ISRG Journal of Arts, Humanities and Social Sciences (ISRGJAHSS)

ISRG PUBLISHERS
Abbreviated Key Title: ISRG J Arts Humanit Soc Sci
ISSN: 2583-7672 (Online)
Journal homepage: https://isrgpublishers.com/isrgjahss
Volume – III Issue -V (September-October) 2025
Frequency: Bimonthly

Photogrammetry and its development in Bulgaria

Miroslav Kokalarov

PhD student, Technical University of Gabrovo, Gabrovo, Bulgaria

| **Received:** 08.09.2025 | **Accepted:** 14.09.2025 | **Published:** 18.09.2025

***Corresponding author:** Miroslav Kokalarov

PhD student, Technical University of Gabrovo, Gabrovo, Bulgaria

Abstract

Social transformations are determined by a certain sequence of different actions and processes that characterize the development of societies. The most sensitive element in this process of social transformations is the labor market. The societies of the so-called socialist camp, which are part of the Council for Mutual Economic Assistance and part of the Soviet space at the end of the last century, fall into severe political changes, leading to changes in society. The research and study of the processes that lead to drastic and significant fluctuations in labor markets are interesting, both of scientific and practical importance. An interesting dependency in these markets is that they all go through the regulation of the primary labor market, through different instruments that are applied by governments. The accompanying severe consequences of the transition from a planned to a market economy lead to a large amount of the economically active population being left without a job and without the opportunity to find one on the primary labor market. The restructuring of the various industries or their closure leads to the impossibility of the workforce with the acquired qualification to secure a suitable job. All this leads to multiple crises that are overcome over a long period. The present study presents and analyzes this period of social transformations in the Republic of Bulgaria.

Keywords: *Applications, Bulgaria, Development, Photogrammetry, Stereophotogrammetry.*

1. Introduction

In the conditions of a global international market, the quality of manufactured products is an indispensable condition for the competitiveness of any manufacturing organization. The measurement and control of machines, assemblies, and parts in their production process are some of the most characteristic operations applied in general mechanical engineering. The application of the basic principles in this area is the main condition for creating mechanical engineering production with high technical and economic indicators (Sakakushev, Karshakov, & Todorov, 2009).

Important parameters that are controlled in general and heavy mechanical engineering are the deviations of linear and angular dimensions, of the shape (macrogeometry), and the arrangement of

DOI: 10.5281/zenodo.17149755

surfaces. The deviations of the shape and the arrangement of planar surfaces are the main geometric parameters that characterize the quality of mechanical engineering products. The measurement of large-sized parts has its own specificity, which is determined by the size of the measured parts, combined with high requirements for the accuracy of the corresponding surfaces (Radev, 2008; Georgiev, Sakakushev, & Georgieva, 2015).

The use of traditional contact methods for measuring geometric dimensions of objects is accompanied by measurement uncertainty, which is due to factors such as wear of the contact surfaces of the measuring instruments (instrumental error), errors in reading the readings (parallax error), errors from temperature deformations/differences (systematic error), imprecision of laboratory-metrological conditions, etc. (Kokalarov, 2019; Sakakushev, Kokalarov, & Parvanov, 2018).

With non-contact/remote measurement methods, this type of error is minimized or some of them are absent altogether, and the achieved measurement accuracy is significantly higher. The measuring systems used in non-contact measurement methods operate on the principle of optical-digital conversion of information or laser scanning. The market price of such industrial control systems is too high for an average production capacity in Bulgaria, and the requirements for the environment in which they will operate and in terms of the qualification of the service personnel are essential. With the improvement of technologies (increasingly accessible software), new, faster, relatively more profitable for business methods and, last but not least, more accurate ones are entering practice, namely the photogrammetric method for measuring large dimensions (Photogrammetry, 2025; Kraus, 1993).

Photogrammetry and its methods determine the shape, dimensions, and position of objects relative to each other; create a spatial model of the photographed object, and solve various scientific and production problems.

2. Photogrammetry – concept and essence

Photogrammetry (from Greek: phos – light; grama – drawing; metereo – measurement) is a scientific discipline dealing with determining the shape, dimensions, position, and other quantitative and qualitative characteristics of various objects on the earth's surface from their photographs.

