1. Tomasz KRASZEWSKI[1], 2. Radosław SOKÓŁ [1] 3. Artur PASIERBEK[1,2],4. Marcin POŁOMSKI[1,2],
2. 5, Anna PIWOWAR[1, 3]

Centrum Badawczo – Rozwojowe GLOKOR Sp. z o.o. (1), Politechnika Śląska, Wydział Automatyki, Elektroniki i Informatyki (2),
Politechnika Śląska, Wydział Elektryczny (3)
ORCID: 1. 0000-0003-2208-85362. 3. 0000-0002-2137-4031; 4. 0000-0001-8785-2377; 5. 0000-0002-5578-3757

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Evaluation of photogrammetric methods for fast identification of defects

Streszczenie. *Artykuł stanowi część prac związanych z opracowaniem linii do automatycznej identyfikacji wad na elementach obrabianych z opracowaniem technologii ich usuwania strumieniową obróbką ścierną na stanowiskach zrobotyzowanych w warunkach przemysłowych. W artykule dokonano oceny metody fotogrametrycznej w szybkiej identyfikacji wad. W badaniach wykorzystano przygotowane zbiory zdjęć oraz wygenerowanych obrazów z modelu 3D obiektu referencyjnego i przedstawiono wybrane efekty badań.*

Abstract*. The article is a part of research related to developing a line which automatically identifies defects of workpieces together with technology of their elimination with the aid of stream abrasive treatment at automated stations in industrial conditions. The work evaluated photogrammetric method for fast defect detection. The research included prepared sets of photos and generated 3D model images of the reference object and selected research results were presented. (****Ocena metod fotogrametrycznych w szybkiej identyfikacji wad****)*

Słowa kluczowe: identyfikacja wad, systemy wizyjne, fotogrametria, fotoanaliza.
Keywords: defect detection, vision systems, photogrammetry, photoanalysis.

Introduction

The article is related to the project of creating a line enabling automatic defect detection in objects subjected to blasting treatment. The vision system is to visualize and measure the defects of the cleaned element. Based on the data collected by the system, an automatic decision will be made to move to the next stage of the process with precise information concerning the location of the defect and the selection of its elimination method. In order to identify and assess the defects of the tested element, an attempt to use the photogrammetry technique was made.

Photogrammetry, also known as photoanalysis, is a measurement technique based on photographic images, obtains information about objects and phenomena by processing and interpreting images and photos. This technique is mostly used in geodesy [3] in the form of aerial photogrammetry [2] and terrestrial photogrammetry (terraphotgrammetry), for example, in ship navigation systems [4]. Photogrammetry is primarily used in the creation of architectural documentation [1], [5] [6], [8], but its non-topographic use, referred to as engineering photogrammetry, deserves attention as well [3]. Despite the fact that construction applications predominate in this category [7], it is also applicable in medicine (e.g. for posture defect examination [9], or as a high-precision tool for controlling element dimensions [10].

