AUTOMATED PROCESSING OF DIGITAL IMAGE DATA IN ARCHITECTURAL SURVEYING

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ABSTRACT

Digital image maps can be produced by assuming an object surface and using the eight-parameter transformation for photo rectification or with knowledge about image orientation and a given object model.The latter is known as an orthophoto where the object model is represented by a digital terrain model.

In close-range architectural applications the hidden-area problem has to be solved. A building structure can be recorded by means of multi-image photogrammetry with several photos. Orientation of the images has to be carried out by bundle adjustment. The result provides photo positions and some object points. Additional line measurements define a geometrical frame. This wire-frame model can be automatically transfered into a surface structure.

The orthogonal projection of digital image data takes into consideration the hidden parts of the object and is getting the gray values from photos with the best intersection. Furthermore the information about texture orientation for ray-tracing programs can be generated.

Algorithms and first experiences with a Windows software package are presented.

1. Building Surveys

Building surveys are carried out for various reasons such as validation, maintenance or facility management, alterations and additions, restoration, settlement of orders or simply recording of the architecture and its details. The „drawings" are presented as floor planes, elevation drawings and section drawings. The range covers large scale plottings from 1:10 for details up to 1:200 or smaller for mass studies.

Today, the surveying results are presented as computer models for further processing by the architects. If photogrammetry is used for facade recordings elevation drawings can be produced as digital image maps. The advantage of those image maps compared to line drawings is the higher degree of detail with less effort. The investigation or interpretation of the plotting can be done by the end- user himself.

Beside the above mentioned purposes there is an increasing demand in modelling urban areas. Since we are going to present architecture in a multi-media environment as photo realistic renderings and animations, digital photogrammetry will become more and more important for moving virtual reality worlds. This will open a much wider range of applications beyond the conventional surveying field. 3D-GIS data bases, multi-media presentations, visualization and integration of distributed data bases with access through the internet is a challenge to the photogrammetrist.

2. The Electronic Image

2.1 Digital Cameras

A metric camera is given if the position of the projection center relative to the image is known and if the lens distortion can be corrected numerically. A digital camera meets with this requirement if the focus can be fixed. Another condition is a plane image surface which can be assumed for CCDs.

Therefore, digital cameras can be calibrated and used for photogrammetric applications if the autofocusis switched off.

We group digital cameras in:

- viewfinder cameras

- 35 mm SLR cameras

- medium format cameras

The viewfinder cameras are equipped with sensors of 2/3" and provide resolutions of about 1280 x 1024 pixel with 24 bit color information. The focal length is indicated as for the 35mm frames. Memory cards are used as storage medium. One sample is the Olympus C-1400L .The cameras are inexpensive, easy to handle but not recommended for the application we discuss here.

Digital cameras like the Kodak DCS 460 are sufficient for photogrammetric measurements. The electronic device from Kodak is adapted to standard SLR cameras like Nikon or Canon. Sensor size is 18.4 x 27.6 mm with a resolution of 2036 x 3060 pixel. This magnifies the focal length with a factor of 1.3. A 28 mm lens will result in a 36 mm. The price is approx. 20 times higher than for a good viewfinder camera.

High end medium format cameras like the Rollei ChipPack or the Rollei Q16 with a full frame sensor of 4096x4096 pixel are developed for studio photography or industrial measurements. Digital medium format cameras suitable for building recording are not available yet.

The gap between viefinder cameras and the Kodak DCS will be closed by single lens reflex cameras like the Minolta RD-175. In this case three CCD´s result in a total resolution of 1528 x 1145 pixel.

Figure 1: Rolleiflex 6008 metric reseau camera

2.2 Film Scanning

For architectural surveying the question of object resolution resulting from image scale and image resolution is important.

The AGFA DuoScan is a scanner with twin plate technology. The optical scan resolution is 2000 ppi vertical and 1000 ppi horizontal. Maximum resolution is 4000 ppi interpolated. Sample depth is 12 bit per color. The scanning surface for positive or negativ films is about 203 x 254 mm.

In combination with the Rolleiflex 6008 metric camera the film scanning process provides the same resolution as the Rollei Q16 metric camera.

The Rolleiflex 6008 is the camera following the well known 6006 model. Figure 6 shows images recorded with a 40 mm lens. An object of about 10 meter length covers an image area of one inch. Object resolution here is 5 mm.

