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Terrestrial photogrammetry and the 3D scanner interface

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Abstract

This article focuses on terrestrial photogrammetry and its applications to practice with the 3D scanner interface. Nowadays, the photogrammetry in a connection with the 3D digital spatial scanning is very demanding. It is used mainly for the reconstruction of historic buildings, but also for the construction of new projects. Photogrammetry consists of several methods and procedures that are directly influenced by software and hardware. The main areas of use are the construction, urbanism, criminal investigation, the medical, aviation and the space industry. Photogrammetry can be used for simple, but also for complex projects to create a visualization of changes, caused by human and natural activity.

Keywords: photogrammetry, 3D scan, visualisation, object

Introduction

Nowadays, terrestrial photogrammetry is one of the most multi-purpose measuring technology, because of its extensive range of options. It may be used for documentation of various spaces and objects. It is a documentation of 2D and 3D objects by contactless measurement of the acquired images.

Accuracy and geometric resolution, these are predefined by the distance of the image and the focal distance of the lens. Therefore, the photography can be taken from a few centimetres up to hundreds of meters. As the definition of distance bounds are not strictly given, the upper and lower boundaries cannot be bounded. Also, we can limit the accuracy and indicate that it ranges from a few micrometres up to decimeters. Furthermore, accuracy depends largely on the used technology such as a camera or video camera, the precision of coordinates measurement, snapshot configuration, the coordinate system definition, precision of fitting and gauge, the used deterministic model of coordinate estimation and stochastic model and other parameters. [1]. Because of these procedures, it is possible to achieve a high accuracy up to 1: 100000 which is normally around 1: 10 000.

Due to the digital photogrammetry options, instruments and technical equipment are very diverse and today's prices are range from several tens of Euros up to 10.000 Euros.

Nowadays, mainly, the following devices are used:

- Large format digital camera,
- Mid-format digital camera,
- Mirrorless cameras and compact cameras,
- Panoramic cameras,
- Stereo cameras,
- High-speed cameras
- Video cameras
- Mobile phones
- Web cameras and various special camera systems.

[2]

Useful application areas:

- Stone quarry measurement,
- Determining defections,
- Measurement of historical monuments and building facade,
- Creation of 3D models of castles, places and cultural heritage (statues),

- Ballistics,
- Aircraft industry,
- Criminal investigation,
- Military research purposes where thermal imaging cameras are used,
- Healthcare, mainly in X-ray examination of patients and detection of tumours by using a special sensing equipment.

Photogrammetry Development

Development of the terrestrial photogrammetry itself was influenced mainly by the introduction of a camera. Subsequently, photogrammetry moved forward thanks to the development of mechanics, electronics, optics and stereoscopy and computing.

Iconometry
The origin was just before the invention of the camera, and it was based on the hand drawing pictures.

Section photogrammetry
It is based on the intersection. In the past, this method often used two images made at the endpoint. At the end of the 19th century, by using this method, High Tatras were mapped at a scale of 1: 25,000. However, the main disadvantage was the difficulty with the identification of the same points in both images.

Stereophotogrammetry
In 1901, the construction of stereo comparator enabled to make the stereoscopic measurements and observations. Subsequently, the problem, with the identification of identical points on the two images, has been removed. Moreover, in 1911, the stereo autograph has been constructed, which enables the drawing along with stereoscopic measurement. [3]

Digital Photogrammetry
It is a digitalisation process that is used today very often. Within this process, the images are acquired directly through digital or standard cameras and subsequently processed in the computer.

A connection of photogrammetry with 3D scans

In the last decade, electronics have improved and moved forward rapidly. Computing technologies can offer high performance and because of these trends, the new opportunities in photogrammetry and scanning are being introduced. An increase of CPU and GPU performance has enabled the significant development of photogrammetric software which can convert images of the object - for example building into a 3D model. These software products may also compete with laser scanners used very often within activities suitable for photogrammetries, such as building constructions or ground-based infrastructure. The main advantage of photogrammetry is high accuracy and the low time consumption when high-quality input data can be obtained in a short time.
The connection of a 3D scan model with the photogrammetry results in very high quality and accurate model. It is basically a connection of high accuracy measurement and a photo. The outcomes obtained through this process in which the outputs of photography and scanner are getting connected, provides the opportunity to view perfect model obtained in real time.