There are geometric relationships between the objects in the area and their photographic image, since the photograph is a central projection of the photographed Earth's surface. However, photographic images cannot be used directly for geodetic purposes. The different distances of the photographed objects from the projection center (for this, the center of the lens can be assumed) also determine different scales of the objects in the photographed surface. The need for plans and maps also determines the main task of photogrammetry - the conversion of photographic images into plans and maps that are orthogonal projections of the photographed Earth's surface (Radev, 2008; Georgiev, Sakakushev, & Georgieva, 2015; Kokalarov, 2019).

There is no single definition of the concept of “photogrammetry” in the specialized literature. According to 6 & 7 photogrammetry is a scientific discipline that studies the geometric relationships and mathematical regularities that exist between objects in space, such as shape, location, dimensions, and other quantitative and qualitative characteristics of objects according to their photographic images. It is widely used in the creation of plans and maps on a large scale, for the study of deformations of buildings and metal structures such as bridges, archeology, medicine, oceanology, design, renovation of monuments, Egyptology, etc.

The beginning of photogrammetry is considered to be 1858, when the French officer Aimé Loseda constructed an aerial camera and took the first perspective photographs of Paris. Initially, photogrammetry developed as a mensural photograph using serrations and was called “metreophotography”.

In 1876, the Austrian professor Jordan introduced the concept of “photogrammetry”.

The first photographic photographs in Bulgaria were taken in 1907 - 1908. in the village of Studena - Sofia region and they were mapped on a mapping device “Stereoautograph” under the direction of Eduard von Orel, lieutenant at the Military Cartographic Institute in Vienna.

Bulgaria is the first country on the Balkan Peninsula to apply stereophotogrammetry for topographic purposes

The name comes from the three Greek words: photos – “light”, grama – “drawn”, and metreo – “measure”, or “measurement on photography”.

According to the American Society for Photogrammetry and Remote Sensing (ASPRS), photogrammetry is defined as the science and technology of obtaining reliable information about physical objects and the environment through the processes of recording, measuring, and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena (Sakakushev, Kokalarov, & Parvanov 2018; American Society for Photogrammetry and Remote Sensing, n.d.).

Photogrammetry is a technique for determining the three-dimensional geometry (location, size, and shape) of physical objects by measuring and analyzing the resulting two-dimensional photographs (Burtch, 2004; Curtin University of Technology, n.d.). It is a technique for measuring real objects using photographs (Karmanov, 2012; Schenk, 2005; Geodetic Systems, Inc., 2014) by non-contact measurement and is based on the principle of triangulation. Photogrammetry allows the determination of the spatial coordinates of a point from at least two photographs.

Photogrammetry was first used in 1851 by the French officer Aime Laussedat in the field of topography. The development of photogrammetry can be judged by (Krasnopevtsev, 2008; Army Foreign and Technology Center, 1974).

As a result of the rapid development of computer hardware and software in the 1980s, digital photogrammetry has become increasingly important.

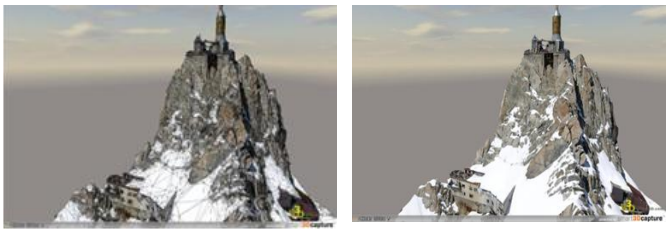
The objects of study can be very diverse - huge in size or microscopic, located on the earth's surface, under it, under or on the water, in outer space, on the laboratory table, or in the conditions of workshop production. Therefore, photogrammetry is often called phototopography or photogeodesy.

In photogrammetry, two types of equipment are used: photographic and mapping, used respectively in the two main stages of work - photography and mapping.

Radar images or recorded electromagnetic radiation on various technical media can also serve as a source of information

DOI: 10.5281/zenodo.17149755

(Maldzhanski, n.d.). For more complex objects, a network of reference points connected in lines is created to orient the individual images when summarizing them (Fig. 1).



a) b)

Figure 1. Photometric image with (a) and without reference lines (b).

