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1st INTERNATIONAL SCIENTIFIC CONFERENCE

28th - 30th November 2012.
Jahorina, B&H, Republic of Srpska

University of East Sarajevo
Faculty of Mechanical Engineering
Conference on Mechanical Engineering Technologies and Applications

ZBORNIK RADOVA

PROCEEDINGS

Istoļ no Sarajevo ï Jahorina, BiH, RS
28-30. Novembar 2012.

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28th ï 30th November 2012.

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PREFACE

Production in developed countries is based on the modernization and optimization of the production processes with the application of new technologies that are the result of scientific research. The application of new technology enables company’s efficient production and competitiveness in the world market.

Faculty of Mechanical Engineering, University of East Sarajevo, organizes the First international conference "COMETa2012 - Conference on Mechanical Engineering Technologies and Application", which has tasks: to increase economic competitiveness in the region and the create a unique European Research Area.

Globally, the worldwide we are witnessing a rapid development and a host of new technological solutions, which occur primarily in the multidisciplinary development (mechatronics) but also in development of completely new technologies, such as nanotechnology, new energy sources, intelligent machines and processes, micro-technique, etc. All of this puts researchers and engineers in the new challenges and creates opportunities for products and technologies that provide a precondition for economic recovery and creation of new jobs.

COMETa2012 conference program structure is consisted of the following thematic areas: Production technologies and advanced materials, Applied mechanics and mechatronics, Development of products and mechanical systems, Energetics and thermo - technique, Renewable energy and environmental protection, Quality, management and organization, Maintenance and technical diagnostics.

Participation in international conference COMETa2012 was achieved by: 182 authors from 9 countries, with a total of 90 papers, including 4 plenary and 3 of introductory, 4 leading commercial companies and many small and medium enterprises. Bruel & Kjear Workshop: "Measurement of noise and vibration", was also organized at the conference, as well as a round table discussion: "The importance of quality infrastructure of B&H within the European integration".

The presence of a large number of participants from Bosnia and Herzegovina and abroad as well as the problems which are processed at the conference, coincide with the themes promoted by the European Union in its development programs.

On the basis of previous exposure, a gathering of scientists and researchers at the international conference COMETa should be understood not only as an exchange of knowledge and achievements of the narrower set of scientists and researchers, but also as a constant and serious attempt to focus social consciousness and social life on activities that ensures progress and prosperity of any society, and that is productive work, creating new knowledge and economic development.

On behalf of the Organizing Committee of the Conference COMETa2012, thank all authors, reviewers, as well as institutions, companies and individuals who contributed to realization of the Conference.

East Sarajevo, October 28th, 2012. *President of the Organizing Committee*

Prof. dr Ranko Antunović

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THE INFLUENCE OF THE DSLR CAMERA SHUTTER COUNT ON THE ACCURACY OF THE PHOTOGRAMMETRIC MEASUREMENTS

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Abstract: *Photogrammetric methods are modern methods of measurement predominantly used in quality control, measurement of deformation and reverse engineering. Thanks to a series of favourable properties their share is growing in modern measuring chains. The accuracy of method is confirmed in each measurement by the so-called selfcalibration, a process in which the system determine its internal characteristics and their impact on the accuracy of measurements. Over time, the characteristics of the equipment components, primarily high-resolution DSLR camera, is changing. In this paper the effect of the shutter count (total number of recorded images) on the accuracy of photogrammetric measurements is examined by comparing measurements performed by cameras with a small and a large shutter count. The presented results show that the measurement error is significant, thus the shutter count affect the quality of the measurement result.*

Keywords: photogrammetry, triangulation, quality control, accuracy and precision of measurement

1. INTRODUCTION

Optical measuring technology have become a standard tool within almost all industries [1]. Conventional measuring machines' tasks, traditionally performed by tactile CMMs, now are carried out with the optical CMM systems [2]. This contactless method is suitable, because the measuring instruments are robust and mobile. Using the optical measuring system significantly reduces the time required to develop and manufacture products, while increasing quality.

Foundation of optical measuring technology is photogrammetry [3]. Photogrammetry is tool for determining the geometric properties of objects from photographic images as the main metrology medium using methods from many disciplines, including optics and projective geometry. This method is suitable for objects of various sizes and complexity [4]. The measuring sensor used in this method is high resolution CCD camera [5]. One standard method of photogrammetry clasification is based on camera location during photography: aerial and close-range

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photogrammetry. In close-range photogrammetry the camera is close to the measuring object. In Mechanical and Civil Engineering photogrammetry offers an accurate and cost-effective solution in a number of different application areas including: Quality Control, Reverse Engineering, Rapid Prototyping, Rapid Milling, Digital Mock-Up, etc.