Another advantage of photogrammetry is that the outcome of scanning, a ready 3D model, has a so-called “weak points” that can be amended. The “weak points” are some areas into which the scanning rays, at the certain angle, cannot penetrate. Therefore, the model is losing more on aesthetic but not on quality. However, the areas can be amended by using photogrammetry. The process is done by measuring common points and subsequently, the picture will overlay the place that was not detected and scanned by the scanner. Then, this ready 3D model meets all the criteria and requirements of quality output.

Figure 1 –photogrammetric data acquisition Chapel

Comparison of scanning and photogrammetry

For years, the laser scanners have been used in various industries. They capture a real-world image, and therefore the digital outputs made from these images are universal and of high quality for further processing. Also, they work with an accuracy of millimetres. However, the scanning process may be slow and costly to SW and HW. This technology also requires highly skilled workers who are not only trained but also enough experienced. Experienced employees will be able to create high-quality real-world of 3D presentations.

Figure 2 –3D model of the chapel from the scanner

Photogrammetric reconstructions achieve similar accuracy to the point clouds obtained from scanning. Pictures catch a large number of points because of the large resolution of the camera sensor. In addition, photogrammetry enables faster data acquisition, and easier subsequent processing and users do not have to take difficult and the time-consuming training to control the software. Photogrammetry produces photo texture of an eye, which in editing is much more clear and understandable for processing than the large point cloud containing noise. It is easier to process the obtained data in a CAD application because it already contains real shapes. The great advantage is cost savings. It shifts photogrammetry to carry out small and large projects, where it is necessary to capture a 3D model with existing conditions in the real locations. And thus, financial modesty may move the photogrammetry to the leading position for small projects processed by the digital camera.

Chapel scanning and photogrammetry: Comparing the time consumption

In this section, I compare 3D model created by the ground 3D scanner with use of the data processing program specified therein and the digital mirrorless standard lenses camera with the use of editing program designed for photogrammetry. We have scanned a Chapel, placed in Kysuce and subsequently captured the images of this object.
Before scanning, we have chosen a suitable location for placement of the scanner and reference spheres. After, we have set up the scanning quality and start up the scanner. The process of scanning itself took around eight hours and after that the acquired data we uploaded to software. So, with this, we have begun the data editing and data postprocessing process. The outcome was processed within five working days, which is 40 hours. The net time spent for this job was 48 hours.

Figure 3 –clear 3D scan with photogrammetry interface

Photogrammetry itself required a brief view of the object. When selecting the starting point of a snapshot, the snapshotting process itself has begun. About half an hour later, the object was scanned, and the data editing process has started in the editing software. Approximately, the time spent for editing took several hours in total.

The comparison itself of the time consumption was quite simple. The final output of the scanner took six days, but the output of the photogrammetry was only one day. Indeed, we acquired 3D models had different accuracies. However, we aimed to link the photogrammetry with the scanning itself. So, we found some common points and linked those two techniques together. The final result was a high-quality 3D model, which met our criteria.

Figure 4 – Comparison of 3D model linked with photogrammetry and with the photo of the Chapel.

Conclusion

Nowadays, the photogrammetry in 3D digitalisation is essential. It is part of the emerging means of improving the quality of the resulting model. Its deployment in collaborative scanning greatly reduces costs and time. Using it in conjunction with a 3D scanner guarantees a high-quality output. These days the process of imaging and scanning are being used more often. Thanks to the development of more powerful software and hardware, their use may increase even in different industries allowing for opening new opportunities and discovering other possibilities of the technology use. The development in the recent decade's enables us to link these two technologies, as well as the others, and then their use may bring progress even to different research areas and industry sectors.

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