THE USE OF VIDEO-TACHEOMETRIC TECHNOLOGY IN THE CONSTRUCTION OF THE SPATIAL MODEL OF AN OBJECT

Ewa Tkaczyk, Emilia Szumowska, Marek Woźniak
Faculty of Geodesy and Cartography
Warsaw University of Technology

ABSTRACT

This paper presents the investigation of measurements using the new instrument Image Station 03 TOPCON (video-tacheometer) and required data processing methods. Video-tacheometer allows to scanning using reflectorless mode of distance measurements. It is possible to join the geodetic measurements with digital photography taken with narrow and wide-angle CMOS cameras built in the instrument. The accuracy effects and functional characteristic of this system in inventory of architecture object were controlled.

1. VIDEO-TACHEOMETRY

The technology of video-tacheometry is a new solution in the sphere of geodesic measurements. It consists in a systemic combination of direct tacheometric measurements and digital photography in one instrument. The devices of this type are called video-tacheometers or photo-tacheometers. They enrich non-reflector measurement to the surface of an object with digital photographs taken with a camera built into the system of an optical tacheometer.

Fig. 1. Video-tachimeter IS-03.
Owing to such a solution, it is possible to obtain integrated spatial data in the form of: a” cloud Station-03 (see Fig.1). Equipped with two digital cameras, it allows to make observations of images and tacheometric observations. The effectiveness of operation is achieved by the use of the specialist software Image Master of points” and images representing an object. All these elements are registered in a very short period of time. One of the newest video-tacheometers on the market is the instrument Topcon Image_Station.

2. OBJECT OF AN EXPERIMENTAL MEASUREMENT

In order to test the usefulness and effectiveness of video-tacheometric technology in building spatial models, a number of measurements were made, especially of a geometrically complicated and architecturally decorative elevation of the main staircase in the Main Hall of the Warsaw University of Technology.

![Fig. 2. View of the Main Hall – the subject of an experimental measurement.](image)

The exceptional geometric variety of the object was used to test both the instrument Topcon IS-03, Topcon Image Master software and the whole technology with a view to building complex spatial models. The object was chosen for two reasons. On the one side it is a rich architectural form and on the other, it is situated in a place ensuring excellent conditions for making measurements and supplementary observations.

3. OBJECT MEASUREMENTS

A number of scanning measurements were made for selected areas in hybrid technology in different scanning density. All the measurements were taken in a uniform system of coordinates based on the established space control.
The highest scanning density of the measured surface was 10 000 points/m² and the lowest was 1000 points/m². The technical properties of the instrument allowed the maximum scanning speed of 20 points/sec.

Fig. 3. Distribution of Canning areas In the main staircase of the Hall.

A selected area of the object was measured from 30 “free” stations, for which the maximum error of positioning did not exceed a few mm. From these stations observations were made: scanning and image registration.

As a result of experimental measurements, 133 files were obtained that contained integrated spatial data (“clouds of points”) and photographic images (photographs of the 1.3 Mpx resolution).

Additionally, measurement and calibration photographs were taken with a separate professional digital camera Canon EOS 5D Mark II of the 21 Mpx CMOS matrix resolution.

4. BASIC ANALYSIS

All observations obtained for selected working areas were analyzed with the Image Master software. It allowed to process geometric data and images in an automatic way in the case of fully correlated tasks.

The above activities could be done according to different consecutive processing of “raw” observations by selected procedures, i.a.:

- filtration of “clouds of points”,
- giving the points the texture characteristics
- creating a TIN network
- generating a surface model,
- superimposing “natural texture” from the registration made in the form of photographs.
5. REFLECTOR-LESS OPERATION MODE OF THE TACHEOMETER

The video-tacheometer Topcon IS-03 enables a fully automatic, non-reflector measurement to the surface of an object. The registration of tachometric data can be made not only in the scanning mode (Non-stop mode – 20 pts/sec) but also in the mode of single point measurement (Stop mode – 1pt/sec).

The choice of operation mode of the telemetric part of the tacheometer depends not only on our decision but also on measurement conditions: conditions of wave propagation, power conditions of the reflected signal, etc. Both ways of measurement were tested in the case of the cross section of a smooth surface, very suitable for measurement.

Working in the Non-Stop mode, the instrument makes observations of “a cloud of points” in a quasi-continuous way. A beam of laser is being sent throughout the whole time of the measurement. On the other hand, the Stop option allows the observation of individual elements of “spot” registration. This manner of spot registration is characterized by a considerably higher accuracy as it is carried out with a more powerful laser beam, with much better acquisition of directional data combined with distance monitoring. The scanning effects are graphically presented in Fig. 5.

There were observed distinct oscillations of consecutive results of profile measurement in its plane and discrepancies between the STOP and NONSTOP measurement. Another important element are the discrepancies between non-reflector measurements carried out in the NP (no_prism) and LNP (long_no_prism) modes.
6. CREATING A SPATIAL MODEL OF THE OBJECT

Building a true model based on measurements is a painstaking and complicated task. In the framework of the experiments made, a number of spatial models of the object fragments were built. One of them was a fragment of the vaulting. It was made in the following stages:

- point representation of the object (“A cloud of points”),
- generating elements of the network of triangles TIN,
- superimposing a surface onto the created network TIN,
- superimposing the texture from photographs onto the prepared surface.

Due to the complexity of the task, individual fragments (architectural details) of the object were developed separately. As a result of such a procedure, we obtained
segments which could be later easily joined to form a larger entity. The constructed spatial model consisted of about 30 surface segments.

![Image of spatial model](image)

Fig. 6. View of the TIN network spread over a cloud of points.

At the stage of data processing, the software enabled:
- automatic photos orientation,
- integration of photographs with point coordinates measured on a station,
- identification based on a photograph of hard-to-recognize elements of the model,
- aiding the filtration process of a cloud of points by the use of photographs,
- automating the process of giving natural texture to the TIN surface from photographs.

7. TEXTURING

On the basis of 500 000 points, a spatial model was built, covered with a texture coming from two kinds of raster images: photos taken with an inner camera of the video-tacheometer and photos obtained with the digital camera Canon EOS 5D Mark II.
The quality of these studies could be different depending on the scale of photographs used for the purpose. Despite a considerably higher resolution of the Canon photographs, these studies are comparable as for the final effect obtained (see Fig. 7).

8. FINAL CONCLUSIONS

The application of the technology combining the acquisition of geometric spatial data XYZ and digitally oriented photographs is a very effective operation, especially in the case of inventory measurements. It is a new technology and its accuracy parameters as well as functional and operational are the subject of studies. In the course of our studies, it was found that the technology is characterized by certain technical limitations:

- the maximum scanning speed of the video-tacheometer is 20 pts/sec and it concerns the horizontal direction of scanning,
- a very useful scanning function of the LINE type is sensitive to sudden
changes in the distance from an object,
● the fidelity of geometrical data depends on the shape complexity of geometrical forms of an object,
● the accuracy of geometrical data depends on the quality of readings of spatial directions Hz, V and distance measurements combined into one record,
● a distinct dependence was observed between distance measurement characteristics and operational mode of the telemeter,
● the software is not capable of automatic production of an appropriate texture of the model’s surface. Texturing is a labor-consuming operation.

The system of video-tacheometry is well suited to studying continuous surfaces having slight changes in their shape. It is quite a new, technologically consistent, hybrid method of measurement.

REFERENCES