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ANALYSIS TERRESTRIAL LASER 3D SCANNER AND THEIR SCOPE

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Statement of the problem. Terrestrial laser scanners are the most common and used among other types of scanners. At present, the development of instruments for laser scanning has been a lot of companies. The most famous are Trimble (USA), Leica Geosystems (Switzerland), Riegl (Austria), Zoller + Fröhlich (Germany), Topcon (Japan), Faro (USA) [1]. Through the use of a wide variety of devices and their specifications, terrestrial laser scanners should be distinguished by certain technical characteristics.

Formulation of the problem. This article is a continuation of the research authors, initiated in of labor [22]. Selecting terrestrial laser scanners in a separate group of devices, the authors analyzed more deeply and characterize their. Considering the latest models of scanners, the authors track the trends in terrestrial and scanning devices are classified according to their technical capabilities.

The main material.

Terrestrial laser scanners identified as a separate group based on the separation of these devices for scanning technology and belong to the active non-contact 3D scanners. They can be either stationary or portable. Since mostly used in geodesy portable scanners that for the period of measurement should be fixedly on a tripod or other mount, but their movement is not time consuming [22], in this article relate to the classification of laser scanners of this type.

The descriptions of terrestrial laser scanners, pay attention to the following settings:

- Method of measuring distances;
- Laser parameters;
- Accuracy of measurement of distance and angle;
- Viewing angle;
- A range of measurement;
- Speed and the density of scan;
- Other settings.

Method of measuring distances

The main characteristic of laser scanners are the type rangefinder. By way of determining distance, scanners divided into phase, pulse and triangular. Bulk of terrestrial laser scanners belong to pulse and phase technology of distances in geodetic works through a small radius of action, triangulation scanners are usually not use. For example, handheld scanner Creaform 3D scanner REVscan (Fig. 1) is be located at a distance of 30cm from the surface scan [2]. Earlier scanners Creaform sold under its own brand ZCorporation. This type of scanners used in the measurement of small surfaces with high accuracy. For example, the accuracy of the coordinates of the surface, using Creaform 3D scanner MAXscan, by resolution is 0.1 mm is 0.020 mm + / - 0.025 mm / m This allows for removal of the structure of complex objects as possible. Thus, the triangular scanners should be used when removing certain architectural sites where important completeness and accuracy of reproduction of the actual state of the surface (Fig. 2).

Figure 1. Hand triangulation laser scanner Creaform 3D scanner REVscan

Figure. 2. The scanning process using a hand scanner.

The difference between the pulse and the phase of the laser scanner technology is manifested in the accuracy of distance. But the use of various technologies and algorithms for calculating coordinates of points in different scanners can neutralize this difference. Therefore, the type of laser rangefinder is not the main parameter for selecting ground-based laser scanner

Laser parameters

From the parameters of the laser depends the distance at which the device can scan and removal precision of. The main characteristics of the laser is:

- Wavelength;
- Laser power;
- Type of laser;
- Diameter of the of laser beam;
- Laser beam divergence.

Since all 3D scanners manufactured abroad, the technical characteristics of the device indicates the laser safety class according to international standard IEC EN60825-1: 2007) [21]. By this standard, most 3D laser scanners fall into the category of 3R, from which injury rate - minimal. The exceptions are some of the long-range scanners. For example, Riegl VZ-6000 with a maximum radius of 6km, uses laser class 3B that are dangerous in the event of a direct effect on the retina.

Depending on the diameter of the laser beam at the output, its differences and step scanning, the scanner at a distance can not fully obmiryaty small part of the environment. The main reason is the increase of the laser point. Therefore, with increasing range scanners for saving the accuracy of scanning of laser beam diameter should decrease.

For example, a laser scanner Riegl LMS-Z390i at a maximum distance of 400m scanning of laser beam divergence is about 0.3 mrad, scanner Riegl LMS-Z420i - 0,25 mrad at 1000m, Riegl LMS-Z620 - 0,15 mrad at 2000m and Riegl VZ-6000 (Fig. 2) - 0.12 mrad at a maximum distance of 6km measurements [6]. Control diameter of laser beam can be achieved by focusing beam at a distance. For example, the scanner HDS 3000, ScanStation and ScanStation 2 laser beam has a focus at a distance of 25m from the scanner (Fig.4). This means that at a distance of 50 m diameter of laser beam does not increase [1].

