THE DIGITAL PHOTOGRAMMETRIC EVALUATION SYSTEM PHAUST FOR AS-BUILT DOCUMENTATION

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ABSTRACT

Nowadays the planning and construction of modern industrial plants is done in a CAD-surrounding. Using modern digital photogrammetric measurement techniques surveyors are able to produce time-saving, inexpansive and precise 3D-geometry of all kinds of object shapes, as a basis for further plannings. After the measurements the object geometry and object attributes have to be transferred into the CAD-system.

ZUSAMMENFASSUNG

Planung und Neukonstruktion moderner Industrieanlagen findet heute im allgemeinen an CAD-Arbeitsstationen statt. Die Planungen erfolgen dabei vermehrt auf der Grundlage von 3D-Datenmodellen. Der Einsatz moderner digitaler photogrammetrischer Meßtechniken ermöglicht eine zeit- und kostensparende sowie präzise Erfassung beliebiger 3D-Geometrien. Parallel dazu erfolgt eine Attributierung der Messungselemente, so daß die Gesamtinformationen dem Planungssystem im Anschluß verfügbar gemacht werden können.

1. INTRODUCTION

Nowadays the planning and construction of modern industrial plants is done in a CAD-surrounding. Problems arise when complex 3D-data of old constructions are needed, for example to combine existing and newly planned elements.

By using modern digital photogrammetric measurement techniques surveyors are able to produce time-saving, inexpensive and precise 3D-geometry of objects. Real object features are required for this and not only a field of 3D coordinates. That means the photogrammetric evaluation process has to generate the geometry of object structures (like pipes, volumes, planes, circles etc.) and in addition, describe their attributes. Via an intelligent interface all data have to be transferred into the CAD-system, to build the basis for further constructions und plannings.

The digital photogrammetric evaluation system PHAUST includes all these features. By using any digital image data-bases that are orientated by bundle block adjustment, it is possible to measure all kinds of points, lines/edges and further 3D-elements. The evaluation can be supplemented by the individual demands of the customer. The complete information is afterwards transferred into MicroStation which is the basis of most common planning systems.

2. PHOTOGRAMMETRIC WORK

The photogrammetric work usually consist of three steps:

- signalizing the object,
- taking of photogrammetric photos
- complementary geodetic surveys

When signalizing the object targets are distributed efficently all over the object to use them as tie points for bundle block adjustment. The targets get a number or special code for an easier identification later on. In the following example 51 points were mounted onto the object.

The photogrammetric taking is nowadays usually done with analogous cameras, e.g. the ROLLEIFLEX 6006 metric. The analogous photos have to be converted into digital images by using scanners with high quality geometry and radiometric features. Latest developments of digital cameras, concerning the size of sensor especially (ROLLEIMETRIC Q 16 with 16 millions pixels, pixel-size 15 µm, image format 60 * 60 mm (Rollei fototechnic 1997)), open up new perspectives for digital takings. This means that the time-consuming process of film development and digitizing of material is no longer necessary.

For the documentation of the heating plant in the included example (Hilgers 1997) 81 photographs are needed for a complete coverage of the object (fig. 1).

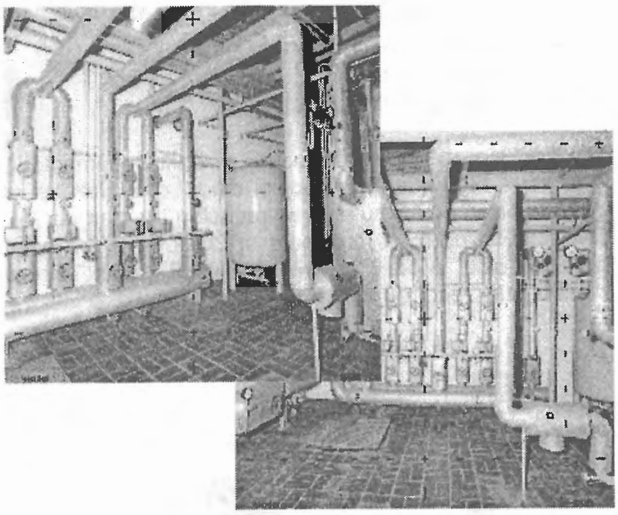


Figure 1 : Selection of images

To fix the photogrammetric model additional geodetic observations have to be made. Seven measured distances and six heights were included in a free net bundle block adjustment to set the scale and level the model. Normally even larger objects do not require more complicated geodetic measurements.

3. IMAGE PROCESSING AND ORIENTATION

After the development of the film the negatives are digitized on a desktop scanner with a resolution of 15 µm (about 1700 dpi, Fig. 2).

