser scanning. Figure 4 is a color-coded representation of this DTM. The areas up to a certain level are colored blue so to suggest coverage by water. For more details see (Herzig et al., 2001).

This project is a first step in establishing a National Park information system. It is thought to be open to various sets of data, thus providing for a multidisciplinary management and analysis tool, to assist in multiple criteria spatial decision making and conflict resolution (scientific, political), as well as for monitoring the past and present state and predicting future developments of the valuable but vulnerable ecosystem of the National Park.

Technical Statements: Applying historical maps and aerial photographs allows for monitoring changes in the past. In hydrologically susceptible areas, precise digital terrain models are also of great importance; nowadays, such models can be derived from airborne laser scanner data.

Financial Statement: For adequate management of national parks, detailed and many-sided information and documentation are inevitable, to be stored and accessed via spatial information systems. To provide for this, considerable financing is inevitable.

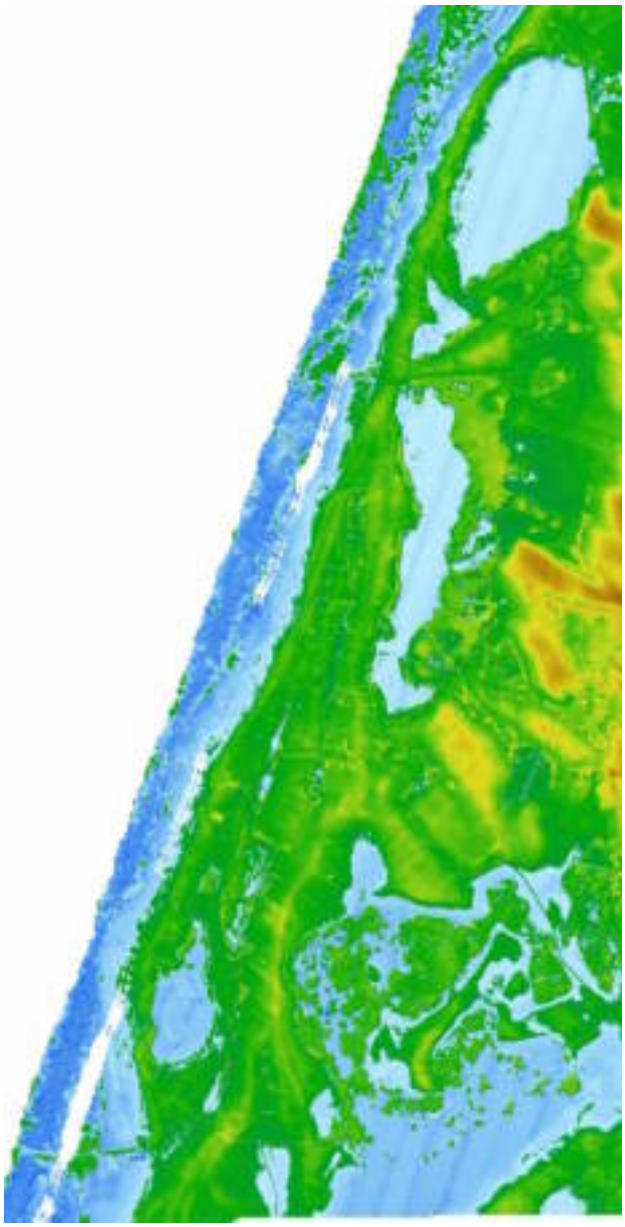

Figure 4: Color coded terrain model derived from laser scanner data.

7. INFORMATION SYSTEM FOR ARCHAEOLOGICAL EXCAVATIONS IN EPHESOS.

A spatial information system, such as the one mentioned at the end of the last section, is under development for the archeological excavations in Ephesos (Klotz, 2003). Ephesos, on the west coast of Asia Minor in Turkey, used to be one of the most important cities of the Roman Empire. Here, Austrian archaeologists have been carrying out research and excavation for more than a hundred years.

A digital orthophoto derived from images 1:15 000 serves as spatial reference co-ordinate system, the orthophoto providing users of the archaeological information system with easy orientation. The orthophoto carries markers linked with further information in the system. Fig. 5 shows a detail of the orthophoto with some vector data overlaid, representing the surroundings of the ancient

East Gymnasium. The vector data have been generated by digitizing and generalization of existing paper plans. The original plans carry individual local coordinate systems in different scales, and with different orientation. It is decided to gradually convert all relevant data of the excavations and of research to the new spatial reference co-ordinate system.

Technical Statement: Digital Orthophotos are well suited as spatial reference co-ordinate system for archeological and other similar information systems.

Financial Statement: Storing various types of information in the same spatial information system allows for distributing the relevant costs among different groups of its users.

