RETURN

DOCUMENTATION, SURVEYING, PHOTOGRAMMETRY

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CIPA Working Group VI

KEY WORDS: Cultural Heritage Documentation, Surveying Methods, Remote Sensing, Photogrammetry, GPS, Scanners

ABSTRACT:

Considering the purpose of cultural heritage documentation, an attempt is made to show the large diversity of documentation projects by describing the types of objects encountered and the role of topography. Different intensity levels for documentation and different possibilities of documentation publication have to be reflected.
Surveying, characterised as the entirety of all methods available to record the geometry of objects and topography, is considered as one part of a documentation project. Photogrammetry is one surveying method among others, e.g. simple and tactile methods, tacheometric and GPS surveys, various scanning methods or remote sensing from satellites.
The Institute for Spatial Information and Surveying Technology (i3mainz) at FH Mainz, University of Applied Sciences, Germany, is involved in various cultural heritage documentation projects. The interdisciplinary decision process used at this institute to develop optimal documentation, publication, and surveying methods for every project is presented.

CULTURAL HERITAGE DOCUMENTATION

Purpose

Documentation of cultural heritage objects is not an end in itself but serves as a tool to make information accessible to those (research experts or any interested persons) who cannot investigate the object itself. Different reasons can be found for the necessity of this information transfer:

- The object is not accessible to interested parties (e.g. rock paintings in caves).
- The object is too large or too complicated to be overlooked and it would be too time-consuming to execute an own investigation.
- The object (or just a part of it) is visible only for a short period of time at its original location (as in archaeological excavations or when un-earthed during civil engineering projects).
- Persons living far from the object cannot afford to visit it.
- The object is in danger of slow deterioration (environmental factors) or sudden destruction (earthquakes and other natural disasters, war and vandalism).

The last two points must be taken into account in any case, additional ones may exist at the same time.

Objects

Cultural heritage objects comprise a large variety of different nature, size, and complexity. Thus, it is not easy to group them in a systematic way. The following sequence of 'conservation subsystems' explained by Rosvall and published by Lagerqvist (1996) seems to be a good approach to such a system since it shows the relation between the subsystems and hence the influence of measures taken in one subsystem on the others:

- "... Natural environment; a global system, which encompasses:
- Ordinary landscapes; which are constituted by:
- Cultural landscapes; which include:
- Built environments; where we find:
- Cities and conurbations; which consist of:
- Buildings and other spatial structures; which are the frames for:
- Artefacts;..."

Nevertheless, every object, even when assigned to the same subsystem, may differ so much from another one that it needs a completely different documentation process. This is the challenge of cultural heritage documentation. But on the other side, it can be the reason for inadequate solutions, too.

Objects and Topography

Cultural heritage objects are always man-made objects. At all time, human beings took advantage of certain geographic and topographic factors when choosing locations for their settlements, fortifications, places of worship, etc. Thus, documentation always should include both, a description of the object itself and of the topography around it. Different cases can be listed where topography is part of the documentation:

- The object has become part of the landscape itself, like agricultural (terraces, irrigation, ...) or transportation systems (roads, channels, ...).
- The object took advantage of the topographic situation and has to be documented together with it (typical for fortifications and places of worship).
- The object cannot be unearthed in its entirety and many excavations have to be combined, possibly over a large period of time (as in modern cities where parts of older city structures become visible during local civil engineering projects).
- Artefacts found on the surface or beneath are removed and their original location has to be documented.
- The distribution of artefacts of a certain type has to be mapped over a regional or continental area.

Again, the range of possible documentation tasks is very large. When a documentation project is started, it has to be decided if available topographic documents (maps, aerial or satellite images) are sufficient or if special surveys have to be carried out.

Intensity

The ideal documentation of an object would allow the user to gain the same complete information as the investigator who examined the original on site. Obviously, such a documentation, including a description of the materials and geometry of even the smallest object part as well as the surrounding topography and environmental conditions is impossible.

It is undisputed that cultural heritage documentation is highly desirable. Knowledge about possible methods and new developments is readily available. At the same time, funds for these tasks are very limited, even in wealthy countries. Developing countries, many of them with a rich cultural heritage, can hardly afford the necessary procedures.

Consequently, priorities have to be decided on. More important and endangered objects have to be documented with high priority and intensity, others have to wait or can only be recorded by simple methods at the moment.

Finally, a competent selection of appropriate methods and a strict management of the documentation project must lead to an economic use of the funds available.

Components

Depending on the type of object itself and on the intensity of documentation applied, the final information system may consist of several parts of different nature.

- The geometric survey (see below) leads to a description based on coordinate values. Those can be visualised when symbol or texture information is added. Results are plans, maps, orthophotos, perspectives, and videos. If funds are limited, photographs may substitute these documents.
- Visual inspection and material testing methods result in a description of the materials used.
- Various age detecting methods allow dating if necessary.
- Textual descriptions complement the above. They are necessary to explain relations between different parts of the object and relations to other objects, and integrate them into the historical background and development.

