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# CONTEMPORARY METRICAL DOCUMENTATION OF STRUCTURES WHICH ARE PART OF THE CULTURAL HERITAGE

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## Abstract

*The paper presents the recent development of the Photogrammetry Department of the Institute of Geodesy and Photogrammetry FGG in the field of metrical documentation of structures which are part of the cultural heritage. Work was focused on developing up-to-date metrical documentation of structures, promoting team work, promoting the use of photogrammetry in the humanities and preparing recommendations for technical standards for structures. A review of the work is supplemented with examples of implemented projects.*

**Keywords:** architectural photogrammetry, close range photogrammetry, computer graphics, three-dimensional models

## 1 INTRODUCTION

In the recent few years, the Photogrammetry Department of the Institute of Geodesy and Photogrammetry FGG has been intensely engaged in introducing contemporary forms of photogrammetric documentation for the needs of protecting the cultural heritage. During this period, the Institute has acted as contractor for the Cultural Heritage Office of the Republic of Slovenia and completed a larger number of projects which are part of an umbrella project entitled Surveys. In 1991, the then Institute of the Republic of Slovenia for the Protection of the Natural and Cultural Heritage placed a five-year project entitled Surveys – Technical Photographs of More Demanding Structures which are part of the Cultural Heritage into the programme of the Ministry of Culture. This was the first time that the Slovene monument protection service discussed the documenting of our cultural heritage more comprehensively as an important part of its activities (Grobovšek, 1996). Since the project was successful and became well-established, it is still being carried out.

The basic goal of the projects was to prepare photogrammetric documentation for monuments, but we also sought new and more appropriate product forms, more advanced technological solutions and improvements to the entire process. Together with the clients and conservators from regional Institutes for the Protection of the Natural and Cultural Heritage, we are building an increasingly more comprehensive system of documentation which will be briefly presented below. We received recognition for our achievements in this field (a Doležal Award) at the last World ISPRS Congress in 1996 in Vienna, while our presentations and publications abroad have received favourable responses and generated interest in our program solutions and implementation concept.

## 2 DESCRIPTION OF OUR DEVELOPMENT

Our development in the above-mentioned projects is oriented into:

- teamwork on projects
- promotion of photogrammetry in the humanities
- production of technologically advanced forms of documentation
- preparation of recommendations for standards.

### 2.1 Teamwork on projects

Professionals from various technical and humanities fields meet in this work, therefore at least a general knowledge of several fields is required from participants. The extent, content and form of the products are agreed with the conservators. Various options are presented and we attempt to find the best possible solution together. The structures differ in their external appearance, condition, type of work required, etc., therefore the procedures and products used are never completely the same. Sometimes it is also necessary to harmonize various work methods on a single project. The success of such cooperation has been demonstrated in the implementation of the Tito Square project in Koper (commissioned by the Rižana water supply company) and professionally coordinated by the Intermunicipal Institute for the Protection of the Natural and Cultural Heritage, Piran), in which photogrammetric, georadar and thermographic measurements were geolocated in a unified form. We were able to compare the products directly and interesting results were obtained. To give only one example: the photogrammetrically evaluated damage to the pavement matched the georadar interpretation of findings below the surface. The project was presented at an international conference of the ICAP (International Committee on Architectural Photogrammetry) in Goteborg (Guček et al., 1997), and the organizers held it up as a model of interdisciplinary cooperation for other participants.

### 2.2 Promotion of photogrammetry in the humanities

Together with the Cultural Heritage Office of the Republic of Slovenia we have thus far prepared two exhibitions at the Ljubljana Cultural Information Centre, the first one in 1996 (Documenting of the Cultural Heritage) and the second one in 1998 (Socerb Castle – The Future of Cultural Monuments). Upon the opening of the first exhibition, a round table discussion was organized about problems in documenting structures which are part of the cultural heritage. Here, for the first

time, representatives of different professions discussed this matter publicly. A thematic issue of a journal issued by the Cultural Heritage Office of the Republic of Slovenia of the Ministry of Culture was titled "Photogrammetry as a Method of Documenting Cultural Heritage". A film (VHS, 15 minutes) entitled *The Socerb Castle – Preservation of a Cultural Monument* was shown at the opening of the second exhibition, at which we presented an example of the work of conservators and photogrammetrists.