Source: Georgiev, G. (2016). *Researching the possibilities of using photogrammetric methods for reconstructing mechanical engineering details* (Doctoral dissertation). University of Ruse, Ruse, Bulgaria.

Modern photogrammetry, as a technical science, is closely related to the sciences of the physical-mathematical cycle, and its development is determined by the achievements of radio electronics, computing, instrument making, photography, and optics.

3. Application of photogrammetry

Photogrammetric techniques are used in areas such as (National Institute for Geodesy and Photogrammetry, 2011; Doneus, 1996; Carneiro da Silva, 2012):

- topography - GIS (GIS - geographic information system - mapping) (Thiele, 1907);
- DroneMapper Aerial Imagery Processing and GIS Services, (DroneMapper, n.d.);
- construction (buildings, reconstruction of CAD models), (Dornaika & Hammoudi, 2009);
- restoration of architectural and historical monuments - sufficient data can be extracted from images of historical sites or buildings to be completely reconstructed in a 3D CAD environment to preserve or restore the original structure (Cultural Heritage Imaging, 2014).
- automotive - photogrammetry is effectively used in measuring the effect of crash tests, as well as in automotive technical expertise (Leifer, 2003; GeoMedia, n.d.);
- shipbuilding and ship repair - is one of the main areas for using photogrammetry as an industrial application in the USA (Luhmann, 2010; Jianga et al., 2008);
- in the field of biotechnology, for example, in biometrics for 3D facial reconstruction (Denzin, 1970; Dornaika & Hammoudi, 2010);

quality control of mechanical engineering products - measurement systems in the field of industrial photogrammetry for large production sites (Sotirov et al., 2021; Stanchev & Sakakushev, 2011) or for laboratory installations (Stanchev & Sakakushev, 2011; Sakakushev, Karshakov, & Todorov, 2009; Zhang et al., 2010) are under development.

The examples of specific applications of photogrammetry are not exhaustive, but they provide grounds to seek broader applications in other areas. An example of a promising direction is the use of photogrammetric methods for car accident reconstruction (Gerbino, Martorelli, Renno, & Speranza, 2004).

4. Advantages and disadvantages of photogrammetry

The main advantages of photogrammetry and stereophotogrammetric methods are (Georgiev, 2015; Maldzhanski, 2012; Mikhail, Bethel, & McGlone, 2001).

- high accuracy of results, due to the high quality of the photographic equipment used;
- high productivity, which is achieved due to the fact that not physical objects are measured, but their images, which is an important prerequisite for automating the measurement process and subsequent calculations;
- objectivity and reliability of information, the ability to repeat measurements if necessary;
- the ability to quickly obtain information about the condition of both the entire object and its individual elements;
- safety at work, since the objects are photographed using non-contact methods. This is especially important when the objects are difficult to access or staying in the area around them is dangerous for human health;
- the ability to study moving objects and rapidly occurring processes. Engineering facilities and buildings, as well as the terrain around them, are subject to various deformations: bending, twisting, tilting, sliding, subsidence, displacement, shear, and cracking. Deformations are due to various, permanently or temporarily acting factors: climatic, geological, hydrological, soil, static and dynamic loads, movement of the earth's crust, possible errors in the design, construction, and operation of objects.

The considered methods also have some disadvantages, for example, the dependence of the quality of photographic capture on illumination, meteorological conditions, still expensive equipment for implementing the method, etc.

The application of photogrammetry in the field of technical measurements would bring economic benefits, such as:

- reduction of time for measuring the accuracy of shape and dimensions (up to 90% - 95%);
- reduction of the workforce used;
- reduction of costs for manufacturing parts and machines by reducing machine time, tooling used;
- reduction of material costs in production by using blanks with optimized geometric shapes, etc.

Leading disadvantages of digital photogrammetry can be listed:

- high memory costs and computational efforts of the computer (reduction by using image pyramids);
- dead zones in the digital image are not detected directly, but by analyzing the neighborhood of pixels and analyzing the difference in point coordinates;
- interpolation can involve points from objects lying at different elevations, i.e. of non-adjacent objects. Overcoming this problem requires a description of the areas and analysis of neighboring areas, which is a laborious procedure;

DOI: 10.5281/zenodo.17149755

- another disadvantage is that in the process of camera operation, parameters such as focus and magnification change dynamically, which requires that they be periodically linked to the base of the received information.