Many existing publications concerning archaeology as well as art and architecture history do not allow a clear separation between facts and conclusions (or even speculations). It should be a basic principle of any documentation to include the original observations and to distinguish strictly between facts and conclusions.

Publication and Information Systems

Until recently, the final result of a documentation consisted of documents printed or drawn on paper. Colour printing and large paper formats of maps and plans made production expensive. Distribution, storage, and public access were difficult.

With the advent of geographic information systems (GIS), a powerful method is available to store graphical and descriptive data with all their links. Analysis and visualisation methods can lead to results that were not deductible from the paper products.

World-wide access has become easy and inexpensive if the results are distributed via data carriers (CD-ROM, DVD) or the internet. Since the availability of cultural heritage documentation to everybody should be a main target of all institutions involved, the use of GIS and the modern distribution possibilities should be recommended strongly (Heinz 1997).

Reading devices for an increasing number of data carriers (punched tapes and cards, old disc and tape formats) are not in operation any more. Other data cannot be read any longer because support for old software products has terminated. Also, magnetic information deteriorates over the years and cannot be read any more. From own unpleasant experience, the authors recommend to produce and store paper copies of all important data as a backup of electronically recorded data.

Co-operation

As mentioned above, documentation consists of contributions of many scientific branches. Persons in charge of documentation projects should have a good knowledge of possible techniques. Scientists from natural and engineering sciences should try to develop methods that can be used by anybody willing to undergo some basic training. The efforts of CIPA Working Group 3 are a typical example for this approach (CIPA, 1999).
On the other hand, certain techniques are so complicated that they can be mastered only by experts. In those cases, documentation cannot be accomplished without co-operation between experts of different disciplines. If willingness is present and funds are available (which is often a problem) such a co-operation can be a rewarding experience.

SURVEYING

General Aspects

Surveying as part of cultural heritage documentation comprises all methods available to record the geometry of objects and/or topography. Thus, any co-operation between cultural heritage recorders and surveyors is of high importance. Photogrammetry will often be a good choice as surveying method but it should be considered together with other methods before a final decision is reached which kind of surveying method(s) should be used in a specific project (Boehler and Heinz, 1996, 1997). New methods and instruments are permanently introduced, and it has become difficult to remain informed about all alternatives. Universities should try to train experts with a good knowledge of many methods and not only specialists for certain branches (such as photogrammetry). CIPA, originating from a co-operation between photogrammetrists and heritage recorders has started to deal with this problem by establishing Working Group 6. But not everybody may be aware that photogrammetry is just one way of surveying, and surveying is just one component of cultural heritage documentation (cf. Fig. 1.).
Although every project has to be considered differently, suitable surveying methods can be found when considering object size and object complexity (cf. Fig. 2).

Figure 1: Photogrammetry is one method of surveying. Surveying results are one part of cultural heritage documentation

Object size is related to the scale of plans since the maximal size of one sheet is about one square metre. The complexity of the survey can be expressed by the number of points to be recorded. This ranges from one point describing the geographic location of a single artefact to some thousand points, typical for a CAD drawing of a building or a topographic situation, to about one million points or more for the description of the whole surface of a sculpture or a digital elevation model.
Besides size and complexity, other factors may influence the optimal method to be chosen:

- Accuracy needed
- Permission to use the method (e.g. aerial photogrammetry may not be permitted)
- Availability of instruments and power supply
- Accessibility of object
- Availability of ideally located vibration-free observation stations
- Permission to touch the object

Different Methods of Surveying

Simple Methods: Many heritage recorders, especially archaeologists and architects, execute their surveys exclusively by direct measurements relative to a local coordinate system represented by strings and plumb bobs. Points are located in this system by direct distance measurement to the nearest string and mapped immediately. This method is smiled at by many surveyors but it can be used very effectively if the site is accessible, not too large, not to steep, and easy to overlook.

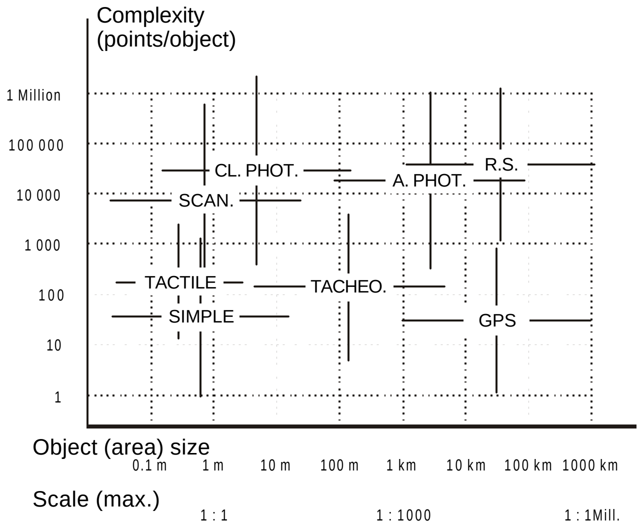

Figure 2: Suitable surveying methods considering object size and object complexity.
(CL.= close range, A.=aerial, R.S.= remote sensing)