### 2.3 Production of technologically advanced forms of documentation

This topic is fairly extensive, therefore only the main developmental phases and achievements will be described. About three years ago we focused our work into 3D production of documentation of structures which are part of the cultural heritage. Today we find that our decision was correct, because trends around the world are identical (Atkinson, Gruen, 1996). Development was based on high-power personal computers and the available software (AutoCAD among others), to which we added our own programs. The first such program was in 3D (Janežič, 1996), and it was later upgraded and renamed ARCHOS. This program enables us to make spatial models of structures from photogrammetric and geodetic data about it. The basic principle employed in making models is to preserve to the greatest possible extent the level of accuracy of the capture of the original spatial data. Our development thus went from the first attempts at modelling individual facades and the production of wire models of structures and surface models to photorealistic models. We placed the highest priority on metrical quality, but visualisation contributed to greater attractiveness and a clearer presentation. A few interesting projects are presented in Chapter 3.

### 2.4 Preparation of recommendations for standards

Without consistently documented procedures and organization of photogrammetric data and results, there is a risk of loss of information or data abuse (Bitelli, 1997). We agree with this assertion, because we have also found that, occasionally, incomplete documentation is submitted and archived. Clients usually receive only graphical products and photogrammetric images. The results cannot be checked or upgraded unless an entire report is available, containing all data, from field measurements and identification of reference points to orientation protocol, etc.

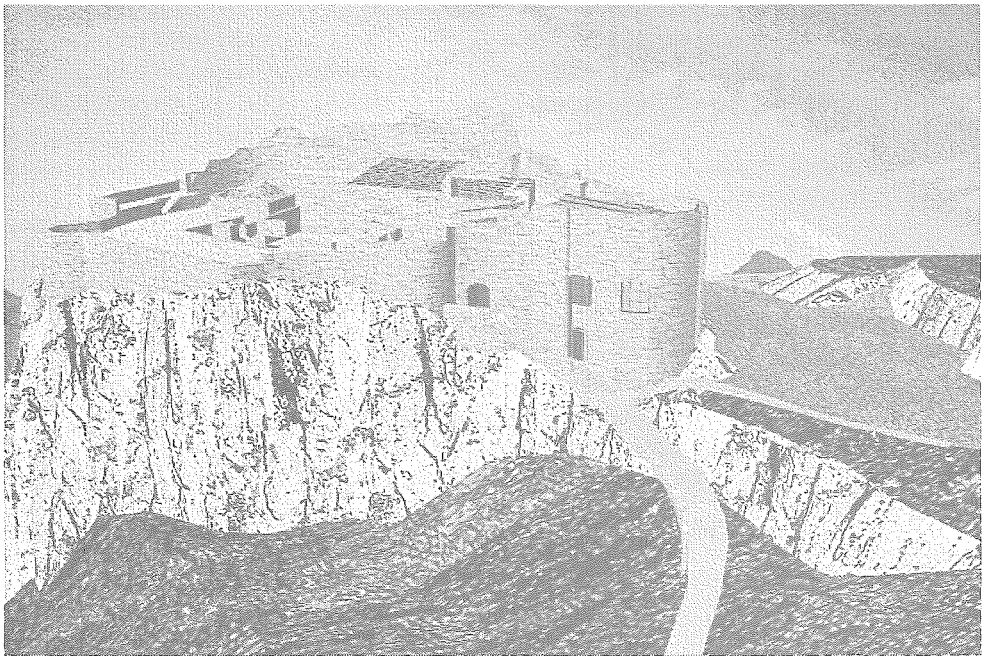
The preparation of minimum standards for technical documentation has therefore become an important part of the Surveys project. This issue is quite extensive and complex and requires a thorough knowledge of the field. On the basis of our experience, study of foreign literature and professional contacts abroad, we have so far prepared recommendations for standards for the technical part of the metrical documentation of structures. In the report we defined the entire photogrammetric process, from field measurements to possible products, and designed detailed technical requirements for each phase. We also determined the compulsory elements that reports must contain. Particular attention was paid to protective photogrammetric surveys, with the objective of achieving such execution of photogrammetric and geodetic surveying of structures of cultural heritage with methods that would enable us, if necessary, to metrically reconstruct the object as a spatial whole with its basic elements, i.e. its facades. Due to limitations in funding, it

is possible to produce complete metrical documentation, from images to the final product, for only a few structures. This method, however, would enable us to document a greater number of structures, and the evaluation of images could be performed later, if necessary. Campaigns for protective photography are in progress.