Figure 2: AGFA DuoScan

3. Digital Object Models

As in all surveying applications 3d object information is reduced to a minimum of points. From those points a data structure with predefined geometrical elements can be derived.

Point co-ordinates are supplied by total station measurements, multi-image photogrammetry or stereo photogrammetric methods.

The multi-image technique is easy to handle on- site. Camera stations can be selected without restrictions. Using different camera systems with focal length changes on different platforms like lifts or helicopters is possible.

Total station measurements supply control point information in a unique co-ordinate system. Complex buildings can be recorded with several separated image bundles.

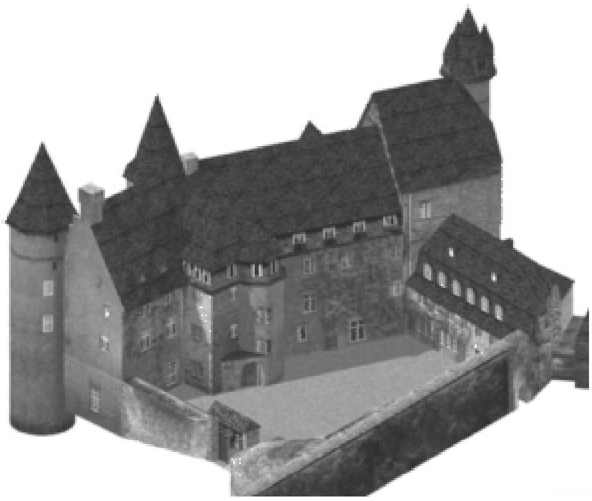
Taking into consideration the increasing demand for multi-media presentations, solutions with sufficient accuracy for the non-photogrammetrists will play a role in the game. The software industry has focused to this people already. A wide range of desktop photogrammetry solutions is available. As mentioned above, the electronic camera, used as a metric device, makes the development possible.

Stereo photogrammetry with respect to automatic point measurement by means of correlation will reach the avarage user as well. Hardware solutions consisting of 8mByte graphic boards, high frequency monitors and image separation techniques, „crystal eyes for example" are already standard in CAD environments.

To give an idea about some of the new interests in photogrammetry, consider the following sample.

Figure 3 shows the photorealistic presentation of a castle. The 3d model is constructed using the information from aerial photogrammetry, multi-image photogrammetry and total-station measurements.

The aerial photogrammetry is necessary for getting the roofing. Control points were observed with total stations, multi-image photogrammetry recording from the ground supplied additional geometry and textures for rendering. The image information is rectified onto the surfaces and adjusted to the model using the rendering software.



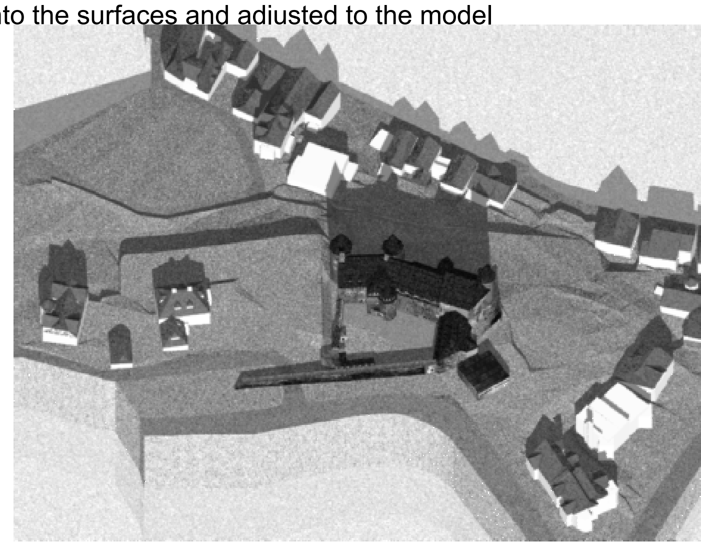


Figure 3 and 4: Textured digital object model and DTM witd object models and surface textures

The complete scene is presented with the digital terrain model and the surrounding buildings. The DTM is calculated from the aerial photogrammetric evaluation. The surface is imported into the CAD system. For this sample the software packages ATLAS, AutoCAD and AccuRender are used. The data material is collected as the base for historic investigation and internet presentations. This project is a co-operation between the City of Herborn and the Universities of Applied Sciences Bochum and Bielefeld.