5. Classification of types of photogrammetry

5.1 According to the information obtained from photographs

According to this characteristic, photogrammetry is divided into metric and interpretative. The task of metric photogrammetry is to determine the location, dimensions, and geometric shapes of objects from their photographs, and at an interpretative level - to recognize objects, to clarify their content and meaning:

- According to the types of lenses;
- According to the methods of photographing objects located on the Earth's surface.

According to this characteristic, ground and aerial photogrammetry (or stereophotogrammetry) are distinguished.

In aerial photogrammetry, images are acquired through aerial photographs from an aircraft, providing topographic maps and details of land use.

In terrestrial photogrammetry (also called non-topographic photogrammetry), images are acquired in places near or on the Earth's surface and provide detailed three-dimensional information of a given object. When the object size and camera-to-object distance are less than 100 m, terrestrial photogrammetry is further defined as close-range photogrammetry, an approach in which images are acquired around an object with highly convergent camera directions, generally pointing toward the center of the object (Jharkhand Space Applications Center, n.d.).

5.2 Depending on the size of the objects

Photogrammetry is divided into long-range photogrammetry, short-range photogrammetry, and very short-range photogrammetry (Gruen, 2000).

Long-range photogrammetry (for areas of m^2) is used in mapping to reconstruct the shape of buildings, etc. Short-range and very short-range photogrammetry are preferred for industrial applications in engineering and are united under the general name “industrial photogrammetry”. In this case, the sizes of physical objects and their elements can vary between 1 mm^2 and 1 cm^2.

6. History of photogrammetry

Historically, close-range photogrammetry has perhaps been most widely used for documenting and presenting the facades of historic buildings and structures. In some cases, two-dimensional graphics may be insufficient to illustrate the object and its context. With the evolution of the activity, digital close-range photogrammetry has become an increasingly accessible and now standard method, with the help of which we obtain detailed three-dimensional, textured models. And by working with three-dimensional information, we can more easily analyze complex structures, with complex geometry and multi-layeredness in architectural stratigraphy.

Close-range photogrammetry is a method for obtaining information about the shape, color, and position in space of a given object, varying in size from 1 cm to over 200 m and with an error level below 1 cm (Yankov, 2007). Interactive Generation of Data Transmission Protocol Between External Device and Computer. Proc. Int. Conference on Information Technologies (InfoTech-2007). St. Constantine and Elena resort, Varna, Bulgaria, vol.2, pp 231-238;

The development of photogrammetry is linked to the work of a significant number of professionals and scientists. 2019 marks the 200th anniversary of the birth of the father of photogrammetry, Aimé Loseda. He was born in the French town of Moulins on April 19, 1819, and died in Paris at the age of 87 in 1907. He went down in history as a scientist, astronomer, surveyor, photographer, photogrammetrist, and cartographer. An engineer, researcher, and professor at the École Polytechnique, director of the National School of Arts and Crafts (Conservatoire national des arts et métiers), he was also a soldier, and after the Franco-Prussian War of 1870-1871, he was responsible for the new borders from 1871 to 1881.

Loseda was one of the pioneers of photography and its applications such as photogrammetry, writing a work on the subject entitled Métrophotographie.

In his time, researchers who had mastered the basics of geometry in space enthusiastically welcomed the art of photography, which began to facilitate scientific and technical observation in 1840. Loseda was a pioneer of photographic iconometry and carried out the first photogrammetric studies in 1849 on the facade of the Hôtel des Invalides in Paris. Loseda's method was initially known as “Iconometry” and later as “Metrophotography”, terms that did not gain common ground. Loseda's method of terrestrial photogrammetric photography was called Menzul photogrammetry or Photogrammetry by Snips. In 1850, he mapped in detail the hamlet of Bouc, near Versailles, and the Château de Vincent with a “Camera lumina” and compiled the first topographic map at a scale of 1:2000 of the fort, using terrestrial photogrammetry with single-base Snips.