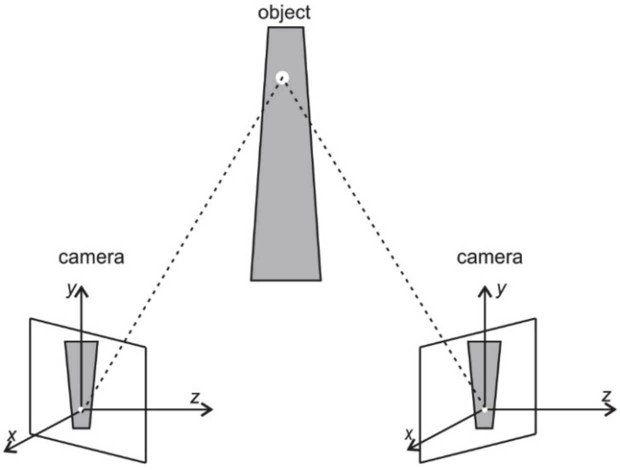


Fig. 1. Imaging an object in photogrammetry

In a nutshell, photogrammetry consists in reproducing, using a camera or a scanner, the course of a ray running from the camera lens to the searched (imaged) point
Its position in three-dimensional space is obtained by intersectig with the ray going to the same point from a different camera position. In order to solve the measurement issue, at least two images from different places should be captured (Fig. 1). In the process of photoanalysis, localization points in the three-dimensional space of the tested object are calculated on the basis of photographs taken at different angles. The images are input for the software responsible for point reconstruction. The advantages of photoanalysis include: lack of contact with the measured object, which limits measurement errors, high measurement accuracy the possibility to register a wide range of objects, regardless of the shape or size, and the possibility to register processes, taking into account their dynamics. Photogrammetric measurement can be fully automated.

Experiment results

Object 1

First, a sample of a material, being a test element for the defect identification system, hereinafter referred to as object 1, was subjected to photoanalysis.

Fig. 2. Test element – object 1

This element is characterized by sharp edges, without small elements in its structure. Object 1 is shown in Fig. 2.

After collecting the input data set consisting of 12 photos, the point cloud shown in Fig. 3 was generated. The input set was created from photos taken with a professional camera in the horizontal plane every 30°. Once the characteristic points were gathered, the point cloud shown in Figure 3a was obtained.

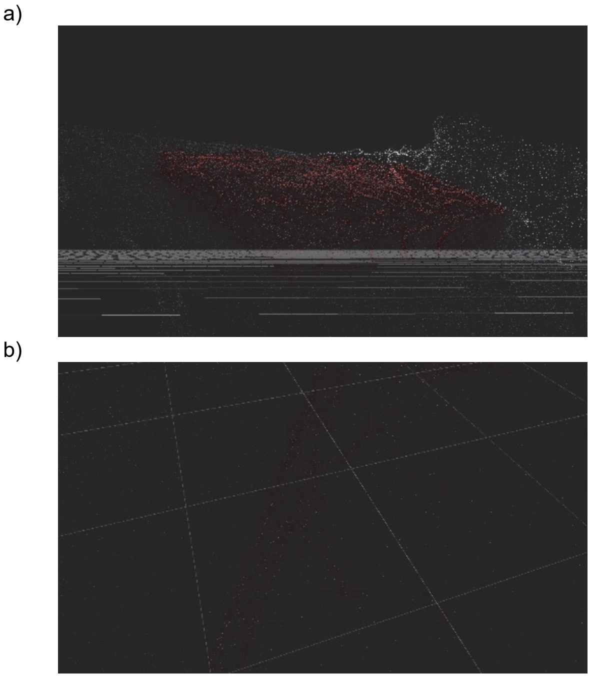


Fig. 3. Object 1 during photoanalysis process: a) point cloud b) selected fragment –zoomed image

In the next stage of image processing, a texture used to cover the previously generated mesh was generated. As a result, the textured model object shown in Figure 4 was obtained.

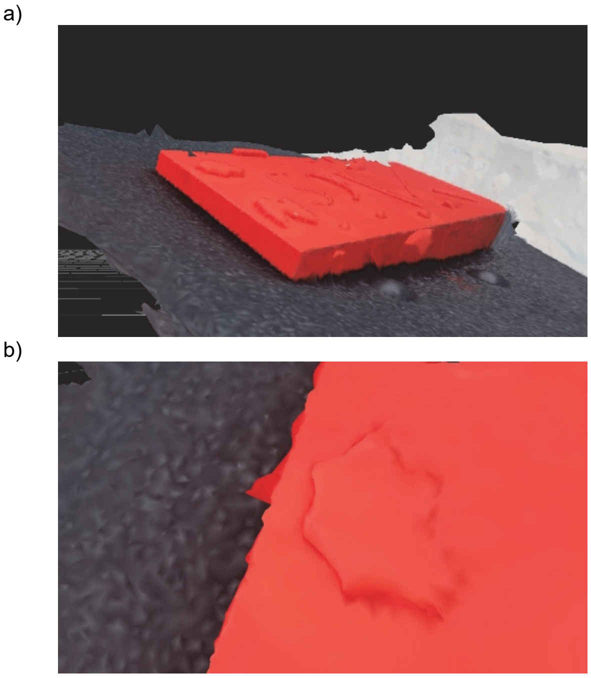


Fig. 4. Result of object 1 photoanalysis a) obtained model b) selected model fragment- zoomed image