4. Image Rectification

4.1 Single Image Rectification

Geometric and image processing procedures for warping an electronic image are known in photogrammetry as rectifications. If an object plane is represented in a photo, the photo can be rectified by using a minimum of four control points with the eight-parameter transformation. Knowledge about the camera data or photo position is not necessary.

Only the relative positions of the control points to each other have to be measured. A metric camera is not required. Functions for the perspective transformation are common in image processing programs. The resulting bitmap can be transfered from the 2D-local co-ordinate system into the 3D-world co-ordinate system using the texture mapping facilities of the rendering program

4.2 Orthophotos

Another more sophisticated technique is the orthophoto production. A 3D-object surface is approximated by triangles calculated from single points using a digital terrain modeller. Photos with known camera data and known positions relative to that model are required. The calculation result is an orthogonal projection. The projection plan eis devided into a grid. For every grid point a grayvalue has to be found by calculating the according point into the image. A perpendicular line, starting at the grid point, hits the surface. The ray continues from here through the projection center and intersects the image surface. From this position the gray value is taken. The orthophoto process is limited to object surfaces where z= f(x,y). Solving the hidden area problem is the aim of this contribution.

4.3 Automated Processing

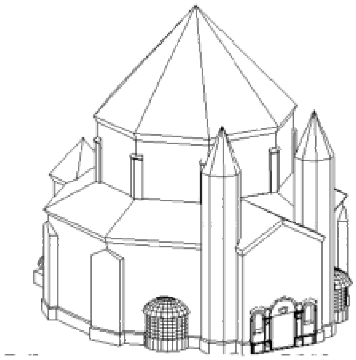
In accordance to the orthophoto process a software package for use in non-topographic applications is designed in co-operation between Rollei Fototechnic, Germany and Help Service, Czech Republic . The program runs on a PC Workstation under Windows. The software is available under the product name OrthoImage.

In building surveys there are beside 2D-orthogonal projections, 2D-true-length drawings and complete 3D-models required. A first example using the OrthoImage program is presented here with the application oft the 2D-orthogonal projection.

The object structure is defined in a DXF fomat definition accepting lines, polylines and 3D-faces. Closed surfaces are not necessary. Different files with DXF information can be overlayed. In the current release of the program it is not allowed that surfaces hide each other in one file.

Since the structure of the file can exist of open lines only, in the first step points are merged together using a snap radius. Afterwards closed surfaces are generated. The number of edges is unlimited. Areas for image rectifications can be altered interactively. As well as several DXF files can be handled, opening of numerous raster files and the definition of their sequence is possible. The raster files are transformed to the surface areas. Pixels outside the selected boundaries are clipped.

Figure 5 shows the complete 3D-model of the church St.Mariae in Aalborg, Denmark. Photos for this sample were taken during a seminar at Aalborg University. Data collection was done with total stations and digital cameras. The following example is based on two images taken with the Rolleiflex 6008 metric. The images shown in figure 6 have to be orientated in the local facade co-ordinate system first.