Figure 5: Digital Orthophoto of Ephesos with the ancient East Gymnasium

8. HERITAGE DOCUMENTATION SYSTEM FOR THE SCHÖNBRUNN CASTLE

The castle Schönbrunn is one of the major attractions in Vienna. It has about 6.7 million visitors per year (http://www.schoenbrunn.at). Permanent restoration activity is inevitable for preserving this jewel. The supporting documents needed are created by applying photogrammetry. Fig. 6 shows a small section of the facade. Vector data are compiled in considering both metrics and topology (Kraus, 2003). Concerning local building conditions, the orthophoto yields valuable hints and information.

Figure 6: Digital orthophoto of a small section of the facade of the Schönbrunn Castle, with vector data overlaid.

On initiative from Dr. Kippes (Castle Schönbrunn, Management) a Building Management System will be created, and all data and information stemming from photogrammetric compilation stored in it. In this process, relational data is specified, linking with other relevant information as stored – such as restoration conditions, origin of the geometric data source, etc. Most of the commonly used systems provide the capability to handle 2 ½ D vector data only. Moreover, the integration of raster data for modeling purposes is not supported (it can only be integrated as surface texture, to serve purposes of visualization). For proper and convenient heritage documentation, a geometric 3D building management system with the 4th dimension – the time scale – is needed.

Technical Statement: 4-dimensional information systems have to be developed, to allow, on the one hand, for relationally connecting geometric models with other special information, and on the other hand, to represent monument and site changes in time.

Financial Statement: Including information as needed by tourism management into the general spatial information system may provide some financial contribution for purposes of heritage preservation.

9. PRESERVING THE „HISTORIC CENTRE OF VIENNA“, DECLARED TO WORLD HERITAGE

Including a monument or site in the World Heritage List (WHL) by the UNESCO is a highly valuable predicate. The list contains currently 754 items; the Buddha sculptures of Bamiyan (Section 5), the Cultural Landscape of Fertö/Neusiedler See (Section 6) and the Palace and Gardens of Schönbrunn (Section 8) belong to it. Year for year there are considerable additions to the WHL; some critics speak of inflationary trends in this respect (e.g. Bartetzko, 2003).

The predicate „World Heritage“ attracts many more tourists; alone for this reason, this status, ones achieved, will be kept as far as possible. This is also true, e.g., for the „Historic Centre of Vienna“ – a status granted in 2001; it resulted in much activity in photogrammetry, laser scanning, and in spatial information science. Applying the data thus acquired allowed the corresponding department of the municipality of Vienna (MA 41) to derive of them a 3D urban model of the city (Figure 7).