Tests have shown that the measurement of image coordinates has to include for example a mesh-wise affine-transformation e.g., in order to allow for geometric errors. It is also possible to rectify the digital images with the help of the reseau as an off-line process before the image point measurements. A special module is integrated in the program system PHAUST; it can be run in batch modus.

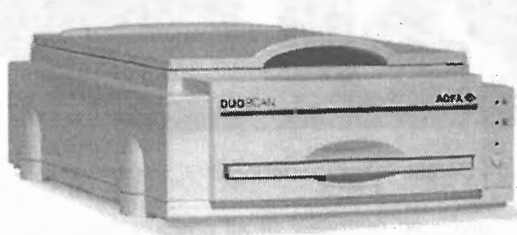


Figure 2 : Agfa Duoscan filmscanner

All orientation measurements, in context with targets, are carried out with the help of digital operators (centre of gravity, ellipse) after defining the approximate values. For building a "visual data base" (e.g. orientated images) interfaces to several bundle adjustment programs are integrated in PHAUST (for example ROLLEIMETRIC PROMPT, CAP etc.). The adjustment determines the interior orientations of the cameras, the exterior orientations of the images and the spatial coordinates of all targets.

In our example the following accuracies were obtained after bundle block adjustment (tab. 1)

	Accuracy (standard deviation)		
Type of point	X [mm]	Y [mm]	Z [mm]
Targets	2,7	2,2	1,5
Natural points	3,2	3,4	1,6
RMS	3,0	2,8	1,5

Table 1 : Point accuracies after bundle adjustement

As an as-built documentation usually requires object accuracies of 1-2 cm, the acquired accuracies rank as very good results.

4. OBJECT MEASUREMENT USING THE SYSTEM PHAUST

Object building or measurement is the main task when generating an as-built documentation for industrial plants with the help of close-range photogrammetric workstations.

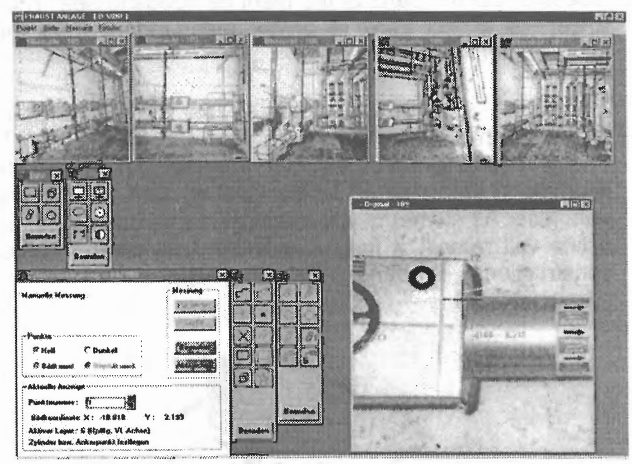


Figure 3 : PHAUST graphical user interface

The measurements include contents all essential parts of the plant, for example aggregates, cable conduits, conrete and steel structures, stages and all kinds of pipes (Kruth 1997). The measurements are normally completed by CAD-construction.

The software used in this example is the photogrammetric evaluation system PHAUST (Woytowicz 1996) with a special "plant"-module. Image selection is done via an active graphical window which shows the position and direction of all orientated images. This is a suitable method to choose the images for actual measurements, without information of the whole image block. Measurements can be done in up to 7 pictures at the same time (Fig. 3).

In addition to the measurements of points and lines special modules for recording cylinders (pipes), circles, planes and volumes are integrated. The visualisation of epipolar lines helps to identify homologous object points.

Superimposition is used for giving a total view of already measured elements.

The measurement of cylinders and circles is done with special adjustment modules. Thus it is possible to measure boundary lines (instead of homologous points) for the calculation of an object (Straub 1996). By using an integrated "merge"-function, it is possible to fit several parts of the axis of pipes. This is an important feature for the CAD-construction.

Further functions are for example the determination of points of intersections or cutting angles.

When recording the plant geometry it is possible to supplement object attributes. These are appended to the geometric elements also called "tags" and can be immediately used in a plant design system.

A distinct structuring of a plant is done by subdividing the measured objects in elements that belong together. Up to 63 layers can be defined in the system to arrange these measurements. This feature is similiar to a common CAD-system, like Bentley´s MicroStation, which is nearly an "industry"-standard as the basis of plant design systems.

By using these layer techniques the operator is able to fade in or out the parts of the plant he needs to see. Thus a general object view is given, independent from the mass of measured objects.

To transfer 3D-data and attributes into the CAD-system an intelligent DXF-interface is integrated into PHAUST. This interface guarantees that the complete available information is integrated in the CAD system without any data loss. All elements will retain their characteristics, so a line will remain a line, a cylinder a cylinder. Further constructions are not nessecary (Fig. 4).

