ARCHIMEDES3D - AN INTEGRATED SYSTEM FOR THE GENERATION OF ARCHITECTURAL ORTHOIMAGES

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Working Group VI

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ABSTRACT:

A true ortho image and it's appertaining digital surface model (DSM) provide most the of geometric information required for the documentation of a building façade. There are different techniques available to acquire the information requested to generate a DSM. In this paper we describe how a motorized and reflectorless total station controlled by the software package Archimedes3D can be used to determine the necessary information. Apart from a total station, a laptop and a digital camera are the only hardware components needed to complete these tasks. After establishing of the site covering reference system the total station is used to scan the surface of the object in a point density which can be adapted to the local requirements. The lower data rate of a total station compared to laser scanners can be compensated by maintaining intelligent control of the measurement process.

1. MOTIVATION

1.1 Introduction

For the documentation of cultural heritage geometric and thematic information is required. There is a large variety of different techniques to acquire the high quality geometric information of cultural significant buildings. Among them are geodetic techniques, photogrammetry and laser scanners. Laser scanners and stereo photogrammetric equipment are expensive and requires skilled personnel for the usage. The application of such expensive equipment and personnel is only justifiable for large projects with big budgets. Most projects have very limited resources and most buildings do not demand the usage of laser scanners at the complete site. Single image photogrammetry and bundle photogrammetry are well suited for simple objects with a limited number of sharply defined geometric features. Tacheometry of the whole object might be a time consuming process, depending on its complexity.

Figure 1. Image of an object

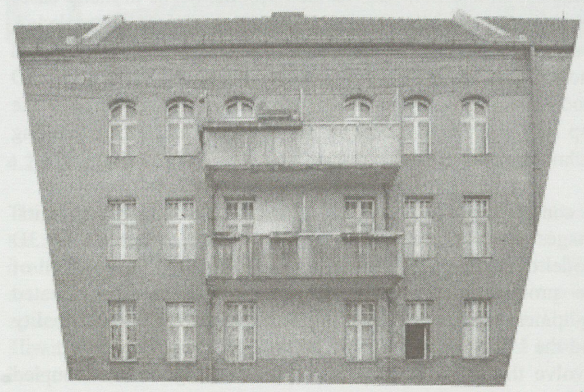

Figure 2. Insufficient result from projective rectification – the balconies are dislocated.

But a total station is required at each documentation site to provide the control network and good digital cameras become affordable. Therefore the idea was borne to combine a modern, motorized total station and a digital camera to derive digital orthoimages of architectural objects, primarily of facades.

1.2 Architectural Orthoimages

A true orthoimage and it's appertaining digital surface model (DSM) provide most of the geometric and radiometric information required for the documentation of a building façade. The geometric quality of the orthoimage depends on the quality and density of the DSM.

There are also different techniques to acquire the necessary 3D information for the generation of the DSM. Among this techniques are again laser scanning, 3D photogrammetry and tacheometry.

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Based on the very dense point clouds provided by laser scanners, the DSM can be derived directly from the laser scanner data (Wehr & Wiedemann 1999). If 3D vector data is available from tacheometry or photogrammetry it is usually necessary to derive a 3D boundary representation CAD-model as an intermediate product (Wiedemann 1996). This additional step is time consuming and may lead to additional errors. Based on these experiences a new strategy has been developed: That is to derive the DSM from intelligent tacheometric measurements, which are to be acquired in an optimized manner.

At the moment the software works with Leica total stations of the TRCM and TCRA types of the 1100 series. The program FAMES for the Façade Measurements uses the GEOCOM interface to control the total stations.

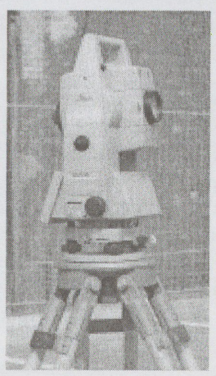

Figure 3. Total station Leica TCRA 1103

2. GENERATION OF DIGITAL ORTHOIMAGES

2.1 Project Preparation

The first step is the same for all serious documentation projects: The establishment of a site covering reference systems. For this purpose the system Archimedes3D provides a geodetic network adjustment. Signalized and natural control points are measured manually.

2.2 Manual Measurements

The next step is the generation of Digital Surface Models of the facades. For this purpose Archimedes3D controls the motorized total station. The process starts with the manual measurements at the facade, providing the system with the approximate extent of the object and lines and areas of special interest. The lines of special interest are vertical and horizontal profiles over the whole object or parts like cornices and window borders. Areas of special interest are reliefs or other decorative elements.

2.3 Autonomous Measurements

After this definition phase, the system starts to determine the exact extent of the object, to measure profiles and point rasters in different regions in a predefined density.

