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USING OF LASER SCANNING IN GEODETIC HIGHWAYS SURVEYS

Arsenieva N. O.
c.t.s., as.prof.
ORCID: 0000-0002-6178-2558
Kharkiv National Automobile and Highway University,
st. Yaroslava Mudrogo, 25, 61002

Abstract. *In modern geodesy, laser scanning is a rapidly evolving technology that allows you to automate work processes, as well as provide the most accurate research results. Laser scanning systems have emerged relatively recently. Despite this, they quickly became popular. First of all, thanks to the minimal labor costs. If earlier these or those manipulations took several hours, now they are performed in a few minutes. All the obtained objects have a three-dimensional shape and the equipment is maximally automated.*

Synchronization with computer programs, which facilitates data processing and makes it more efficient. Carrying out measurements in those places where the presence of people is not recommended, or even life-threatening. High shooting speed. It reaches a million measurements per second. All of the above shows how effective the use of modern laser scanning.

Key words: *laser scanning, laser scanners, geodetic highways surveys, laser scanning technology.*

Introduction.

Like any other field of activity, geodesy does not stand still, using modern advances in science and technology. Undoubtedly, one of the innovative solutions for geodetic research was laser 3D scanning. This method of topographic surveying allows to obtain images of complex architectural and industrial objects, mine workings, quarries, etc. Laser scanning is an innovative technology for collecting spatial data for various objects using 3D scanners. This allows us to transfer physical objects to a digital model of the highest accuracy. It is used in such areas as architecture, construction, medicine, mining, construction of road infrastructure and linear objects, and in geodesy.

The modern development of design, construction and operation of engineering structures requires the introduction of three-dimensional design methods, which in turn require the use of the latest technologies and methods for performing engineering and geodetic surveys, which are responsible for the reliability and efficiency of determining three-dimensional geodetic data. The more accurately, more objectively and more fully the real state of the object is displayed, the more justified decisions are made by engineers and designers on the choice of methods aimed at achieving the set goals. Thus, the degree of erroneousness of the decision being made is minimized. One of the methods that meet these requirements is laser scanning.

Main text.

Technologies for conducting engineering surveys do not stand still. Market specialists believe that at present one of the fastest and most accurate methods for obtaining characteristics about a structure and the place where it will be or is already located is laser scanning. Laser scanning is understood as a technology for measuring

volumetric surfaces using special equipment - laser-type scanners. Unlike all the usual satellite and geodetic methods, their work is characterized by high measurement accuracy, similar speed and detail. Laser scanning has also found application in mine surveying, archeology, road infrastructure and geodesy. Laser scanning, despite the need to use relatively expensive equipment, is increasingly used in geodesy, design and construction of structures. The principle of laser scanning technology is to measure the distance from the scanner to the surface of an object and form point clouds with spatial coordinates based on this. Modern models of laser scanners allow you to shoot at a speed of more than a million points per second and with high accuracy. The result is a digital copy of the object, which allows you to use the received data to create drawings. It also allows you to create a digital model of an engineering structure. It enables the creation of three-dimensional digital visualization, with subsequent use in conjunction with BIM technologies, and this is the main advantage of laser scanning. Laser scanning is primarily a reduction in terms of work with an increase in accuracy. What is especially important when implementing new projects with precise geo-referencing.

Special 3D scanners are used for laser scanning. They produce up to a million measurements per second, so we get a cloud of points with spatial coordinates, which are the basis for obtaining 2 and three-dimensional models of the object. The obtained data are used for various measurements, analyzes and calculations. To date, there are 3 main types of laser scanners [1 – 3]:

1. pulse (TOF) scanners – calculate the distance as a function of the time of passage of the laser beam to the object under study and back;
2. phase scanners – a method of obtaining data based on determining the phase difference between the signals sent and received;
3. triangulation 3D-scanners – the principle of operation is based on the solution of a triangle, where the role of spatial points: the emitter, object and signal receiver.

Depending on the nature of field work and the object, there are 3 main methods:

1) ground-based laser scanning – is carried out stationary for the survey of complex industrial facilities, opencast mining, as well as architectural structures of historical and cultural value;
2) mobile laser scanning – used for surveying railways and highways, bridges and tunnels, as well as linear objects (pipelines, power lines, etc.). The essence of the method is that the scanner is installed in the car, which allows you to perform scanning in continuous motion;
3) aerial laser scanning – one of the types of aerial photography. The scanner is installed on the aircraft, which allows you to shoot under the treetops, as well as in densely populated areas.

In recent years, laser scanning in surveying and surveying has become very popular. After all, the main goal of engineering and geodetic research is to obtain the most accurate and fast result with the maximum level of detail. The main advantages of laser scanning [2 – 4]:

- three-dimensional model of the object is obtained in seconds, the accuracy of measurements is very high;

- data collection is carried out very quickly - optimization of field work, defects and deviations are simple – you only need to compare the resulting design with the design 3-dimensional model;
- safety of shooting dangerous and hard-to-reach objects;
- topographic plans are obtained through virtual survey;
- non-contact scanning method (remote sensing) allows you to easily work with architectural monuments.

