A GENERAL APPROACH FOR OBJECT ORIENTED 3D-MAPPING IN DIGITAL CLOSE RANGE RESTITUTION

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ABSTRACT

This paper deals with a general approach for digital restitution and orthomapping of close range objects of almost any shape and size and with almost no restriction to images or objects.
The idea behind this new approach is strict object oriented. All of the objects are regarded to be describable in their general surface by a certain number of geometrical faces that can be regular or irregular, but can anyway be modeled in a CAD environment. The data needed to get this surface can come from any photogrammetric, tacheometric or other source with any particular one wants to have for the results. All the details that lie on that surface don't have to be restituted by analog or analytical point measurement but can after that be projected onto this surface from any photo, from any side and with any camera they have been taken. A "digital projector" does the projection of the photos from the same positions and with the same inner orientation as of the photographic camera. The approach has been proofed with several projects, two of them will be illustrated in this paper.
The results of the restitution can be presented in many ways. One of them is to create orthoimages in any scale. Other results are any perspective or parallel view of the object. Other use of the strict 3D map-covered object for visualization (e.g. in architecture and archaeology applications) is possible and will be also illustrated in this paper.

1. INTRODUCTION

Most of the orthomapping techniques that are used in the present are restricted to surfaces that arise from a function of "ground coordinates" $z = f(x, y)$, so-called 2½-D objects. Some techniques are also restricted to surfaces with a kind of smooth shape or even to regular surfaces, but all of them are established to rectify images (although increasingly digitally). The idea behind this new approach is quite on the contrary object oriented. Arbitrary 3D objects can be reconstructed as a digital virtual object, without compromise, visible from all sides at the same time and with all its details.

2. THE APPROACH

The idea of this approach is an inversion of the photographic technique and is (on the contrary to the "rectification approach") strictly object oriented. All of the objects are regarded to be describable in their geometrical shape by a number of particular faces that can be regular or irregular but can anyway be created in a CAD environment. The data needed to get this surface can come from any photogrammetric, tacheometric or other source with any particular one wants to have for the results. All the details that lie on that surface don't have to be restituted by analog or analytical point measurement but can after that be projected onto this surface from any photo, from any side and with any camera they have been taken. A "digital projector" does the projection of the photos from the same positions and with the same inner orientation as of the photographic camera.

The object itself can be of any 3D shape in any coordinate system one likes. Whenever only the cameras and their inner and outer orientation are known, a projection can be performed to do a detailed restitution of this object. This has big advantage not only for architectural and archaeological but also for any close range photogrammetric restitution.

Figure 1 illustrates the scheme of the approach which shows the system of the data flow from data acquisition to the final virtual 3D-computer model.

Considering an architectural restitution first a complete reconstruction of the building's shape has to be done using e.g. any digitally matching method (e.g. Streilein, 1995) or a bundle adjustment program (Kager, 1980) followed by a definition of lines and surfaces in a CAD environment. A few of the already before used images are then chosen to do a "digital slide projection" onto the surface to achieve a restitution of the architectural details on the facades of the building. The surfaces of the different objects are not restricted to planes but were also of regular curved (e.g. cylinder etc.) and even irregular or free formed shape.

Using this approach any measurements of any details on the facades can be done easily. No detail of the object can be neglected, none can be forgotten, no prior filtering of details has preceded this using. The full information of the original photos is available in the results. The accuracy that can be achieved is mainly correlated to the particular of details on the geometric reconstruction of the surface.

3. SURFACE AND PROJECTION

To proof the feasibility of this approach we have applied it to several objects. Some have been architectural, archaeological and even some others forensic projects.

The practical work has to be done in three stages: The first is to get both, the external and internal orientation of the camera and the detailed 3D-model of the object's surface. The second stage completes the missing (e.g. hidden) features within a CAD program, the third stage is projecting the images onto the object's surfaces by using a "digital projector".

"digital slide". Every spot light projects on those parts of the object only which had been selected by the criteria of the best angle of intersection and its visibility to the particular surface. The other surfaces will be projected by any of the other digital projectors.

Before using an image for projection, an enhancement has to be performed for these images to adjust their radiometric levels to each other. Some other improvement has to be done brightening shadows in some of the images and erasing reseau crosses or other disturbing parts.