The extents are located by stepping outward from the initial border points until the measured distance is significantly bigger than the initial distance or undefined. The last surface point is located using a suitable approximation procedure.

The profiles are measured automatically in the predefined horizontal or vertical profile plane (Juretzko 2002). They are automatically densified by a process to locate discontinuities in the profiles.

Due to the limited speed of the total station the acquired point density is much smaller than that of laser scanners but can be adapted to the actual requirements. The data rate is rather low with about 1-3 seconds per point. Therefore the operator must consider this data rate during the definition of the local raster density.

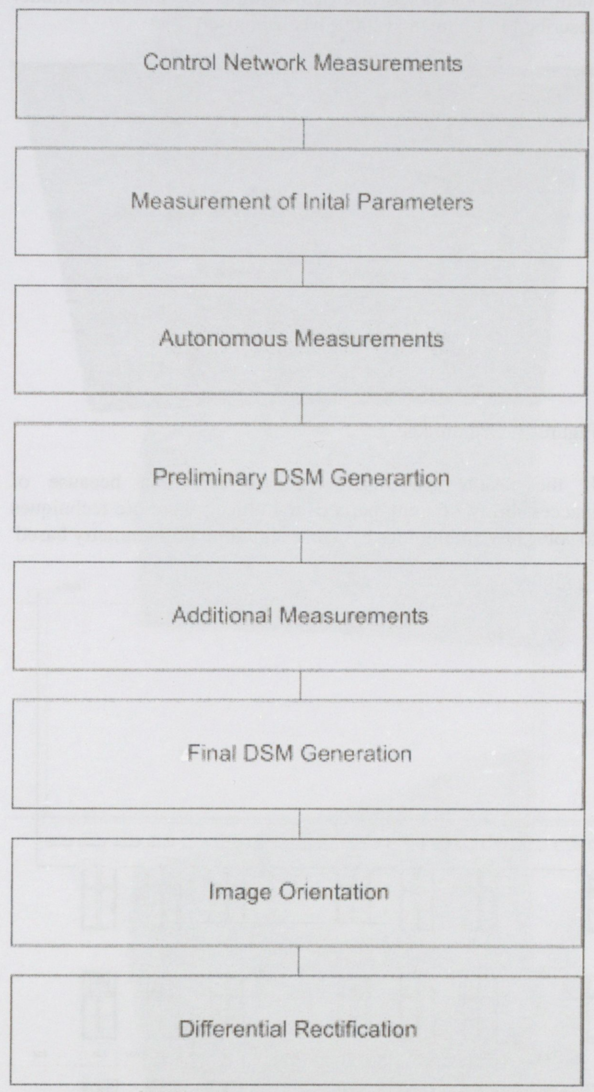

Figure 4. Data flow in Archimedes3D

2.4 DSM Generation

Starting with the overall profiles the data is used to produce a Digital Surface Model of the facade. Gaps and discrepancies in the DSM are located and closed by additional measurements. This process is automatic and requires no manual interaction.
During this process, the operator can take pictures with the digital camera. A lot of points and features are geodetically measured. Therefore sufficient control information is available to do a "calibration on the job". To achieve a better geometric stability it is recommended to restrain the quantity of interior orientation data by avoiding zoom and auto focus. Tools to

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support the operator during the orientation process are still under development.

2.5 Differential Rectification

The DSM and the oriented image data are combined and digital orthoimages are created in a short period of time. We used a digital consumer camera (Nikon Coolpix 4300). Because of the significant distortion of the optics, it was necessary to consider them in the orientation and rectification. The distortion model described in Luhmann (2000) has been used.

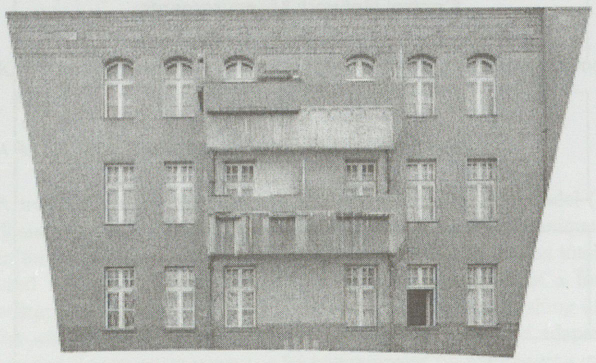

Figure 4. Orthoimage

If the results are insufficient, for example because of inaccessibility of some parts of the object, there are techniques to solve any ambiguities by using digital photogrammetry based