Attempts to map larger hilly regions followed. Initially he used kites. Then he switched to balloons, to which he attached a heavy camera with glass plates. In 1862, Loseda's research methods were officially adopted by the Madrid Academy of Sciences. Initially, photogrammetry was developed as a mensural photograph using cross-sections and was called “Metrophotography”.

In parallel, in 1860, the German architect Albrecht Meidenbauer (1834 - 1921) was experimenting with photogrammetric techniques. He was entrusted with the task of restoring buildings from the Prussian heritage. For this purpose, in 1867, he designed his own measuring instruments and used them for his architectural studies. It occurred to him that this technique could be used in topography. He came across the pioneering development and measuring tools of Loseda, in particular – the first phototheodolite and his Paris plan, created thanks to photography and presented at the World Exhibition in Paris in the same 1867. At the end of December of that year, Meidenbauer published an article on the new measuring technique, called photometry.

As a soldier, Loseda was responsible for the cartography of the Pyrenees and trained soldiers interested in topographic techniques. His student was the young naval officer Edouard-Gaston Deville, who left the army and after the war of 1870-1871 emigrated to Quebec, where he became the chief surveyor of Canada.

On July 18, 1860, Aimé Loseda and Amédée Mannheim, a young surveyor, observed a total solar eclipse in Batna, French Algeria,

DOI: 10.5281/zenodo.17149755

describing with particular care the exact beginning and end of the eclipse.

Loseda contributed to the creation of the photographic archive at the Conservatory of Arts and Crafts. He participated in the French Society of Photographers, where he was honorary president almost until the end of his life.

Despite Loseda's experience, the first and most preserved aerial photograph is that of Boston. It was taken by photographer James Wallace Black in 1860. An airplane, similar to the Wright brothers' prototype, rose to an altitude of about 600 meters and photographed Boston. The photograph is kept in the Metropolitan Museum of Art in New York (Sea Blue, n.d).

7. Development of photogrammetry in Bulgaria

Bulgaria was the first on the Balkan Peninsula to start applying photogrammetry. This happened only 30 years after the end of the Russo-Turkish War (1877-1878). During its long and fruitful path, marked by the fruitful efforts of three generations of professionals, Bulgarian photogrammetry went through all the main stages of development:

- Terrestrial, aerial, space;
- Uniform, analog, analytical, digital;
- Topographic, cadastral, and special mapping at different scales, for different purposes and in different forms (graphic and digital);
- Non-topographic applications (close-range photogrammetry, such a type is photogrammetry for technical measurements in mechanical engineering).

In the recent past, about 20 institutes, enterprises, and services have developed and applied photogrammetry in various fields. Objects of different nature and purpose have been produced, including those abroad. Due to the subsequent changes in the structure of geodetic and cartographic production in the country, this activity is decreasing, the applied technologies and the technical means used are becoming obsolete, and a significant part of the qualified production workers is being redirected to other related activities. However, about 10 years ago, a new upsurge began, in which modern photogrammetry is being applied, both by structures with experience in this activity and in new professional units.

Photogrammetry penetrated Bulgaria in 1908. In 1908, near the village of Studena, not far from Sofia, terrestrial photogrammetric photographs were taken, which were mapped at the Vienna Cartographic Institute by Eduard Ritter von Orel (1877 - 1941) using the Stereautograph he created. Some of the photographs and the mapped material were published in 1920 and 1923. Immediately after the First World War, several photographs were taken in the Rhodope Mountains and around Sofia, but a more significant attempt to implement terrestrial photogrammetry for topographic purposes was made in September 1928. In 1928, E. Berchtold and Eng. Assen Raykov made a more significant attempt to implement terrestrial photogrammetry around the village of Bankya, not far from Sofia. With the newly constructed Wild phototheodolite, they photographed about 2.5 m^2 of an area, the mapping of which at a scale of 1:10000 was carried out at the Wild Heerbrugg factories with the newly created stereo mapping device for terrestrial photographs, the Autograph A-2.