### 3 EXAMPLES

#### 3.1 Socerb Castle

In this project, we developed a system of comprehensive structure documentation on the basis of a 3D model. The practical objective of the project was to produce metrical documentation of the existing condition of the castle at different levels of accuracy and in different forms. A geodetic site plan existed for the castle and its surroundings, as well as an approximate 3D surface model of the castle's exterior. The conditions for field work were difficult, because the castle is partially inaccessible (it is built on a cliff), its walls are made of rock and the surfaces of its exterior facade are irregular. The castle was originally much higher, but it was destroyed by a fire caused by lightning.



*Figure 1: Computer visualization of the Socerb Castle*

Additional geodetic and photogrammetric measurements first improved the accuracy of the existing surface model. The consistency of the model's topology was checked and corrected. Due to the stone structure of the facades, we used model rendering (adjustment of texture to the surfaces) with photogrammetric images (possibility of combining vectors and rasters provided by AutoCAD r14). A so-called photo model was obtained. This term also appears in foreign professional literature

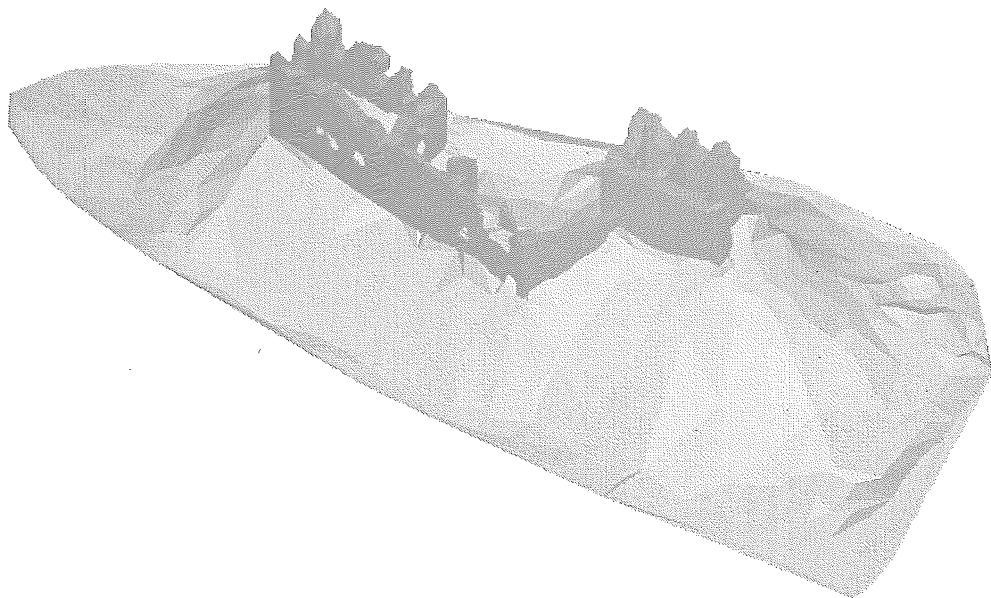
(3D-Photomodelle – Kraus, 1997). The mean error of the produced model is  $\pm 20$  cm. Certain facades and details needed to be evaluated at a greater accuracy, i.e.  $\pm 2$  cm, therefore digital ortophotographs were made. Digital ortophoto plans are a very suitable form of metrical documentation, because the interpretation of details is performed by the professionals themselves. The use of functions and filters for the digital processing of images is an additional help. Photomosaics were prepared for certain parts of the castle and some details were photographed for purposes of interpretation. In order to be able to unite all these different products into a single system, we produced a photographic-attribute database, which was connected with the produced three-dimensional model through graphic icons. By clicking the icons, the following information can be obtained on the existing documentation: is it photography, photomosaic or digital orthophoto; are the images analogue or digital; what is the accuracy of the product, etc. If the image is in digital form, we can view it, if it is in analogue form, we can find out where it is located in the archives. Notes can be added to data. The described contents of the database were prepared especially for this project, but any information can be included. For this purpose we produced our own program entitled FOTO-AT. Finally, we also created a visualization of the model in the 3D Studio MAX r2 program, whereby we used standard rendering parameters. In our further work on the project, we are planning to produce reconstruction of the castle on the basis of the existing pictorial materials (Valvasor's drawings, a photograph of the castle before work on the structure in 1925).