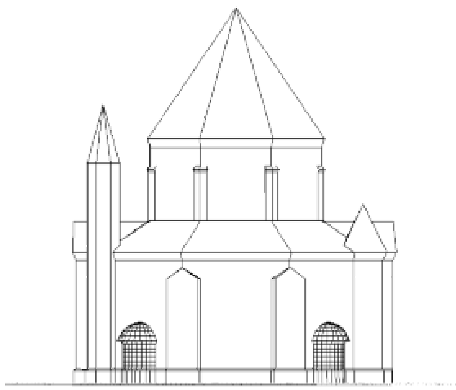


Figure 5 and 7: 3D model in perspective and orthographic View

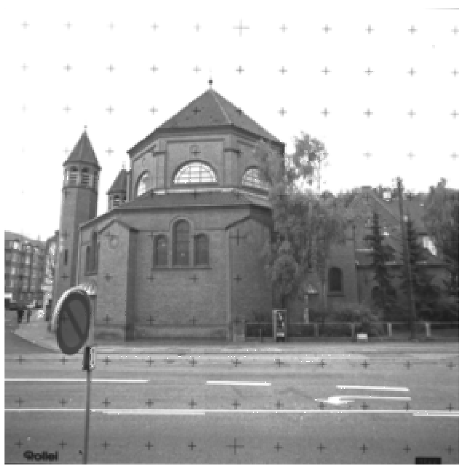


Figure 6: Photos from the image bundel

A transformation of the 3D-model into a user co-ordinate system parallel to the facade was performed. Over this co-ordinate information single image orientation, model calculation and bundle adjustment were calculated to find the photo positions. Using more than one photo for the orientation increases accuracy and enables error detection. The RolleiMetric CDW multi-image software is best suitable for this job. The surfaces of interest were marked in the CAD system and exported to DXF.

Following this preparations the OrthoImage program does rectification and clipping automatically. The boundaries around the selected polygon areas are calculated into the images first. With this information the program can offer values for resolution. The polygon areas are devided into triangles during the calculation. Results are stored in separate files and can also be mosaiced as well with the program. It is possible to store huge jobs frame independent and to mosaic rectangle areas.

Since the bitmaps are geo-coded the calculation for the orientation of the bitmaps into the world co-ordinate system according to the internal file structure of the rendering program can beperformed as well.

Due to rectification process the réseau crosses are deformed and disturb the image. In this case a réseau shape with eight or nine crosses is recommended. An alternative is the integration of non-metric photos, using a second camera body. Investigation should be done in the use of resampling procedures to eliminate those artifacts.

Figure 8 indicates a final calculation result. Some surfaces are shown here with reduced length information.

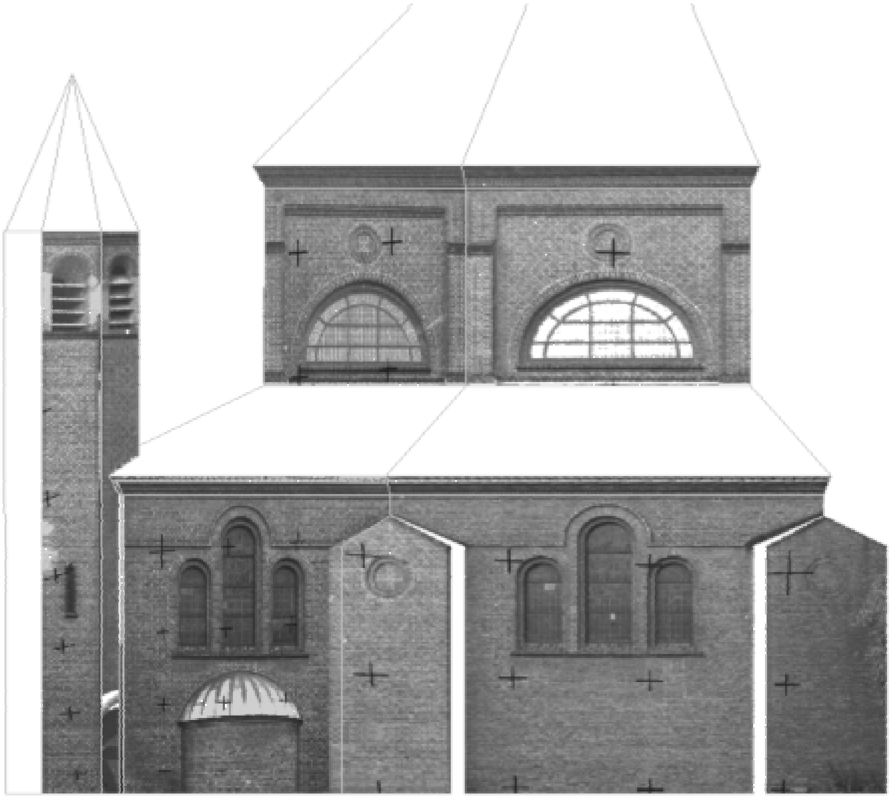


Figure 8: Automated generated orthographic view from the 3D object model and the oriented image bundle

5. Conclusion

Digital close-range photogrammetry in combination with CAD and ray-tracing software is a suitable tool for data collection and the presentation in multi-media environments. Future aspects of the presented process outside professional photogrammetry will find a perspective in further development of digital cameras and automation. The development of algorithms for detecting hidden areas, selection of best intersecting conditions and fast resampling has already begun for the described software package.

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