The first implementation of uniform photogrammetry in our country began with the creation of plans of settlements and a plan in M 1:2000 of the irrigation field of the Alexander Stamboliyski Dam, which was being built at that time. A series of objects completed in a photogrammetric manner followed, as well as organizational and technical changes for the widespread implementation of photogrammetry in practice:

- 1912 - During the Balkan War, aerial photographs were taken for reconnaissance purposes, as well as photos from a balloon;
- 1914 - 1918 - During the Balkan and World Wars, ground photographs were taken in Belasitsa and the Southern Front for military purposes, as well as between Skopje and Bitola for the construction of a railway line;
- 1917 - Aerial photography was carried out from the airship of Graf Ferdinand von Zeppelin (1838-1917) over Gabrovo from a height of 1700 m;
- 1920 - 1921 - Ground photogrammetric photographs were taken around Sofia and the Rhodope Mountains, but the results are unknown;
- 1922 - The State Geographical Institute raised the issue of applying ground and especially aerial photogrammetry, which was called “Aerophotogrammetry” or “Aerogeodetics”;
- 1926 - Aerial photography was carried out from an airplane over Gabrovo from a height of 1900 m;
- 1930 - The State Geographical Institute carried out trial ground photogrammetric photographs intended for creating a topographic map at a scale of 1:25000, as well as trial aerial photography of an area of 50 km^2 around the village. Bozhurishte near Sofia, the phototransformation of which was carried out in the same and the following year. Aerial photography with the Wild hand-held camera (focal length 165 mm) was carried out from a height above the area of 1500 and 2500 m, using glass photographic plates from different manufacturers;
- 1931 - DGI carried out aerial photography with the Wild hand-held aerial camera (focal length 165 mm) from a height of 3350 – 3400 m (scale of the photographs 1:20000 – 1:21000) of an area between Plovdiv, Asenovgrad and Krichim with an area of about 650 km^2. Not particularly suitable Dar III and Focke-Wulf biplanes were used with 30% longitudinal and transverse overlap between adjacent aerial photographs;
- 1932 - DGI begins a new topographic survey of the country at a scale of 1:25000. For this purpose, the topographic and photogrammetric department in the following years formed topographic and photogrammetric sections and groups;
- 1934 - DGI performs a terrestrial photogrammetric survey along the Vacha River (Maldzhanski, 2018).
- 2009, 2010, 2011 - For the first time in Bulgaria, Dr. Eng. Boris Sakakushev, full associate professor at the University of Ruse “Angel Kanchev”, published, in co-authorship with other Bulgarian scientists, a number of articles on the application of PMI for measurements in mechanical engineering, in the journal “Union of Scientists” - Ruse, with the following titles:

✓ “Stereophotogrammetric method for measuring deformations of mechanical engineering structures” and

DOI: 10.5281/zenodo.17149755

"Application of the photogrammetric method for measurement in mechanical engineering", Journal "Notices of the Union of Scientists – Ruse", series 1 Technical Sciences, 2009, ISSN 1311 – 106X;

- ✓ "Approbation of a photogrammetric method for measurement in mechanical engineering". Journal "Notices of the Union of Scientists – Ruse", series 1 Technical Sciences, 2010, ISSN 1311 – 106X;
- ✓ "Transformation coefficient and analysis of the measurement error by the photogrammetric method in mechanical engineering". Journal "Notices of the Union of Scientists – Ruse", series 1 Technical Sciences, 2011, ISSN 1311 – 106X;
- ✓ Assoc. Prof. Dr. Eng. Boris Sakakushev is considered a pioneer in Bulgaria in the application of the photogrammetric method for measurement and control of mechanical engineering products;
- ✓ 2016 – Dr. Eng. Georgi Georgiev, Chief Assistant Professor at Thracian University – Stara Zagora, Faculty of Engineering and Technology – Yambol, successfully defended his dissertation for the award of the ONS "Doctor" with first scientific supervisor Assoc. Prof. Dr. Eng. Boris Sakakushev on the topic: "Researching the possibilities of using photogrammetric methods for reconstructing mechanical engineering details".

8. Conclusion

The application of photogrammetry in the field of industrial measurements/industrial photogrammetry or also known as digital precision close-range photogrammetry, as well as for determining the accuracy of the dimensions of machine parts, where the dimensions of the objects are significantly smaller, is at a relatively early stage at the global level. Digital precision close-range photogrammetry differs from modern industrial scanning systems for tracking the product, such as "Machine Vision", which have found wide application in modern serial production, such as automated mechatronic systems for control and correction of the location of output products on assembly lines, etc.