### 3.2 Ruins of the Vodriž castle near Slovenj Gradec

In the opinion of Dr. Ivan Stopar, a reputed Slovene medievalist and castleologist, the ruins of the Vodriž castle are extremely important, because they are the only ones in Slovenia that have preserved certain medieval construction elements. Extensive conservation work is being prepared for the structure, therefore the production of metrical documentation was essential. From the technical point of view, documenting of ruins is difficult, because their surroundings are usually covered in vegetation, their locations are difficult to access and there is a large danger of crumbling. The use of remote measurement is therefore the most suitable. The remains of the Vodriž castle have all of the above-mentioned technical properties of ruins. The object lies on a hill and is surrounded by a tall forest. The technical conditions for photography were very difficult, because the lines of sight are steep and photogrammetric images are highly oblique. In addition to the ruins themselves, the nearby terrain had to be measured as well.

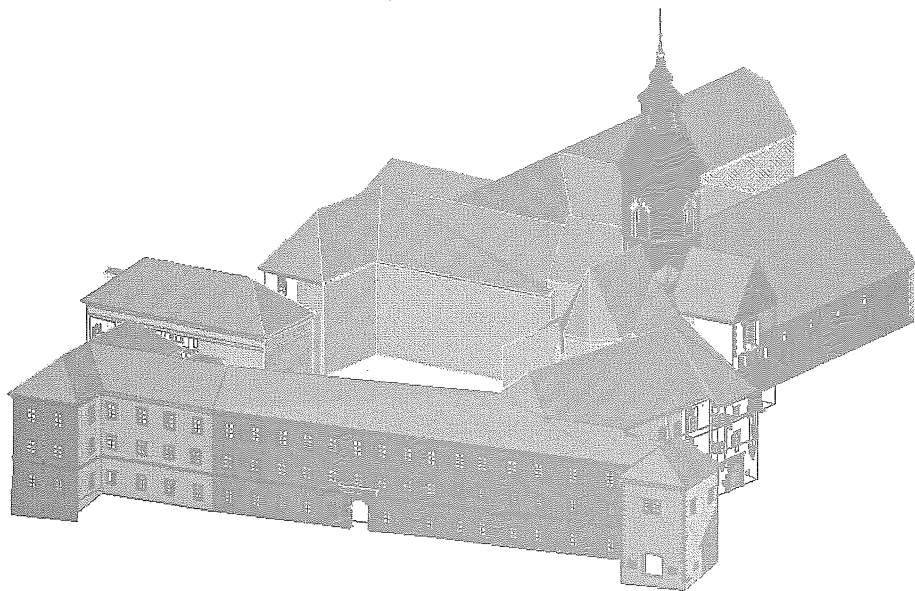
A special method of facade edge measurement was created for this project. Due to poor conditions for photogrammetry it was not possible to produce stereoscopic images, but only individual convergent images, which are suitable for point photogrammetric evaluation. The greatest difficulty was the large interpretation uncertainty of structure edges. All photogrammetric images were taken with a Rolleimetric 6006 metric camera. Analogue photographs were scanned and included in the photographic-attribute database, especially all the important details of medieval construction elements. In further work, it will be possible to perform simulations of castle reconstructions, check hypotheses, prepare conservators'

proposals and variants of solutions, etc., with such a model, but above all it will be possible to monitor all conservation work on the object.