Object 2

Another attempt aimed to obtain the photometric model of the motor gear - hereinafter referred to as object 2. Object 2 is characterized by sharp edges and contains a lot of detailed elements, Fig. 5. Analogically to object 1, a point cloud was generated for object 2, as shown in Figure 6. Contrary to the previous experiment, six times as many photos were used (72 photos), which resulted in much more accurately reproduced model.

The cost that had to be born was a several times longer photo processing time (the time needed to obtain the result was about ten times increased).

Fig. 5. Motor gear– object 2

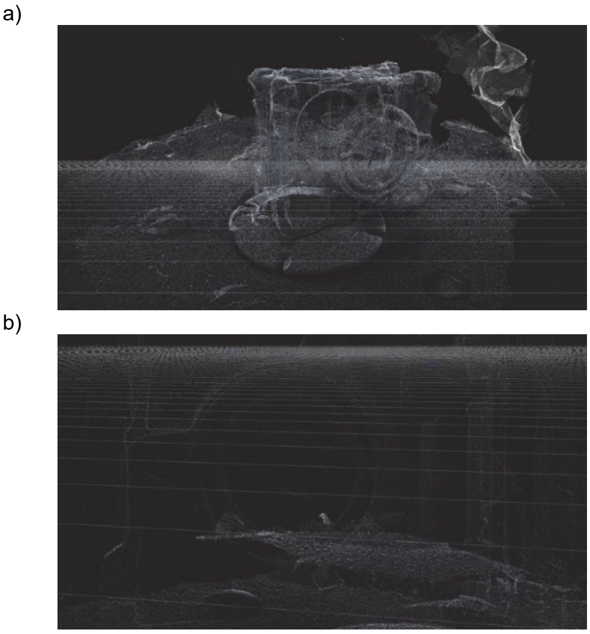


Fig. 6. Object 2 during the photoanalysis process: a) point cloud b) selected fragment- zoomed image

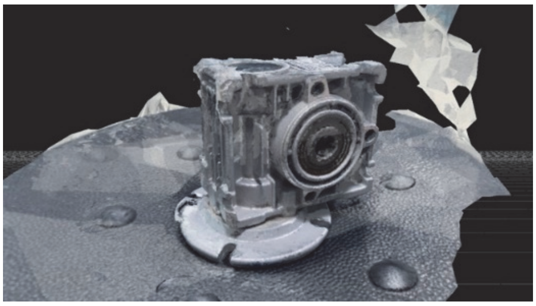


Fig. 7. Result of object 2 photoanalysis: a) obtained model b) selected fragment- zoomed image

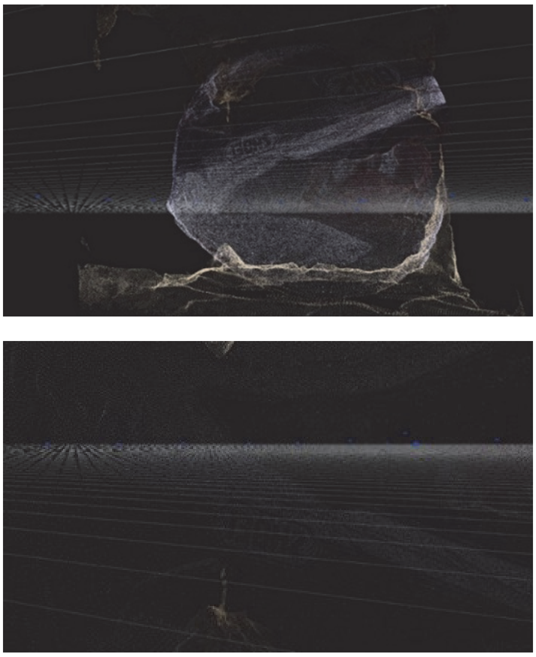
Applying texture to the resulting mesh enables a fairly good reproduction of the model, which can be used to create 3D scenes in computer games or educational tools as a didactic aid.