With simple configuration measuring objects for the entire measurement just a few photos is taken. However, for large and complex geometric objects measuring project requires recording dozens or even hundreds of measuring images. This number is significantly higher in the case of deformation measurements. Then, for any observed configuration a separate measuring project is created. In such cases, the total number of images recorded by measuring equipment is growing rapidly, much faster than in the classical case of shooting professional photos. This fact raises the question of whether such a trend in the recording images affects the accuracy of the measurement method?

A single-lens reflex (SLR) camera typically uses a mirror and prism system. Digital single-lens reflex cameras (also named digital SLR or DSLR) are digital cameras combining the parts of a single-lens reflex camera (SLR) and a digital camera back, replacing the photographic film. DSLR cameras incorporate a shutter mechanism capable of moving extremely fast to help capture split second detail. However, as with everything mechanical, it may need to be serviced or replaced someday. Shutter count, shutter actuations, or the number of pictures taken on the camera shutter is one of the indicators of the camera's state. In this paper, the influence of this parameter on the measurement accuracy and precision is investigated using industrial solution TRITOP.

2. BASICS OF PHOTOGRAMMETRY

The fundamental principle used by photogrammetry is triangulation. The basic idea of photogrammetry is to look at markers applied on object's surface (reference points) from different directions by taking photographs from at least two different locations with the largest possible angle to each other. It is possible to calculate the camera location using this reference point relation by means of images. Then, so-called lines of sight can be developed from each camera to points on the object, as depicted in Figure 1. The reference points visible in an image have a fixed relation to each other.

Main hardware and software components of conventional photogrametric measuring system are: (a) High-resolution digital camera with interchangeable lenses of fixed focal length, (b) Storage medium, (c) Flashlight, in order to optimally light the measuring object, (d) Coded reference point families; each point has its own ID in order to generate an image set that can be automatically evaluated in software and to allow for calculating the camera positions, (e) Uncoded reference points, to get 3D coordinates of the measuringrelevant parts of the object to be measured, (f) Certified scale bars for scaling the measuring results; they have ultra-precisely measured reference points for determining their length, and (h) Application software for analyzing and evaluating the image sets and measuring results [6].

The main task of software is to precisely find ellipses (a perspective view of reference points) in all images of the image set and their 3D orientation. The, software interprets the images and generates 3D measuring data. The measuring data can be used in CAD comparison and inspection or made available to subsequent systems like, for example, ATOS.

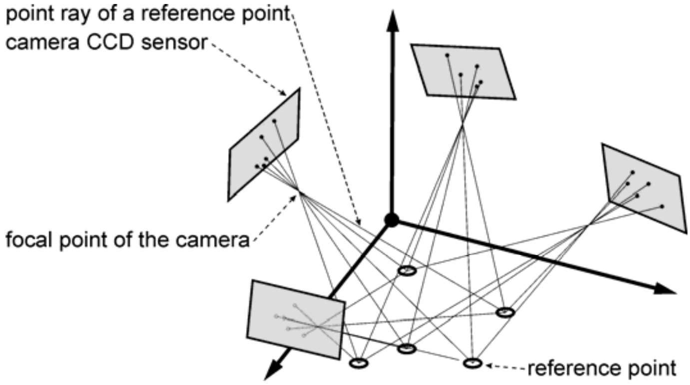

Figure 1 Principle of photogrammetry

3. SETTINGS OF TRITOP PHOTOGRAMMETRIC CAMERA NIKON D200

Different camera systems are supported. The cameras are based on professional digital reflex camera housings in connection with a manual fixed focus lens and a ring flash. Each TRITOP camera system is factory-verified and certified in order to guarantee the measuring accuracy. The use of the photogrammetric camera considerably differs from normal photography because other criteria apply for photogrammetry. Therefore, most of the automatic functions need to be disabled. Photogrammetric systems from GOM are factory-preadjusted. Therefore, user generally do not need to make any configuration settings for the camera and software. The information given in Table 1 only ensures that the correct settings are adjusted on both cammeras [7]. Setings of parameters non related to camera is shown in Table 2.

It should be noted that TRITOP image group is always recorded with fixed camera settings. The camera and lens settings should not be changed while recording an image group. The focus is set by means of the distance between camera and measuring object and never by using the focusing ring of the lens.