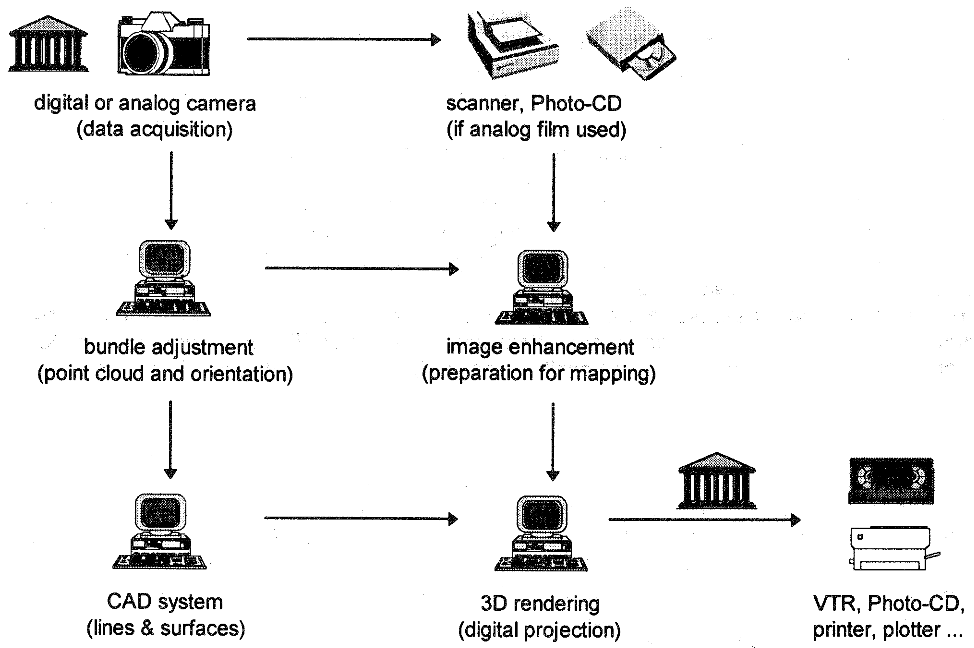


Figure 1: Data flow scheme of the approach

We used a common bundle adjustment software to determine the external and internal orientation for each camera station and the object points' space coordinates which have been selected on the object's edges and surface representing the border lines and faces of the different parts of the object.

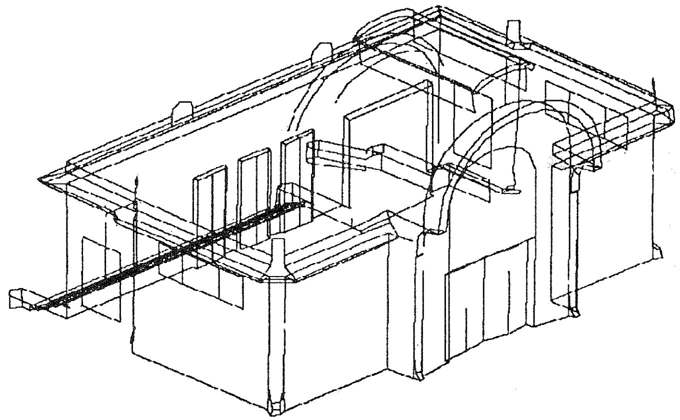
The 3D-model for the object has been edited and completed. Hidden parts have been reconstructed and surfaces have been defined. At least holes in the projection surface have been closed, all that using a common CAD program. Rendering the object proofed the completeness of the model's surface.
Figure 2 shows this process with the results of the described steps of creating the projection surface.

To get a virtual model of the object's reality with all its fine details, a spot light, the so called "digital projector", has been used to map the images onto the object's surface. These projectors shine from the camera's positions and with the same focal length and twist angle through a

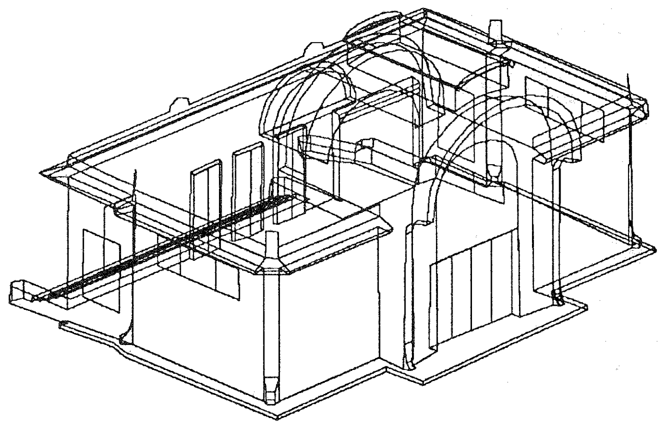
4. TEST PROJECTS

Two projects have been chosen to show the results of the approach. The first one is the test project "Otto-Wagner-Pavillion Karlsplatz Vienna" (Waldhäusl, 1991) which has been adopted by the International Committee for Architectural Photogrammertry (CIPA) for testing the accuracy of non-metric cameras for monitoring the world's architectural heritage. 13 small format images have been transferred to Kodak Photo CD (Hanke, 1995) and were orientated by bundle adjustment using self calibration. The 3D model of the object has been created in the same way. About 1000 detail (mostly plain and cylindrical) faces describe the facades of the impressive Karlsplatz object. The digital projection is done using 7 of the original images covering all of the surface with its texture.

