

HOW TO OPTIMISE THE RECORDING OF GEOMETRICAL DATA AND IMAGE DATA FOR THE PURPOSE OF ARCHITECTURAL SURVEYING

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ABSTRACT:

In architectural surveying it is much more effective to closely integrate different surveying methods than to use them side by side. Based on this experience, new hardware and software as well as corresponding new measuring tools were developed. The hardware is based on a notebook-directed robot-tacheometer capable of reflectorless measuring, making it possible to run various new measuring functions, for example precise tacheometric scanning. This type of instrument is also called an intelligent tacheometer. Various surveying technologies were developed which are all based on control circuit mechanisms: The ability to traverse feedbacks distinguishes the active, object-oriented robot-totalstation fundamentally from the passive, not object-oriented laser scanner.

In combination with an additional digital camera, the instrument may be used in a lot more possible ways. I. e. it offers the possibility to direct the instrument's telescope by mouse clicking on a photo being displayed on the notebook's screen and to exactly measure the coordinates of the point indicated by the cursor. In this operation-mode the image may be taken from an arbitrary position. This technique makes it quite easy to do online rendering or to establish a virtual model.

1. INTELLIGENT SCANNING WITH TACHEOMETERS

The "intelligent" tacheometer is characterized by the possibility of setting out directions computer-controlled via servo-assisted motors and to measure the distance to the object. The first reflectorless measuring instrument of this kind was developed at the Ruhr- University Bochum, Germany and presented in 1994 (Scherer, 1995); now the companies Leica and Trimble sell a whole range of such devices with varying specifications (see fig. 1).

For this type of instrument, various surveying technologies were developed which are all more or less based on control circuit mechanisms: The ability to traverse feedbacks distinguishes the active, object-oriented totalstation fundamentally from the passive, not object-oriented laser scanner. Special techniques to determine single points, points on spacial curves and points on surfaces are used.

Intelligent scanning is opposed to the undifferentiated scanning with a laser scanner, where millions of points are taken, but a single point is without importance. Laser scanning does not immediately take the object into account. The instruments are still very expensive, the factor between time on site and time in the office varies between 1:10 to 1: 30. Often an additional tacheometer is needed to establish a coordinate network. And it might also be taken into account that the tacheometer is the most universal surveying instrument usable for many different tasks and not a special construction like the laserscanner.

In chapter 2 different functions of the work with an intelligent tacheometer are described. Chapter 3 gives an impression of the enhancement of the large spectrum of possibilities when digital photos are added.

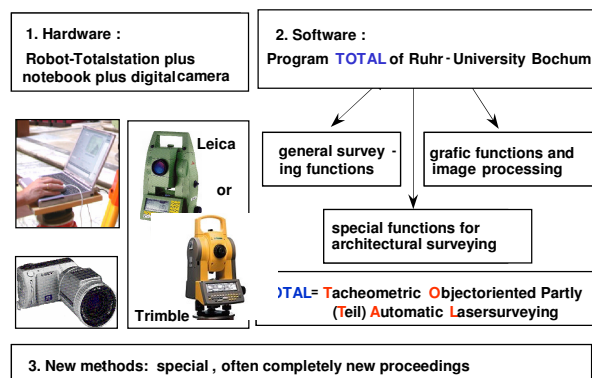


Figure 1: Characteristics of intelligent scanning

2. SPECIAL FUNCTIONS OF THE INTELLIGENT TACHEOMETER CONTROL OR: WHAT LASER SCANNERS ARE NOT ABLE TO DO

Figure 2 contains a summary of various surveying technologies for the "intelligent" controlled individual point recording. One of these tools will be introduced or exemplified.

