"Zurich city hall"

A reference data set for digital close-range photogrammetry

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Abstract:

A reference data set for testing and evaluating different software packages and tools of digital close-range photogrammetry for the purpose of heritage recording and documentation is compiled. The purpose and the material of this reference data set established by the CIPA Working Group 3 on "Simple Methods for Architectural Photogrammetry" and 4 on "Digital Image Processing" is described. The main intention of this data set is to get indications and measures about the practical handling of different systems and tools, the flow of data and the derived results in terms of consistency, completeness and value for the task of heritage recording. In context with the reference data set a questionnaire is developed in order to collect the achieved results and opinions. The returned answers and results will be compiled and distributed via the CIPA web server. All persons interested in the field of heritage recording are asked to use the reference data set with their own software, with photogrammetric tools they have access to and to contribute to the questionnaire.

Keywords:

Digital, CAD, close-range, non metric, restitution, reference data set

1. Introduction

The main purposes of the International Scientific Committee for Documentation and Architectural Photogrammetry (CIPA, 1999a, Article 2) are:

- To promote recording, documentation and study of status and changes of cultural objects, monuments, groups of buildings, including their environment, villages, towns, sites and cultural landscapes by means of further development of applications of photography, photogrammetry and related disciplines and techniques.
- To actively pursue programmes, which define research needs, stimulate and support research activity, and increase exchange and dissemination of relevant information in order to promote greater understanding in the field.
- To actively pursue international co-operation in that domain.

As a discipline, architectural photogrammetry is currently undergoing profound changes. New technologies and techniques for data acquisition (CCD cameras, Photo-CD, photoscanners), data processing (computer vision), structuring and representation (CAD, simulation, animation, visualization) and archiving, retrieval and analysis (spatial information systems) are leading to novel systems, processing methods and results. Hence, modern digital architectural photogrammetry is characterized by the following components:

- Digital image acquisition by CCD-cameras or scanning of photographs,
- Semi-automated procedures for data measurement and further processing,
- Object-oriented approach to measurement,
- Use of CAAD models in a priori and a posteriori modes,

- Application of modern techniques for visualization and animation of results,
- Administration of data in Monument Information Systems (MIS).

The intention of the reference data set for digital close-range photogrammetry, as proposed in this paper, is to follow up the idea of the first CIPA test "Otto-Wagner-Pavillon" (Waldhäusl, 1992), which was established to compare different types of cameras, bundle adjustment software, calibration, measuring devices, derived accuracy, etc. At the time of the first test only a minority of the participating persons and institutes used digital image data and/or digital image processing and analysis techniques. Since then digital methods and techniques have been improved in different ways (sensor resolution, image analysis aspects, data management aspects, low-cost tools).

The data set "Zurich city hall" is therefore initiated to provide a basis to test and compare different digital methods, software packages and tools in order to derive geometric, topologic and thematic information of a building, and methods for storing, retrieving and maintaining these data sets. Main intention should be paid to the user-friendliness and practical handling of such a system and of the derived results in terms of topology, consistency, accuracy and reliability.

The paper describes the material and availability of the reference data set. The number and types of digital images available, the arrangement of the image sets (i.e. stereo image pairs, arbitrary image bundles or single images) and a description of the three-dimensional coordinates of geodetic reference points available.

The data set in general is suited to apply for all tasks or sub-tasks of photogrammetric building reconstruction. This holds in particular for the three-dimensional building reconstruction, bundle adjustment with convergent image rays, bundle adjustment with self-calibration, stereo photogrammetry, single image rectification, image mosaicing or CAD overlay.

The main intention is to get measures and reflect practical experiences about

- the handling of a system/tool,
- the flow of data,
- the management of a project,
- the reconstruction of an object,
- the derived results in terms of topology, consistency, accuracy and reliability,
- the import and export of data and data types and file formats that can be handled,
- the amount of photogrammetric knowledge necessary to handle the system/tool.

2. Object description

The city hall of Zurich (see Figure 1) serves as the test object. It is built in the years 1694-98 in the style of the late Renaissance. The city hall is located in the center of the city partly on the river Limmat. Its approximate dimensions are 35x12x18 meters.

Figure1: Zurich city hall (seen from south-west).

3. Reference data set

The data set is generally intended to be applicable to any task or subtask of photogrammetric building reconstruction. It consists of a complete description of the interior orientation of the used cameras, the images taken with these cameras and the co-ordinates and the description of the reference points measured on the facades of the building by geodetic means. In addition a questionnaire (CIPA, 1999b) related to this reference data set is available.

3.1 Camera

Digital cameras can be subdivided into different classes depending on the point of view. Looking from a consumer point of view they generally fall into three categories: point and shoot cameras, modified 35mm cameras and studio cameras

Point and shoot cameras generally offer an image resolution of about 800x600 pixels and an image quality high enough for small enlargements, some printed material and for sending images electronically via email or the web. At the upper level of the point and shoot category are cameras provide resolution of about 1’200x1’000 pixels and are suitable for professional desktop publishing work. Modified 35mm cameras generally provide higher shutter speeds, removable storage options and interchangeable lenses. The resolution of these cameras is in the range of 1’500x1’200 pixels up to 2’000x2’000 pixels, suitable for professional purposes such as photojournalism and pre-press applications. Studio Cameras are cameras capable of capturing images about 5’000x5’000 pixel. Prices for these cameras run as high as US$ 55’000.

For the image acquisition of the test object two standard, point and shoot cameras were used, a Fuji DS 300 and an Olympus C1400L. Both cameras can nowadays be considered as “typical” for the use of digital cameras in heritage documentation applications. They are affordable and easy to use. The quality of the derived images can be

judged on the spot and the storage medium has usually enough capacity to hold the images of an entire project.