In geodesy and surveying laser 3D-scanning is used for:

- ✓ conducting geodetic surveys;
- ✓ drawing up topographic plans;
- ✓ conducting executive survey – control of construction and installation works, detection of deviations in accordance with the design documentation;
- ✓ calculation of volumes of warehouses of loose materials, earthworks;
- ✓ control of stability of quarry boards, monitoring of landslide processes.

The most widely used terrestrial and mobile laser scanning, due to the versatility and simplicity of the method, variety and lower cost of equipment. It is most actively used in the survey and construction of engineering facilities (construction control, architectural supervision), mine surveying (calculation of volumes, regular measurements and surveys), and reconstruction of geometrically complex objects.

Terrestrial laser scanning differs significantly from other methods of collecting spatial information. Among the differences, we highlight three main ones [4, 5]:

– fully implements the principle of remote sensing, which allows collecting information about the object under study, being at a distance from it, i.e. there is no need to install any additional devices and fixtures (brands, reflectors, etc.) at the facility;

– in terms of the completeness and detail of the information received, none of the previously implemented methods can be compared with laser scanning, the density and accuracy of points determined on the surface of an object can be calculated in fractions of a millimeter;

– laser scanning is characterized by unsurpassed speed – up to several hundred thousand measurements per second.

The essence of the scanning technology is to determine the spatial coordinates of the points of the object. The process is implemented by measuring the distance to all determined points using a phase or pulsed reflectorless range finder. Measurements are made at a very high speed – thousands, hundreds of thousands, and sometimes millions of measurements per second. On the way to the object, the pulses of the scanner's laser range finder pass through a system consisting of a single movable mirror, which is responsible for the vertical shift of the beam. Horizontal displacement of the laser beam is performed by turning the upper part of the scanner relative to the lower one, which is rigidly attached to the tripod.

The mirror and top of the scanner are controlled by precision servomotors. Ultimately, it is they who ensure the accuracy of directing the laser beam to the object being photographed. Knowing the angle of the mirror and the upper part of the scanner at the time of observation and the measured distance, the processor calculates the coordinates of each point.

All control of the device operation is carried out using a laptop computer with a set of programs or using the control panel built into the scanner. The obtained point coordinates from the scanner are transferred to the computer and accumulated in the database of the computer or the scanner itself, creating a so-called point cloud. The scanner has a defined area of view, or in other words, a field of view. Preliminary aiming of the scanner at the objects under study occurs either with the help of a built-in digital camera or based on the results of a preliminary sparse scan. The image received by the digital camera is transmitted to the computer screen, and the operator performs visual control of the orientation of the device, highlighting the required scanning area.

Airborne laser scanning has the highest cost of equipment with significant risks of breakdowns. Therefore, it has not received much distribution yet.

The main technological task of a surveyor is to provide reliable and as complete information as possible about the position of an object in space and its geometric characteristics. The main type of equipment that allows you to collect a large amount of information in the shortest possible time is precisely laser scanning systems. They allow you to get a point cloud in which you can track a huge number of parameters of the object under study. The very technology of laser scanning opens up a number of new, previously inaccessible possibilities. This is primarily due to the more complete use of modern computer technology. The resulting point cloud or 3D model results can be quickly moved, scaled and rotated. There is a possibility of a virtual tour of the image with a record in a standard multimedia file for further display.

No other method can give such a complete idea of the object. At the same time, the specialist works not just with an image, but with a model that preserves the full geometric correspondence of the shapes and sizes of a real object. This state of affairs makes it possible to measure real distances between any points or elements of the model. Despite the exceptional novelty, the technology provides for the possibility of automatic or semi-automatic receipt of information and documents in the usual form for a highway - drawings of profiles, cross-sections, plans, diagrams. The ability to exchange via common graphic data formats makes it easy to integrate laser scanning technology into the scheme of already used software.

Summary and conclusions.

The article analyzed the laser scanning technology. The most suitable for road surveys can be considered the technology of terrestrial and mobile scanning. Thus, laser scanning makes the design process fast and practical. In addition, the cost of measuring work is reduced, and the quality of the project is radically improved. The human factor in laser scanning is minimized. The result of the measurements can be published in different formats. It can be further processed in computer programs. The introduction of laser scanning technology allows you to get a lot of advantages compared to traditional survey methods. Its main advantages are the high speed of measurements, the detail of shooting, as well as the completeness and accuracy of the results obtained. Due to its versatility and a high degree of automation of measurement processes, a laser scanner is not just a geodetic instrument, a laser scanner is a tool for quickly solving a wide range of applied engineering problems. It is safe to say that this technology opens up new opportunities for work and provides

the necessary information for the development of a modern method of three-dimensional design of objects.

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