*Figure 2: Surface model of the Vodriž Castle ruins*

### 3.3 Cistercian monastery in Stična

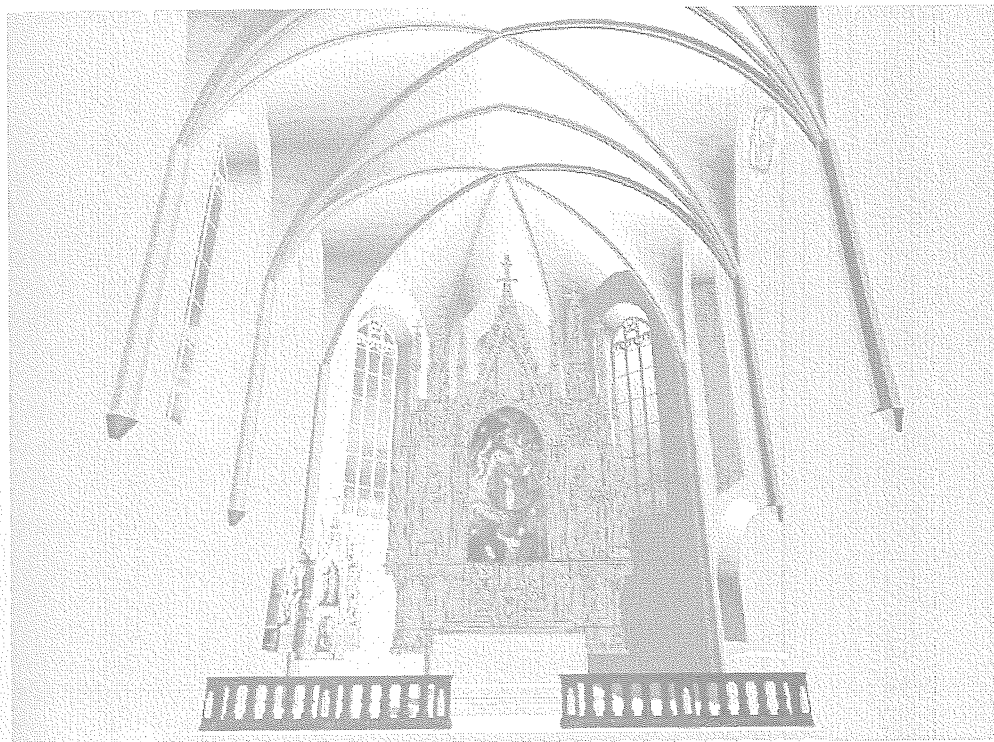


*Figure 3: Three-dimensional model of the Stična monastery*

This project will remain embedded in our memory for a long time, because it has been our largest project with respect to the extent of documentation prepared. At first glance, the complex is simple to measure, but its size is quite considerable. From geodetic and extensive photogrammetric measurements we have produced an accurate three-dimensional model of the monastery's exterior. The model is basically made of wire mesh, but in order to achieve a better visual effect, certain parts of the facades were made in a surface manner. The details of external facades (windows, the door, portal, etc.) were made in 3D with all the details. The produced model will serve for entry of the existing manual measurements and supplementing of documentation (elements of facades in the inner courtyard, the church attic with a preserved upper floor of a Romanesque basilica, cloister, etc.).

#### 3.4 Novo Mesto Chapter Church

For the production of computer animation of the proposal for new location of the tabernacle, we first produced a surface model of the presbytery's interior from the existing photogrammetrically made plans (ground floor, cross sections). The model was equipped with textures in the 3D Studio MAX r2 program. The position of the tabernacle was changed and the visual effect of this change on various views in the room were studied. We also produced a virtual stroll through the room (on computer and VHS) for the existing and the proposed new tabernacle locations.



*Figure 4: Proposal for new location of the tabernacle in the presbytery*

#### 4 CONCLUSION

We have succeeded in establishing a modern and operational concept of documenting structures of cultural heritage in Slovenia. The solutions constantly needed to be adapted to the specific requirements of individual projects, but this made work in this field very interesting and creative. However, for the time being, the various possibilities for the use of such documentation by professionals in monument protection institutions are insufficiently exploited, the reason being insufficient computer equipment and computing knowledge at the regional institutes for the protection of the natural and cultural heritage. This problem is being dealt with in agreement with the Cultural Heritage Office of the Republic of Slovenia.

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