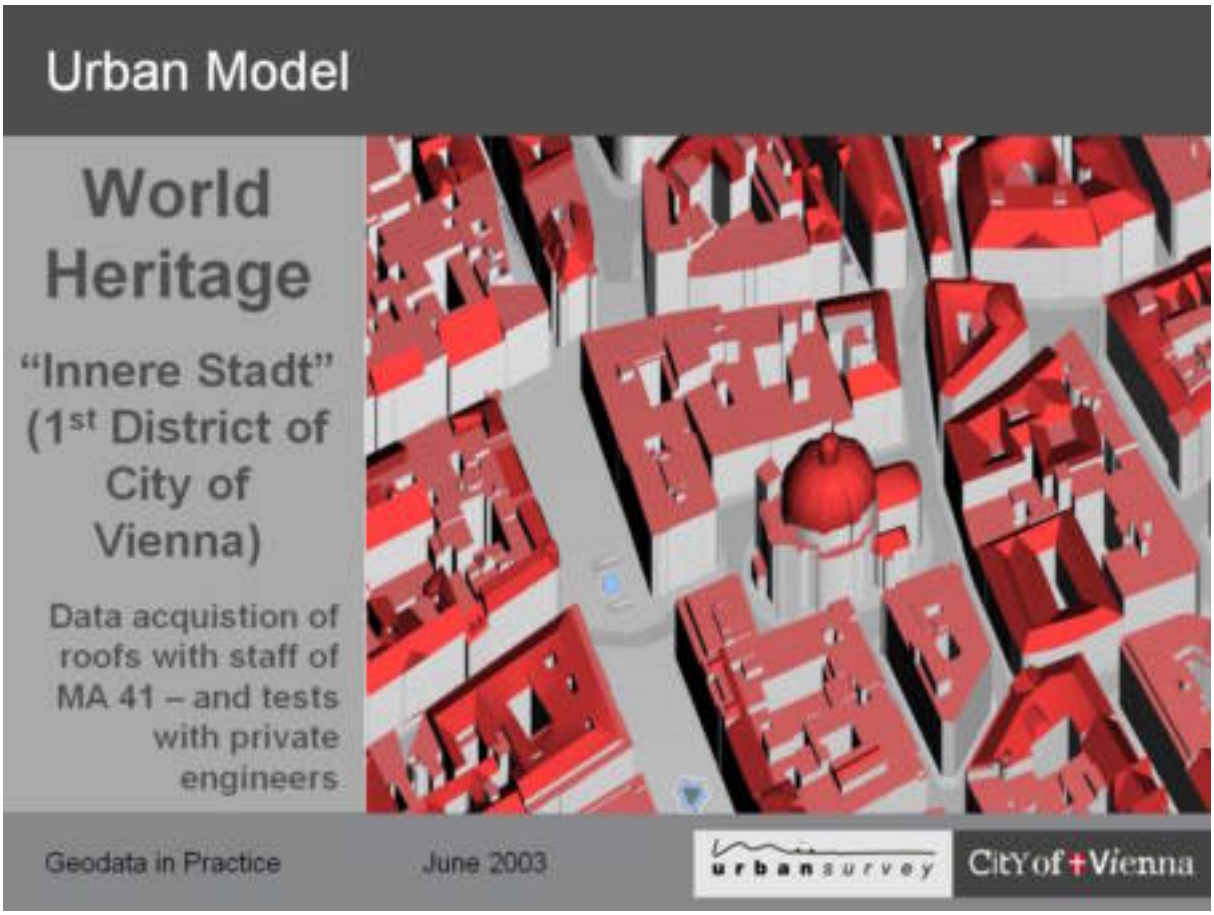

Figure 7: 3D urban model of Vienna

New projects of construction have to be considered carefully when historical sites are affected. In Vienna there is currently an intensive discussion about the project „Wien Mitte"; it is about constructing several high-rise buildings in a buffer zone to the city, the highest of which is planned to be 97m tall (Klotz/Zunke, 2002). In discussing the project with UNESCO´s World Heritage Committee, the 3D urban model of Vienna provides valuable information and attractive visualizations. The publication cited above describes the points of view of the Magistrate of Vienna; there, one can read the following: „All analyses and visualizations relating to architectonics and monument protection, in particular, the visibility analysis on the basis of a 3D urban model developed on the basis of scientific criteria, show that the visual integrity of the old historic center of Vienna is not endangered by the project. "

Technical Statement: Nowadays in applying photogrammetry it is possible to create 3D urban models with different levels of detail and of accuracy.

Financial Statement: Inclusion in the World Heritage List of the UNESCO initializes and finances numerous activities involving technology belonging to the realm of ISPRS.

10. Closing Remarks

The ISPRS represents nowadays a wide field of methods and of technology. In this paper I have tried to take a fast look at this field. The methods and techniques mentioned are at disposal of the ICOMOS community. At the same time, the tasks and requirements as formulated by the ICOMOS yield impulses for further research and development by the ISPRS in its realm of methods and technology. CIPA with its RecorDIM initiative intensifies this communication and knowledge transfer in both directions – from ICOMOS to ISPRS and vice versa.

REFERENCES

Bartetzko, D.: Das Boot läuft über. Frankfurter Allgemeine Zeitung, 5.7.2003.

Dorffner, L.: Der digitale Behaim Globus - Visualisierung und Vermessung des historisch wertvollen Originals. Cartographica Helvetica 14/96, S. 20 - 24.

Dorffner, L., Kraus, K., Tschannerl, J., Altan, O., Külür, S., Toz, G.: Hagia Sophia - Photogrammetric Record of a World Cultural Heritage. International Archives of Photogrammetry and Remote Sensing, Volume XXXIII, Part B5/1, Amsterdam 2000, pp. 172 -179.

Fleishman, J., Yee S.: Artful thieves snatch 10-inch sculpture worth $57 million, 2003, http://archives.seattletimes.nwsource.com/cgi-bin/texis.cgi/

web/vortex/display?slug=sculpture12&date=20030512

Gruen A., Remondino F.: The Buddhas of Bamiyan, 2002, http://www.p.igp.ethz.ch/p02/research/bamiyan/location.html

Herzig, A., Horvath, D., Kraus, K., Naumann, K.: Renaturalization of Parts of the National Park Neusiedler See-Seewinkel/Fertö-Hansag by the Aid of Laser Scanning. XVIII. International CIPA Symposium "Surveying and Documentation of Historic Buildings-Monuments-Sites, Traditional and Modern Methods", Potsdam, 18-21. September 2001. S. 61-68, 2002.

Klotz, S.: Photogrammetry in Ephesos – Recording Basic Spatial Data. To be found in these proceedings, 2003.

Klotz, A., Zunkel, R.: The World Heritage site „Historic Centre of Vienna“ and the project „Wien-Mitte”: background from the perspective of the City of Vienna, Sondernummer “Perspekltiven” der Stadt Wien, 2002.

Kraus, K.: Photogrammetrie, Band 1 (Geometrische Informationen aus Photographien und Laserscanneraufnahmen), 7. Auflage, Walter de Gruyter Verlag, voraussichtlich 2003.

Waldhäusl, P., Ogleby, C.L.: 3x3 rules for simple photogrammetric documentation of architecture. Invited paper. Symposium ISPRS Commission V. (presented by C.L. Ogleby). International Archives of Photogrammetry and Remote Sensing XXX-5, Melbourne, March 3, 1994, pp. 426-429.