Tactile Methods: All tactile methods rely on the registration of the coordinates of the tip of a probe brought in contact with the object point to be recorded. Several new developments in the last few years aim at applications in mechanical engineering and also in heritage object recording. Different technical solutions have been chosen to locate and record the probe position:

- In coordinate measuring machines, separate scales in x, y, and z-direction are used.
- In robot-like machines, the probe is connected to the last of a series of hinged arms (e.g. Faro, 1999).
- In photogrammetry-based systems, a camera is connected to the probe locating its position from fixed points in the vicinity (aicon, 1999), or several fixed cameras observe LEDs on the probe (Metronor, 1999).
- The probes in systems developed for archaeology are fixed to large pantographs or tapes connected to three fixed positions (e.g. Trigomat, 1999).

Except for coordinate measuring machines, all systems are portable but need stable mountings for the reference parts. A common problem is the danger of scratching the object when needle tips are used; spheres on the other hand can only record a surface parallel to the object and cannot reach sharp grooves.

Electronic Tacheometers are indispensable for recording single points in medium size areas. They can be used for polar surveys (with or without a reflecting mirror at the target) or using a section solution (if the target is inaccessible but can be identified from two different observation stations).
New developments include instruments with automatic target detection where the measuring process can be carried out by just one person. This should be an advantage in many heritage recording projects.

The Global Positioning System GPS has become a well-known method for navigation and surveying. It is not generally known, however, that there are different GPS technologies giving any accuracy between the 100-metre and the millimetre range. Small hand-held receivers can produce decimetre accuracy when used in differential mode using carrier phase information and have proved very useful in heritage projects comprising large areas and for control point surveys for photogrammetric or satellite image processing.

Close Range Scanners: Considerable developments can be observed in the field of close range scanning devices. Two basic concepts are in operation:

- Laser scanners, where a laser beam is deflected by a scan mirror. When returned by the object surface, range and reflectivity can be recorded (e.g. nav, 1999).
- Light pattern scanners use a projector for the generation of the light pattern on the object (often stripes) and record the resulting images with a digital camera (e.g. cyberware, 1999).

Since all instruments have limited resolution and view angles, the most important development is the recent generation of powerful software for the automatic combination of partial scans to create complete digital object models, e.g. for large and complicated sculptures (igd, 1999).

Close Range Photogrammetry. Many fine examples for the use of close range photogrammetry have been presented and published by CIPA.
The advent of digital cameras that store a digital image obtained from a CCD frame or line element has caused discussions wether film or CCD cameras are best for close range photogrammetry. A resolution of 2000 x 2000 elements or less is too poor to produce anything comparable to a film image. Experiments with a 4000 x 4000 pixel prototype metric camera have shown good results for both, image matching and point determination purposes (Heinz, 1998). Further experiences show, however, that the prototype could not yet be developed into a reliable instrument. In spite of the problems encountered presently, it can be taken as granted that reliable metric cameras of this resolution will be available soon.
Digital images from CCD cameras or from scanned films in conjunction with matching techniques have made it possible to produce digital object models also from complicated surfaces such as sculptures (Boochs and Heinz, 1996). Such a description

comprises a more objective and complete record as compared to the traditional photogrammetric CAD vector plots which rely to a considerable extent on the interpretation of the operator.
Very interesting for cultural heritage documentation is the recent development of low cost (around 3 000 US$) 3D-cameras by Minolta (Metacreations, 1999) and Kodak with 3D processing software including surface triangulation.

Aerial Photogrammtry is a well established method of surveying and standardised to a large extent. Topographic mapping in intermediate scales is usually best accomplished by this method (provided that aerial photogrammetry is not prohibited). Larger scales are possible if devices like balloons or miniature aircraft are used.
CCD line sensors, combined with navigation devices, may gradually replace the aerial film camera systems in the future.

Remote Sensing from satellites is a useful method in documentations comprising larger areas (Boehler, Heinz, Scherer, 1997). The advent of systems with dramatically improved resolution, although not quite in the time schedule originally anticipated, will be of great importance to cultural heritage documentation, especially where aerial photos are not available (Boehler and Heinz, 1999).
Imaging and processing techniques of remote sensing and photogrammetry are becoming more and more identical, so that in the future a distinction between photogrammetry and remote sensing may be more or less superfluous.