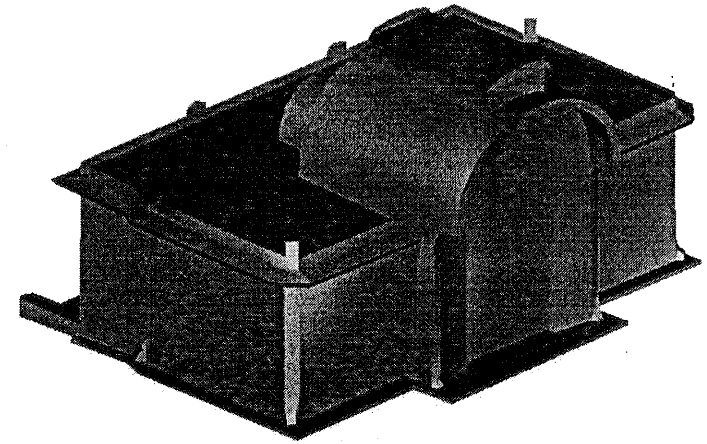
One of the most important results are orthoimages for each facade containing all of the details of the object. Figure 3 shows one of the orthomaps of the Karlsplatz



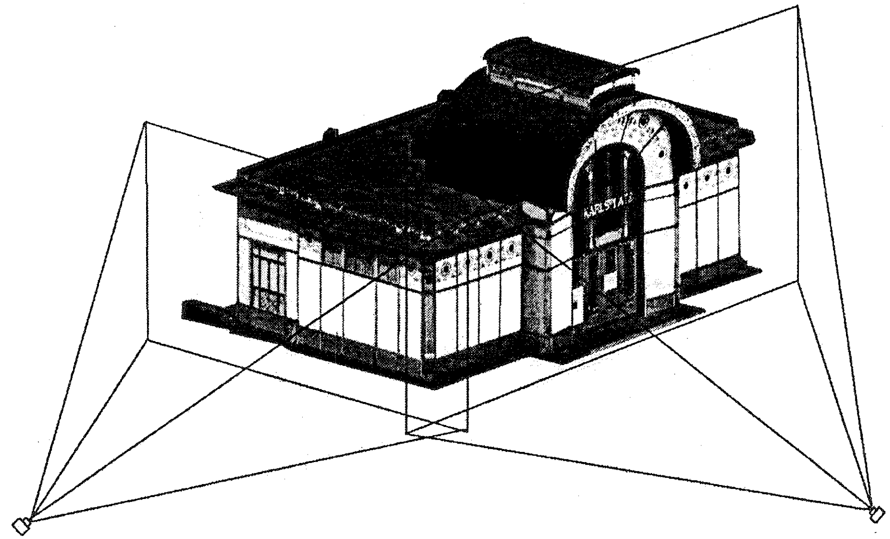
a) wireframe model from bundle adjustment



b) improved wireframe model after CAD editing



c) surface model ("screen") before projection



d) image projection onto surface model

Figure 2: The steps leading to the virtual 3D object.

Figure 3: Orthoimage of the front facade of the CIPA testproject "Karlsplatz"