Figure 2: Fuji DS 300.

The Fuji DS 300 (see Figure 2) records images at a resolution of 1’280x1’000 pixels. They can be stored in uncompressed TIFF format or in one of three JPEG compression schemes on Type I or Type II PC cards in 24-bit color or monochrome. The image capacity is up to 64 images on a 10 MB card. The camera has a built-in 3:1 optical zoom, which covers focal lengths equivalent to the 35-105 mm range of a 35 mm camera’s zoom lens. The camera can be operated as a fully automatic point-and-shot device or as a completely manual professional camera. Subjects are framed through an optical viewfinder. The f-stops are set manually (3.5, 5.6, 8 and 11), so varying the aperture opening will affect the depth of field. In addition the user can override the auto-focus to

Figure 3: Olympus C1400L

set the distance to the subject.

The Olympus D1400L (see Figure 3) records the images with a progressive scan CCD and creates images of 1’280x1’024 pixel resolution. The camera has a built-in 3X zoom lens of 36mm to 110mm focal lengths and TTL (through the lens) single lens reflex type viewfinder. The D1400L comes with a 4 MB card that can store 4 - 50 images. One or as many as nine images can be viewed on the LCD Back Panel. Three modes of image capture are available: standard quality, high quality, and super high quality allowing for flexibility in selecting image size and levels of compression. In addition the camera features a focus lock, manual override focus systems and exposure compensation with three f-stop increments.

For both cameras the complete set of parameters of interior orientation, determined by a testfield calibration, are available.

3.2 Images

The images were taken in order to cover the entire building with all four facades and to enable the complete reconstruction of the building. Therefore the arrangement was set up to be suitable for photogrammetry with convergent image rays as well as for the “classical” stereo photogrammetric approach. The focus of the lens of the cameras was fixed during exposure.

The image acquisition with both cameras took place in a very similar way. The main purpose was to cover any detail of the object with at least two image rays and to allow as well the restitution of the object from stereo image pairs.

The two cameras were used to produce image sets of different file formats, compressed JPEG format on the one hand and uncompressed TIFF format on the other. Hence, with the Olympus D1400L a total of 16 images was taken to cover the entire object. The images are in compressed JPEG format with a file size of approximately 0.8MB each and 12.8MB for the entire set of images. With the Fuji DS 300 a total of 15 images in uncompressed TIFF format was taken. Each image has a file size of 3.75MB, makes 55MB for the entire set.

Figure 4 depicts the basic arrangement for the images taken with the Olympus D1400L. The images are taken to cover the entire object and to enable also stereo photogrammetry. For the purpose of self-calibration a number of images was taken with a rotation of 90 degrees.

Figure 4: Selection of images taken with the Olympus D1400L

3.3 Reference co-ordinates

In order to support the photogrammetric measurement in some specific cases (e.g. only the restitution from a part of one facade with one stereopair of images) a set of twenty-one, well-distributed reference points was measured geodetically in a local coordinate system. Figure 5 depicts as an example the distribution of the reference points on the west facade.

Figure 5: Reference points on the west facade

The reference points were selected amongst the natural points of the object (i.e. no special or signalized), which are easily identifiable and separable. Figure 6 shows an example for the types of reference points, where the upper right vertex of the interior wall socket serves as reference.

The co-ordinates of the reference points were determined by polar measurements with an electronic theodolite Leica TC 3000 and a reflector-free EDM Leica DIOR3002. It should be explicitly mentioned here again, that the accuracy of the reconstruction is not the main purpose of this reference data set, but the reference coordinates are meant if there is a need for reference points for stereo measurement or for other reasons.

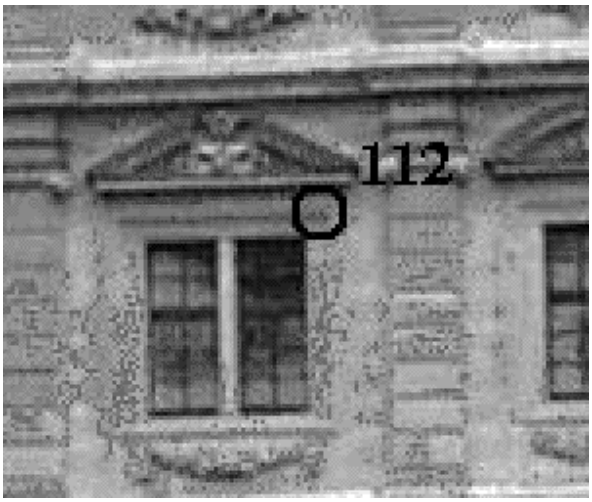

Figure 6: Reference point no. 112.

4. Call for participation

The main intention of this reference data set is to reflect and share practical experiences about the handling of a system/tool for the photogrammetric documentation of cultural heritage. In particular to get measures about the data flow, the derived results in terms of topology, consistency, accuracy and reliability, the requested input data, the possible export format, the amount of photogrammetric knowledge necessary to handle the system/tool, etc.

While making this reference data set available for the CIPA community the authors would like to encourage people from the scientific and from the practical point of view to use this material in order to derive results with different hardware, software and methods.

Hence, interested persons are asked in particular to

- use the data set
- use different software packages and/or tools for the reconstruction
- to reconstruct the object in different ways (2D/3D, CAD/map, entire object or parts of it, different degrees of detail)
- critically review the data import and export
- give a description of the data flow / automation, accuracy measurements, statistical data
- to report about their experience by filling in the questionnaire (CIPA, 1999b)

5. Availability of the reference data set

The reference data set as well as the complete questionnaire can be downloaded from the CIPA web site (URL: http://cipa.uibk.ac.at).

6. References

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