Object 3

In order to compare the effects of photogrammetric methods, object 3, a motorcycle helmet, was analyzed. The choice of this item was determined by its features, which the previously tested elements missed: no sharp edges, complicated colors and a relatively high reflectivity of light rays. The analyzed helmet is shown in Fig. 8.

Fig. 8. Motorcycle helmet – object 3

Due to the above mentioned object features, the number of photos was increased to 48. The obtained result of photoanalysis was presented in a form of a point cloud in Figure 9.



a)

b)

Fig. 9. Object 3 during the photoanalysis process: a) point cloud b) selected fragment- zoomed image

Similarly to the case of objects 1 and 2, textures were generated based on the photographs. The obtained result is visually satisfactory. When analyzing the point cloud, large areas with missing points can be seen, which can be masked with texture. The object is suitable for visualization applications. However, filling the missing points in the flaw detection process is practically impossible.

a)

b)

Fig. 10. Result of object 3 photoanalysis: a) obtained model b) selected fragment- zoomed image

The processing time depended on the number of photographs selected by the algorithm for further processing. The number was 12 for object 1, 72 for object 2, and 48 for object 3. The total photo processing time was respectively:

- for object 1 approximately 2 minutes,
- for object 2 approximately 5 minutes,
- for object 3 approximately 15 minutes.

Conclusions

The research used prepared sets of photos and generated images from the reference 3D object model. Selected research results were presented in the following section. However, the generated models on the basis of the prepared set of virtual projections were omitted, since the transformation results were not satisfactory. Attempts with higher resolution were also unsuccessful. A more accurate object 3D model was obtained, but at the cost of significantly extended analysis time.

Using the photogrammetry method, the assumed accuracy of 0.1 mm was unattainable. Rounded shapes, without clear, sharp edges require more photos, longer processing time and give worse results than samples with sharp edges and distinct shapes.

The presented research can be summarized with the conclusion: photogrammetry is a possible solution to the posed problem, however, it does not guarantee such high precision (0.1mm) and requires a combination of two elements: a data source with the highest possible resolution and an enormous computing power. The analysis conducted by the CBR GLOKOR research team proves that the optimal solution would be to record several dozen (about 60) images with a resolution of 20x20 px/mm^2, which gives about 64 MB per image, while reducing the accuracy to about 1mm. .. Such a data stream would require the use of huge computational clusters to determine the 3D object model with an accuracy of 1.0 mm, which still exceeds the assumed maximum time of 120 seconds.

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***Autorzy**: dr inż. Tomasz Kraszewski, dr inż. Radosław Sokół, Centrum Badawczo – Rozwojowe GLOKOR Sp. z o.o., ul. Górnych Wałów 27A, 44-100 Gliwice t.kraszewski@glokor.eu, r.sokol@gloor,eu, dr inż. Artur Pasierbek, dr inż. Marcin Połomski, Politechnika Śląska, Wydział Automatyki Elektroniki i Informatyki ul. Akademicka 16, 44-100 Gliwice e-mails: artur.pasierbek@polsl.pl, marcin.połomski@polsl.pl, dr inż. Anna Piwowar, Politechnika Śląska,Wydział Elektryczny, ul. Akademicka 10, 44-100 Gliwice, e-mail: anna.piwowar@polsl.pl.*

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