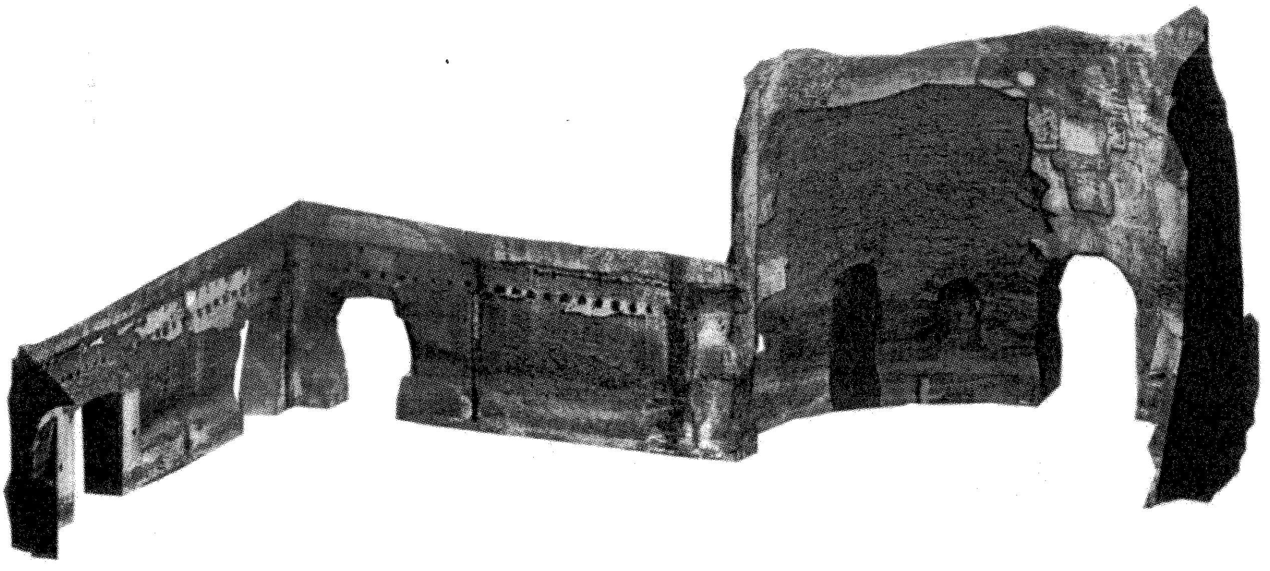


Figure 4: Partial view of the virtual model of ancient "Caracalla Thermal Springs", Rome, Italy

project. The mean accuracy that has been derived from that orthomap (scale 1:100) is about 2 cm between different control points of the CIPA testproject.

The second project that is shown in this paper is a part of ancient "Caracalla Thermal Springs" in Rome, Italy. This photogrammetric project was originally part of an archaeological investigation of this interesting monument by the Austrian Academy of Science done in 1988. The rough and weather-beaten surface itself is very different to that of the Karlsplatz project and looks more like a DTM. 18 metric images contained the data to restitute 2974 individual faces which were needed to describe the surface of the shown part of the object. 10 of the images have been used to do the digital projection onto the 3D-surface.

Figure 4 shows a perspective view of this ancient archaeological site in Rome. Figure 5 shows a tourist's virtual view into the cylindrical part of the famous Caracalla Thermal Springs.

We also did animation for both projects: walking around and flying over the object to show it from different positions and levels. Using this new approach it is possible to record and visualize any architectural or archaeological object in a very accurate and realistic way.

5. CONCLUSION

This new approach leads to an accurate 3D virtual model of an object in its real shape and with all of its details as long as photos are available. The method aims mainly to close range applications in architecture and archaeology but can also be useful to any other kind of realistic photogrammetric 3D restitution Even aerial applications will mean no problem.

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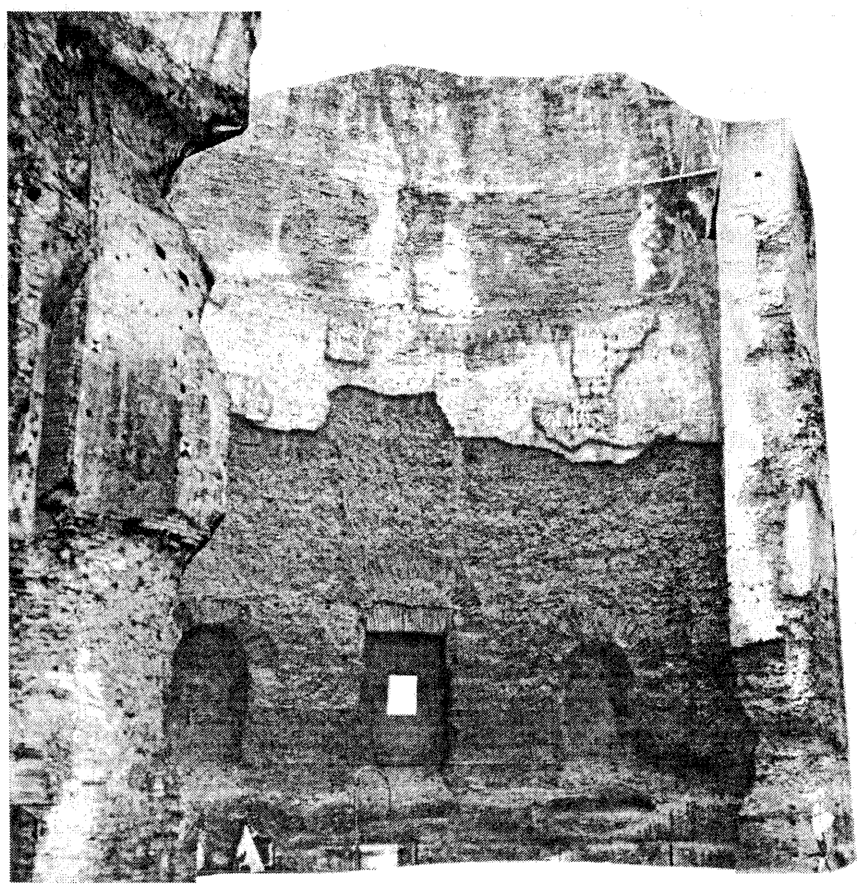

Figure 5: Tourist's view for part of the Caracalla virtual model.