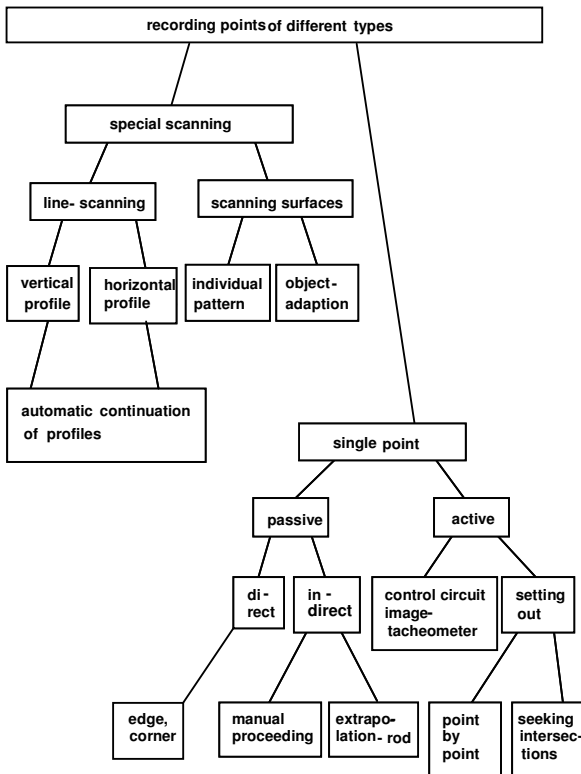


Figure 2: What laser scanners are not able to do

Measurement of horizontal and vertical profiles

When documenting monuments the profile-measuring function proves a very powerful tool, making location-independent horizontal and vertical profiling possible. Vertical or horizontal profiles are taken absolutely independent from the position where the totalstation is stationed. They are automatically continued everywhere in the monument e.g. on both sides of a wall. Further useful tools, like initiating measurements out of the graph shown on the screen of the notebook enable fast, effective work. In practice the steps are: define the plane of the profile, determine the thickness of the slice in which the profile points should be situated – i.e. 5mm-, and define a fixed distance between the points, independent from their distance to the totalstation - i. e. 3 cm.

Recording of surfaces

On this particular functionality the totalstation and the laser scanner have the most similarities: there is no differentiated selection of the measured points, but merely a polygonal separation of the measurement area with subsequent automated measuring of the matrix points (see figure 3, 4). The steps in the practice using this function are: define the area by surrounding it with the laser point, determine the grid density; then the point positions to be measured is computed and the coordinates are automatically determined.

Figure 3 shows a bust scanned with a small ray diameter.

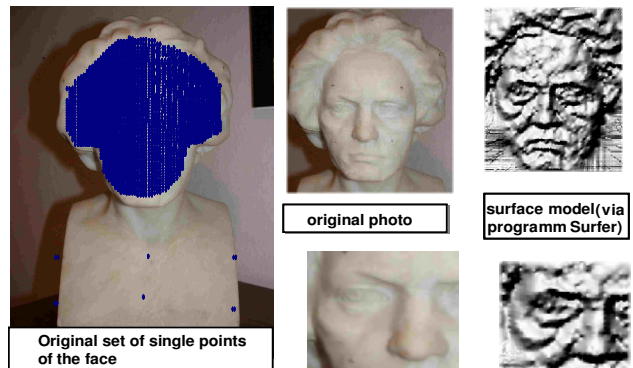


Figure 3: Scanning a small object

In some cases the accuracy exceeds a laser scanner. In general it does not matter that this method needs more time, because the totalstation operates automatically. It is not required to measure an unnecessary high amount of points because a variable point density can be set according to the quality of the surface. The intelligent scanning can be further enhanced through automated recognition of the normals of surfaces to reduce the amount of points and to increase the quality of the points by considering the slope of the object. Another possible enhancement may be through automated distance correction for signals of variable intensity.

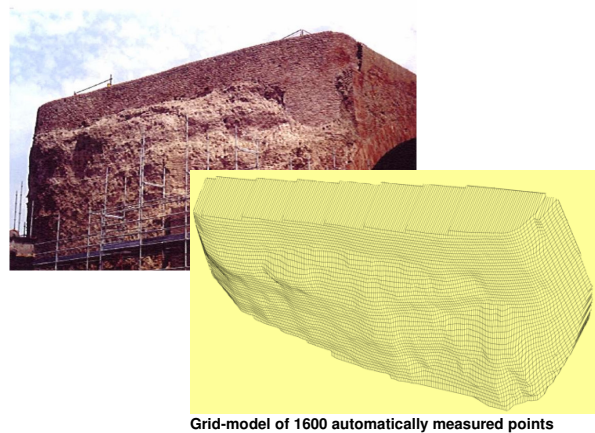


Figure 4: Scanning a large region

Figure 4 shows the scan of a larger region, but with points at greater distance. Both examples show that scanning with the tacheometer might be a low-cost alternative to typical laser scanning.