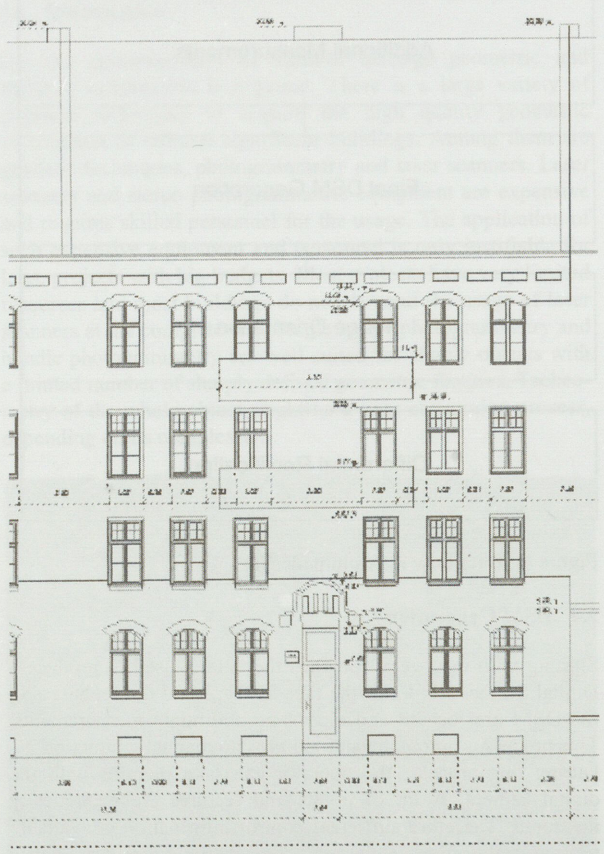

Figure 5: Drawings derived from the Orthoimages and some additional geodetic information.

on the acquired and oriented images at any time after the campaign.

In the result the balconies are located at the correct location. Above them are some occluded areas, which have been colored in gray in the orthoimage. If additional image from a better point of view are available this gaps in the orthoimages can be closed during the mosaiking process. The roof has been removed. The image of the roof is not suited for this purpose, because of the inappropriate aspect.

3. DRAWINGS

Based on this orthoimages line drawings of the object have been derived. This has been performed by monoplotting on the orthoimage. A small part is shown n Fig. 5. The heights of the roof and the chimneys have been added based on geodetic measurements.

4. MOSAIKING

Digital orthoimages or rectified images can be combined to mosaics. The example for this is a parametric rectification of three digital images (Fig. 6). The exposure time was selected automatically, so that the images show very different brightness and contrast. After a parametric rectification (Fig. 7), using Archimedes3D Basic the three rectified images are mosaiked geometrically (Fig. 8). The differences in brightness and contrast are clearly visible. To avoid this a radiometric mosaiking tool, based on the approaches for satellite image data (Kähler 1989) has been adapted for architectural images. The concept is an equalisation of the sum histograms. The result of this fully automatic process is shown in figure 9.

5. CONCLUSIONS

Using this package, a total station and a digital camera become a high quality documentation system providing detailed data for the generation of real orthoimages and other requested products in heritage documentation.

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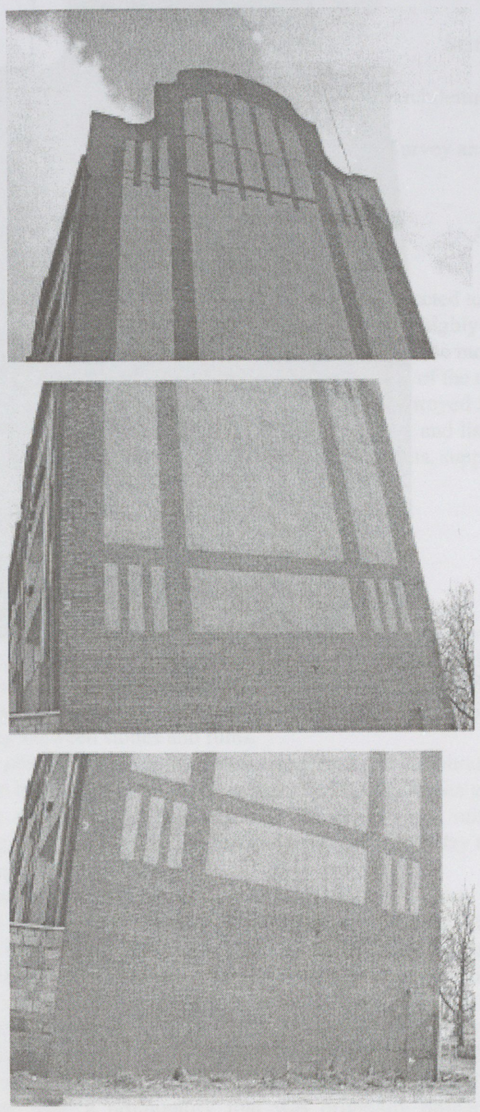