REALIZATION OF A DOCUMENTATION

Decision Process

As shown in figure 3, a documentation project manager should decide first on the disciplines to be included in the specific project. Ideally, this should be done in a conference where all disciplines are represented.
The way of publication should be decided on as early as possible (at the same time as step 1, or as step 2, at the latest). In many projects, this decision comes too late, causing extra cost and delay due to conversion and re-formatting problems.
As far as the surveying part is concerned, a board of specialists should decide on the most effective method of surveying. Since surveying has become very specialised, it is not sufficient to leave this decision to a land surveyor or a photogrammetrist or the project manager. As many of the different available surveying techniques (cf. Fig. 2) as possible should be represented. In easy cases, it may be decided that simple surveying methods are sufficient and no further professional help from the surveying side is necessary. In complex cases, several methods have to be applied. As a result, a co-ordination may be necessary at this level.

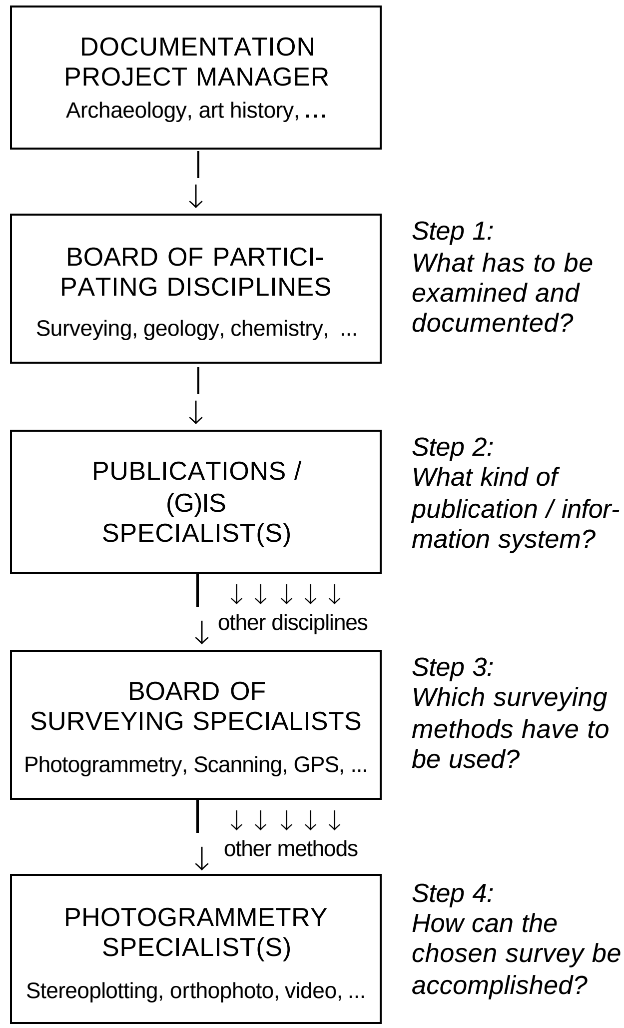

Figure 3: Decision Process

i3mainz

In co-operation with many partners from cultural heritage agencies, surveying services were provided by FH Mainz (Germany), University of Applied Sciences, for cultural heritage projects since some dozen years. In 1998, i3mainz, Institute for Spatial Information and Surveying Technology, was founded (i3mainz, 1999). The institute offers assistance in cultural heritage surveys. Since surveying experts for all methods are pooled in this institution, it can solve all problems from step 2 to step 4 in the scheme shown in figure 3. Through a close co-operation with Roemisch-Germanisches Zentralmuseum at Mainz, the management and execution of complete documentation projects can be offered, too.

RETURN

CIPA

It is not easy to provide a common forum for conservationists and surveyors at large. CIPA is one of the few organisations trying to do so. Through the effort of some very dedicated persons and with the aid of modern communication technology, considerable progress has been achieved in the last few years. Various Working, Task, and Expert Groups provide assistance for special questions (concerning steps 2 and 4 in figure 3). For an outside investigator it may be irritating, however, that WG 1's (Recording, Documentation and Information Management Principles) "goal is to provide a forum for photogrammetrists and conservationists" only (CIPA, 1999), whereas WG 6 (Surveying Methods for Heritage Recorders) deals with "all non-photogrammetric methods" (CIPA, 1999) separately.
Tactile and scanning systems may or may not rely on photogrammetric solutions and often solve similar tasks as imaging close range photo-grammetry . Thus, they should be considered (Dold, 1999) and evaluated (Heinz, 1998) together.

CONCLUSIONS

Cultural heritage recording and documentation comprises a wide field of objects, disciplines and technologies. Because of those large diversities, every project is different. This makes the task difficult. Co-operation between different scientific and professional disciplines is necessary. On the other hand, these requirements make it very challenging and rewarding to work in this field.

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