Precise determination of edges and corners

Due to the fact that the diameter of the footprint of the laser beam measures only one centimeter, edges cannot be otherwise determined with high precision (figure 5).

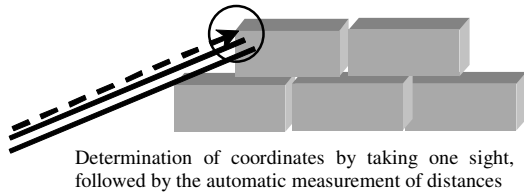


Figure 5: Precise determination of edges

Recording of hidden points

Another tool is a specially coded extrapolation-rod which is used to measure hidden points quickly, precisely and widely automatic (figure 6). For practical work the rod may be shortened or lengthened: The operator must not pay attention, because of the coded distances of the benchmarks.

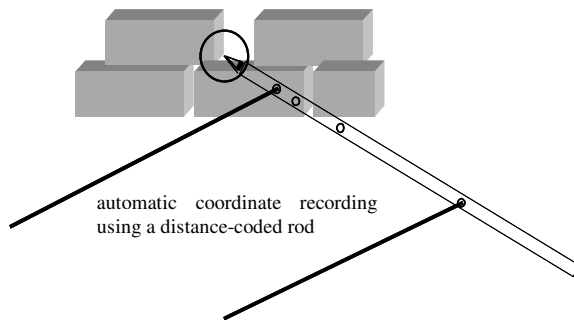


Figure 6: Measuring hidden points

3. ENHANCEMENTS OF THE APPLICATION SPECTRUM THROUGH INTEGRATION OF GEOMETRICAL AND VISUAL FUNCTIONS

Taking the image into account is an advantage in three different areas: for documentation and archiving, for targeting, and for visualization and modelling, e.g. to generate ortho-images (figure 7).

Below some of the numerous applications are explained in more detail:

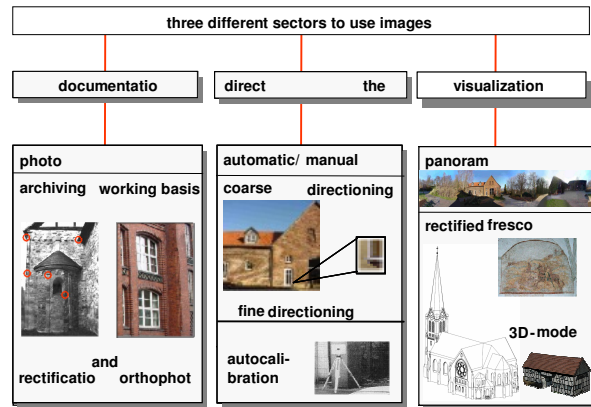


Figure 7: The role of the image

Rectification and Orthophoto for restoration purposes

So called 4-point-rectification is possible either through distances measured in the images or through coordinates. When determining the coordinates on site with the total-station

- the steps of identification and referencing are omitted,
- known geometric properties may be taken into account (parallelism, rectangular angles)

Parametric rectification with automatic direction of the instrument

This procedure allows a particularly fast on-site generation of ortho-images and 3D visualization with the following steps (see figure 8):

- a) Make the photo, save it to a laptop and orient the image using control points to be measured in the course of the process. This delivers the position and the orientation of the camera at the time of recording.
- b) Click on a point of a surface in the image; automatic steering of the distance measuring laser dot to the corresponding point on the object takes place. The real coordinates of the clicked point are automatically measured. Thus the area (plane) may be defined by three points.
- c) Click the corners of the surface in the image, connect them and cut out image planes resp. triangles for visualization software.