References

1. Sakakushev, B., Karshakov, M., & Todorov, T. (2009). Application of the photogrammetric method for measurement in mechanical engineering. *Notices of the Union of Scientists – Ruse, Technical Sciences Series, 5*, 20–24. ISBN 1311-106X.
2. Radev, H. (2008). *Metrology and measurement techniques* (Vol. 2). Softreid. ISBN 978-954-334-077-4.
3. Georgiev, G., Sakakushev, B., & Georgieva, K. (2015). Study of the applicability of the photogrammetric method for measuring very small dimensions. *Collection of Scientific Papers*, ISBN 1311-3321.
4. Kokalarov, M. (2019). Predetermination of the uncertainty budget and error analysis of the photogrammetric method in heavy machinery. In *Proceedings of the 30th DAAAM International Symposium* (pp. 914–920). https://doi.org/10.2507/30th.daaam.proceedings.127.
5. Sakakushev, B., Kokalarov, M., & Parvanov, S. (2018). Perspectives for the application of the photogrammetric method for large-scale details and structures. In *Proceedings of the 28th International Scientific Symposium Metrology and Metrology Assurance* (Vol. 28, pp. 160–162). ISBN 1313-9126.
6. *Photogrammetry*. (2025). In *Wikipedia*. Retrieved August 20, 2025, from http://bg.wikipedia.org/wiki.
7. Kraus, K. (1993). *Photogrammetry. Vol. 1: Fundamentals and standard processes*. Dümmlers. ISBN 3427786846.
8. American Society for Photogrammetry and Remote Sensing. (n.d.). *ASPRS*. Retrieved September 8, 2025, from http://www.asprs.org.
9. Burtch, R. (2004). *History of photogrammetry*. Center for Photogrammetric Training, Ferris State University, Big Rapids, MI.
10. Curtin University of Technology. (n.d.). *History of photogrammetry*. Center for Photogrammetric Training. Retrieved September 8, 2025, from https://spatial.curtin.edu.au.
11. Karmanov, G. (2012). *Photogrammetry*. St. Petersburg National Research University of Information Technologies, Mechanics and Optics. http://open.ifmo.ru/.
12. Georgiev, G. (2016). *Researching the possibilities of using photogrammetric methods for reconstructing mechanical engineering details* (Doctoral dissertation). University of Ruse, Ruse, Bulgaria.
13. Schenk, T. (2005). *Introduction to photogrammetry*. Department of Civil and Environmental Engineering and Geodetic Science, The Ohio State University.
14. Geodetic Systems, Inc. (2014). *The basics of photogrammetry*. http://www.geodetic.com.
15. Krasnopevtsev, V. (2008). Key events in the history of photogrammetry in the 19th and 20th centuries. Moscow State University of Geodesy and Cartography (MIIGAiK). http://bvkras.narod.ru.
16. Army Foreign and Technology Center. (1974). *Development of photogrammetry in the Soviet Union*. National Technical Information Service, U.S. Department of Commerce.
17. Maldzhanski, P. (n.d.). *Photogrammetry I-part: Lecture course for the specialty "Geodesy"*. University of Architecture, Civil Engineering and Geodesy – Sofia. http://uacg.bg/filebank/att_2122.pdf.
18. National Institute for Geodesy and Photogrammetry. (2011). *Application of earth photogrammetry, photogrammetric documentation and stereomapping on archaeological, national objects and monuments*. https://geodezy.wordpress.com.
19. Doneus, M. (1996). *Aerial archive*. University of Vienna, Department of Prehistoric and Historical Archaeology. http://www.univie.ac.at/Luftbildarchiv.
20. Carneiro da Silva, D. (Ed.). (2012). *Special applications of photogrammetry*. InTech. https://doi.org/10.5772/2517.
21. Thiele, Y. (1907). *Phototopography in modern development*. K. L. Ricker. http://147.45.22.130/.
22. DroneMapper. (n.d.). *Aerial imagery processing and GIS services*. http://dronemapper.com.
23. Dornaika, K., & Hammoudi, K. (2009). Extracting 3D polyhedral building models from aerial images using a featureless and direct approach. In *Proceedings of MVA2009 IAPR Conference on Machine Vision Applications* (pp. 1–4). Yokohama, Japan.