Table 1 *Factory-preadjusted settings of TRITOP photogrammetric camera*

Cammera Settings	
Image Quality:	*JPEG Fine*
Image Size:	*L (3872 x 2592)*
JPEG Compression:	*Optimal Quality*
ISO Sensitivity:	*200*
Image Sharpening:	*Optimize Image > Custom > Image Sharpening > None*
Tone Compensation:	*Normal*
Non-CPU Lens Data:	*Focal Lenght 24 mm, Maximum Aperture 2.8*
Auto Image Rotation:	*Off*
Exposure mode:	*M (manually)*
Shutter speed:	*250 (1/250 s)*
Aperture setting:	*11*
White balance:	*S (single frame)*
White balance:	*A (Automatic)*
Focus mode:	*M (manually)*
Focus area:	*Center*

Table 2 *Other system specific settings*

Flash Light Settings	
Recommended flash light power for distances up to 2 meters is ¼. Use of build-in wideflash adapter is mandatory.	
TRITOP Software Settings	
Project Settings	
Minimum ellipse radius:	*2.0 pixels*
Ellipse quality:	*0.3 pixels*
Camera Settings	
Image width:	*3872 pixels*
Image height:	*2592 pixels*
Principle point offset:	*0 each*
Pixel size:	*6.1 μm*
Binarisation offset:	*5*

4. EXPERIMENT AND RESULTS

There is no way to accurately determine the DSLR camera shutter count. While there are third party software applications designed to read a cameras shutter count, this number is not always accurate because the shutter release times may be reset by firmware updates, or reset in the service department. Since an exact number of releases before failure cannot be exactly calculated, a formula is used to estimate when it may occur, called Mean Time Between Failures (MTBF). Based on testing and past performance, along with service information, an estimated average number of shutter releases that can be expected before probable shutter failure is formulated. Estimated number of shutter actuations for most of NIKON DSLR models are tested to 150,000 cycles [8].

Instead, there are several options to monitor DSLR camera's shutter use. Most of available solutions use photography as a medium for the transmission of information about shutter count. This information is contained in the EXIF data [8]. Because EXIF data is erased by external applications, photo (NEF or RAW files, or untouched JPG's) must be taken with the camera without any external processing. Shutter count is determined by uploading image to a website that processes and displays the information [9].

Reference measurement is performed with a camera with small shutter count (Fig 2a). This measurement is considered as accurate because the camera is in excellent condition, and the overall accuracy of the measurement system is guaranteed by the manufacturer. Ten measurements were performed by camera with a large shutter count. The fixed focus lens used in measuring with the two cameras is shown in Figure 2b while Figure 2c shows configuration of the measuring device ready for measurement. According to EXIF data from images based on the first measurement shutter count of the reference camera is 13228, while for the investigated camera is 164911.

The accuracy check of the measuring device was performed on a simple set-up (Fig. 3). Comparison was done by measuring the distance between the randomly placed reference points. Ideally, the scale bars fit 1:1 to the measuring object. The measured distances corespond to 10%, 25%, 50%, 75%, and 100% of scale bars lenght. For measuring this simple project eight images is need, four calibrating images made from the top and four images recorded laterally at an angle of approx. 45°. An image group consists of overlapping images recorded in succession combining the right and the left side as well as the front and the rear side of the model in order to avoid accumulated errors.

Results of accuracy test are shown in table 3.

(a) (b) (c)

Figure 2 Photogrammetric camera: (a) NIKON D200 body, (b) fixed focus lens, and (c) camera prepared for measurements

Figure 3 Measuring Set Up

Table 3 *Accuracy experiment for TRITOP photogrammetric camera NIKON D200*

Number of Measurement	Percent of scale bars lenght				
	~10%	~25%	~50%	~75%	~100%
	Measured reference length				
	98,902	249,510	495,784	747,473	981,264
1	98,900	249,507	494,881	747,479	981,248
2	98,907	249,519	495,787	747,462	981,263
3	98,908	249,521	495,787	747,747	981,270
4	98,920	249,525	495,792	747,478	981,278
5	98,914	249,525	495,797	747,476	981,272
6	98,893	249,512	495,779	747,469	981,264
7	98,927	249,522	495,795	747,478	981,273
8	98,915	249,524	495,786	747,467	981,252
9	98,904	249,503	495,775	747,471	981,258
10	98,917	249,509	495,781	747,469	981,253
Standard deviation	0,010	0,008	0,286	0,087	0,010
Min-Max Value	0,034	0,022	0,916	0,285	0,030
Mean value	98,911	249,517	495,696	747,500	981,263
Precision	0,102	0,033	0,578	0,117	0,010
Accuracy	0,025	0,015	0,903	0,274	0,016

5. CONCLUSION

Compared with tactile measuring systems, typical optical measuring system provides significant benefits, especially for complex geometry. This is the most cost-effective and affordable way to do accurate 3D measurement. It does not require any complex, heavy and maintenance-intensive hardware. Also, the measuring machine comes to the object.

Photogrammetric measurement accuracy can fluctuate significantly, because it depends on several interrelated factors. The most important factors are: quality and resolution of the camera used to measure, size of measured object, the number of recorded images in the project, the geometric arrangement of images in relation to the object, and in relation to each other images. Photogrammetry is more accurate in the x and y direction than in the z direction.

Based on the measurements we conclude that the accuracy and precision of the measuring device decreases over time. Keeping track of shutter count is important in making sure camera is serviced at the proper intervals and the shutter and mirror are replaced at the appropriate times in order to ensure that the device does not introduce measurement error.

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