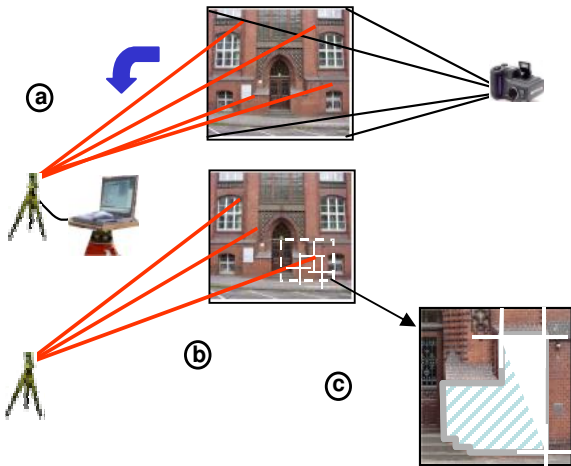


Figure 8: Intelligent control through external images

Dynamic measurement protocol

A continuously growing graphical measurement protocol is generated through the parametric link between the coordinate system and the image. In an oriented image, single points and connecting lines are faded in automatically (figure 9).

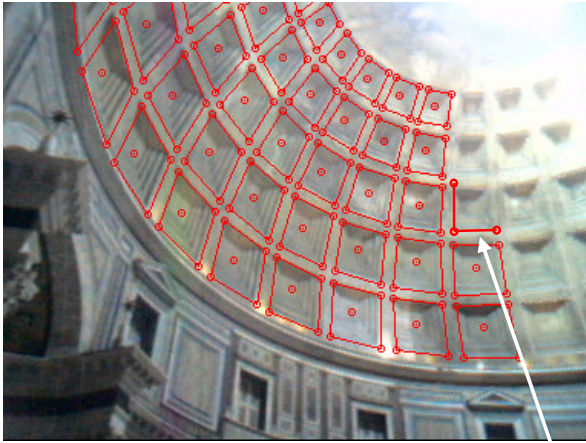


Figure 9: Dynamic measurement protocol

Point numbers can be registered for future applications, e.g. for monitoring or densification of the network or referencing for photogrammetric purposes. The link between the images and the coordinates is permanent. Therefore the totalstation can be adjusted at any time by clicking on the points in the image.

4. FUTURAL DEVELOPMENTS?

In 1994 the first tacheometer with servomotor measuring reflectorless and directed by computer was developed at Bochum. This type of instrument is now working worldwide in various models and applications: in recording, control in engineering surveying and for setting out. Meanwhile this type of instrument was modified. To make it more flexible cameras were integrated into the tube of the telescope (see figure 10).

Two wide-angled cameras with different focal lengths are in the casing; a third camera is located in the plane of reticule. This so called ocular camera is automatically focused by a gearing in the tube of the telescope. The appliance can be remote controlled through the images and measurements directed towards the zenith can be done without any problems. For subsequent identification, the measured points can be documented at the time of the recording for various purposes. This is particularly important for work with “natural points”

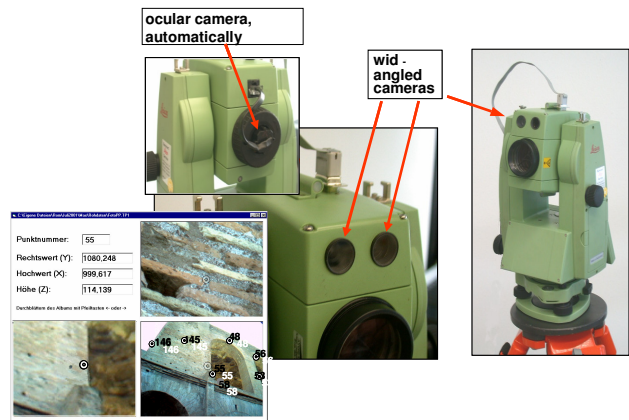


Figure 10: Integrated cameras and a set of photos of a natural point

With the aid of the cameras documentation of object points and directing the instrument via notebook are simpler than using the photos of the external camera described in chapter 3, because now the parametric orientation is not necessary.

This new type of instrument - robot-tacheometer with integrated cameras - may be called a “video tachymeter”. Maybe in some years it will be a custom instrument, like the servo-driven reflectorless measuring tacheometer, which was developed at university of Bochum ten years ago.

In chapter two and three the broad application spectrum of the reflectorless measuring servo-driven tacheometer, especially when using a digital camera was shown. “Low-cost scanning methods” are possible with this equipment. However it should not be understood as a competition to Laserscanners but as a powerful enhancement and sometimes as an alternative.

Everybody has to decide on his own which method should be chosen, depending on the characteristics of the object, costs and on the result which is asked.

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