Figure 6: Three digital images

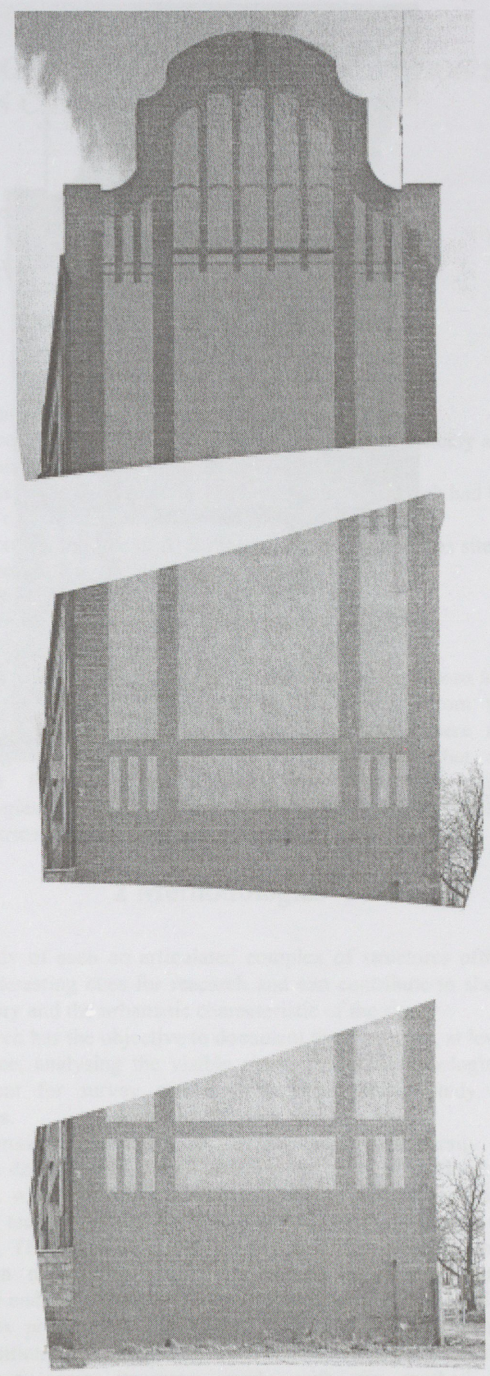

Figure 7: Parametric rectified images

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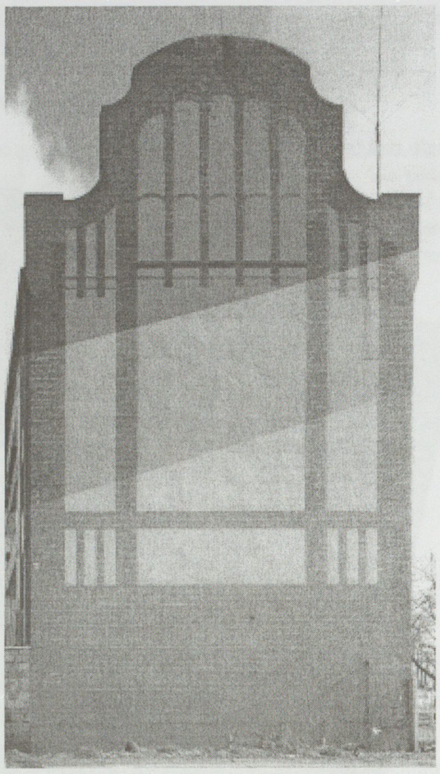

Figure 8: Geometric image mosaic

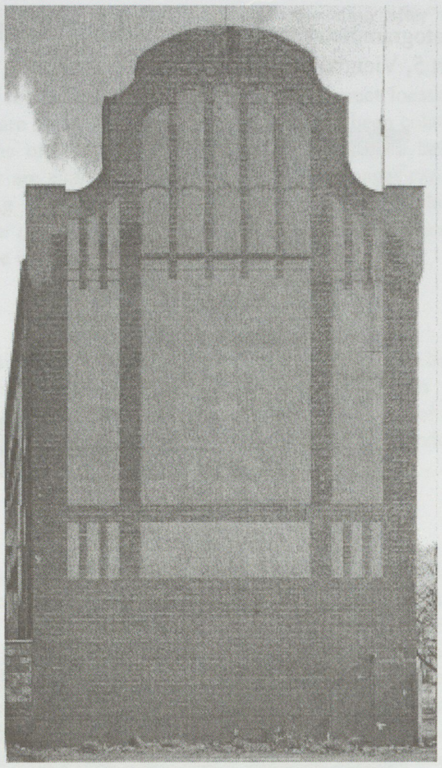

Figure 9: Mosaic after radiometric adaptation