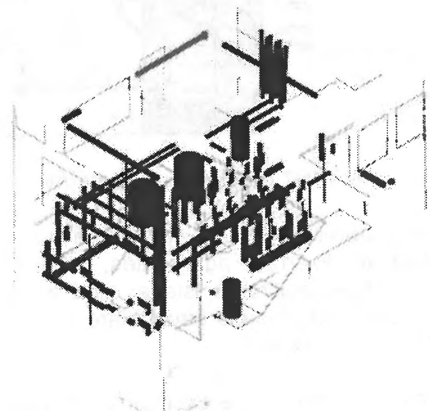


Figure 4 : General view of objects measured in PHAUST

5. CAD-CONSTRUCTION

After the mass evaluation with the photogrammetric workstation the aim of the CAD-process is to complete the photogrammetric model. Manual measurements on the one hand, and obtaining object information from existing 2D-plans on the other hand are the basis for the contruction of missing elements.

Generally this concerns the construction of circular lines, large vessels or other complex objects e.g. pumps. In this context it is sometimes nessecary to generalize the model to the main structures (edges and knotes). Further steps in a possible work-flow are characterized by

- assignment of materials
- camera drive
- object animation
- building of virtual realities by VRML

The first aim of photogrammetric as-built documentation is to get a high quality 3D-object model of a plant. A second one can be formulated by reducing the part of CAD-construction up to a maximum of 20-30% of the whole project costs. Modelling with PHAUST "plant"-module meets these requirements (Fig. 5 and 6).

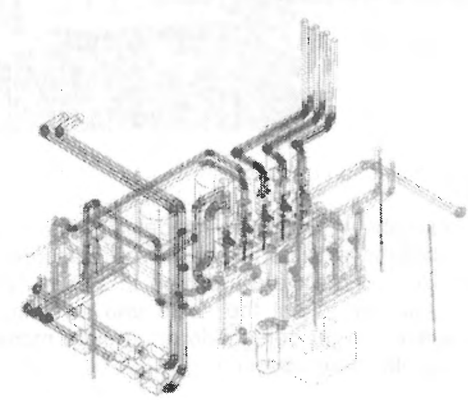


Figure 5 : General view of the plant after CAD-construction

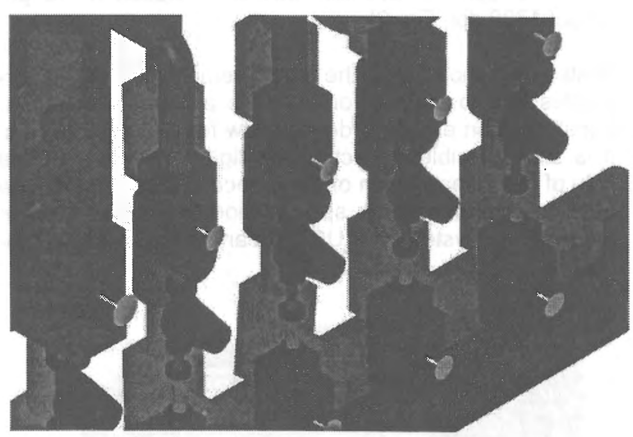


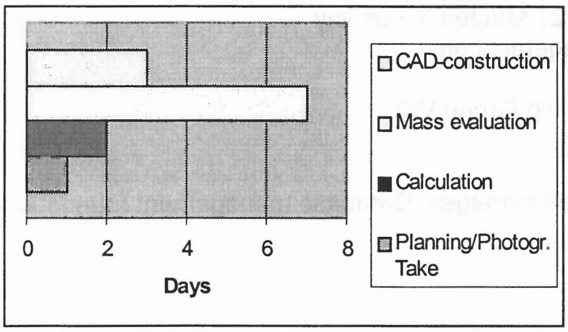
Figure 6 : Details (after rendering)

Table 2 gives an overview of all process steps and necessary times.

A useful effect concerning CAD-construction is the integration of libraries with standard structural parts used in plant design systems. Those elements might be for example gate valves, stopcocks, etc. These structural parts are used to be inserted via 3D-points (measured in PHAUST) into the 3D-plant model.

Another possibility is to generate of macro-programs, which work this job automatically. The overall aim of these modules consist in a maximum reduction of time and costs while constructing the 3D-model.

At present PHAUST interfaces to existing piping modules and further plant design systems are being developed.



Tab. 2 : Overview of working steps

6. RESULTS

Methods and tools that have emerged in the field of close-range photogrammetry represent an efficient alternative to hand-made measurements which is still widely used today. With the help of close-range photogrammetry industrial plants can be measured and registered in a geometrically exact, fast and cost-saving way.

The presented example proves that the complete survey of a plant is not problematic at all. It may be useful, however, to integrate geodetic measurement systems into the measuring process, e.g. in case of object parts that are hardly accesible.

7. LITERATURE

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