DOI: 10.5281/zenodo.17149755

24. Cultural Heritage Imaging. (2014). *Photogrammetry*. http://culturalheritageimaging.org.
25. Leifer, J. (2003). A close-range photogrammetry laboratory activity for mechanical engineering undergraduates. In *33rd ASEE/IEEE Frontiers in Education Conference* (Session F2E). University of Kentucky, Department of Mechanical Engineering, Boulder, CO.
26. GeoMedia. (n.d.). *GeoMedia*. Retrieved September 8, 2025, from http://www.geomedia.bg/index.php.
27. Luhmann, T. (2010). Close-range photogrammetry for industrial applications. *ISPRS Journal of Photogrammetry and Remote Sensing*. Elsevier.
28. Jianga, R., Jáuregui, D. V., White, K. R., & White, R. (2008). Close-range photogrammetry applications in bridge measurement: Literature review. *Measurement, 41*(8), 823–834. Elsevier.
29. Denzin, K. (1970). *The research act in sociology*. Aldine.
30. Dornaika, F., & Hammoudi, K. (2010). Person-specific face shape estimation under varying head pose from single snapshots. In *Proceedings of the 20th International Conference on Pattern Recognition (ICPR 2010)* (pp. 853–856). Istanbul, Turkey. https://doi.org/10.1109/ICPR.2010.853.
31. Sotirov, B., Tonev, D., Parvanov, S., & Kokalarov, M. (2021). Determining the geometrical elements in the photogrammetric method for measuring linear dimensions. In *Proceedings of the 32nd DAAAM International Symposium* (pp. 275–280). https://doi.org/10.2507/32nd.daaam.proceedings.039.
32. Stanchev, T., & Sakakushev, B. (2011). Approbation of the photogrammetric method for measurement in mechanical engineering. *Notices of the Union of Scientists – Ruse, Technical Sciences Series, 5*, 1–5. ISBN 1311-106X.
33. Zhang, D., Liang, J., Guo, C., Liu, J., Zhang, X., & Chen, Z. (2010). Exploitation of photogrammetry measurement system. *Optical Engineering, 49*(3). SPIE Digital Library.
34. Gerbino, S., Martorelli, M., Renno, F., & Speranza, D. (2004). Cheap photogrammetry versus expensive reverse engineering techniques in 3D model acquisition and shape reconstruction. In *Proceedings of DESIGN 2004, the 8th International Design Conference* (pp. 1–8). Dubrovnik, Croatia.
35. Georgiev, G. (2015). Possibilities for reducing the cost of production by using new methods for design and production of parts. *Scientific Papers of the University of Ruse, 54*(2), 135–139. ISSN 1311-3321.
36. Maldzhanski, P. (2012). Advantages of digital photogrammetry over analog photogrammetric technologies. In *Proceedings of the International Anniversary Scientific and Applied Conference UASG 2012* (pp. 1–5).
37. Mikhail, M., Bethel, J., & McGlone, J. C. (2001). *Introduction to modern photogrammetry*. Wiley. ISBN 0471309249.
38. Jharkhand Space Applications Center. (n.d.). *Photogrammetry*. http://jsac.jharkhand.gov.in/photogrammetrycontent.htm.
39. Gruen, A. (2000). Development of digital methodology and systems. In K. Atkinson (Ed.), *Close range photogrammetry and machine vision* (pp. 78–104). Whittles Publishing.
40. Yankov, K. (2007). Interactive generation of data transmission protocol between external device and computer. In *Proceedings of the International Conference on Information Technologies (InfoTech-2007)* (Vol. 2, pp. 231–238). St. Constantine and Elena resort, Varna, Bulgaria.
41. Sea Blue. (n.d.). *Най-известните първи фотографии в историята*. Retrieved September 8, 2025, from https://www.sea-blue.org/bg/news/nay-izvestnite-parvi-fotografii-v-istoriyata.html.
42. Maldzhanski, A. (2018). Application of close-range photogrammetry in architectural documentation. *Architecture, 4*, 15–24.

DOI: 10.5281/zenodo.17149755