Fig.3. Terrestrial laser scanner Riegl VZ-6000

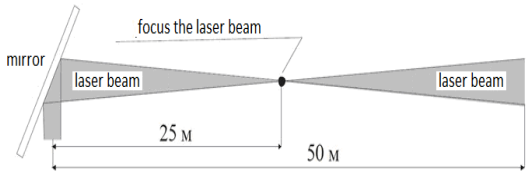

Fig.4 Focusing the of laser beam

So the parameters of the laser will depend on the main area using 3D scanner.For example, for mapping glaciers or the mining industry is an important distance scanning (Fig. 5).Therefore, in these works the best is to use the scanner Riegl with a range of up to 6km and accurate determination of the coordinates of about 10mm.When you work with architectural objects, more importance will be the accuracy of the data obtained. Therefore,the use of scanners Riegl in this area is limited.

Figure .5. Crawl spaces Greenland using terrestrial laser scanner Riegl VZ-6000

Accuracy of measurement of distance and angle

Accuracy calculate the coordinates of the surface points of an object depends on the accuracy of the distance and the vertical and horizontal angles. Measurement accuracy distances associated with type rangefinder used in the unit (phase considered more accurate than pulsed). Different scanners measurement accuracy distances in the range from about 0.3 mm to 15mm. We note that this parameter depends on the distance to the object and the reflective properties of the surface is scanned. Scanners of different manufacturers in other aspects indicate different conditions determine the accuracy of the scan.

The accuracy of the laser beam deflection in different devices as different, but usually it is the same in the vertical and horizontal plane. For example, a laser scanner Topcon GLS-1500 makes measurements of angular precision 6 "[7], Leica ScanStation 2 - 12" [8] and Z + F imager 5010 - 25 "[9]. So the accuracy of measuring angles and distances, laser scanners can be divided into nyzkotochni (error coordinates is obtained from 8 mm), high accuracy (3 to 8 mm) and precision (less than 3mm).

Viewing angle

Models of scanners previous years, due to some peculiarities of their structure, have a limited field of view. For example, Trimble GX (Fig. 4) with a full horizontal viewing angle (360 °), limited to 60 °-th vertical scanning area. [10] Because of this, for a full scan area need to create more stations standing device, compared with scanners larger viewing angle. The same viewing angle and new models of terrestrial laser scanner Riegl.

Figure. 6. Land laser scanner Trimble GX

The use of a scanner with a vertical field of view of 270 ° or more, makes it possible to avoid the creation of redundant stations. Scanner Leica HDS7000 (Fig. 7), due to its construction, covers 320 ° area scanning vertically and 360 °-horizontal [8], which is within completely scan area. No scaning zone is an area that is under the scanner (Figure 8).

Figure. 7. Land laser scanner Leica HDS7000

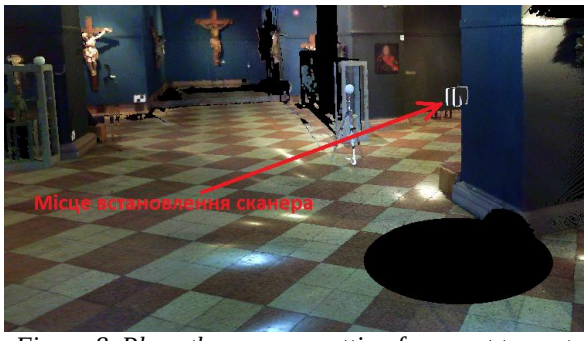

Figure 8. Place the scanner setting fragment to spot patterns

In most scanners when configuring the scan mode there is an option choice area removal, which can not conduct redundant measurements and save time. After scoping scan (lowest quality parameters and resolution), obtained by a panoramic image can be limited angle scanner.

A range of measurement

Range of measurement depends on the laser power, receiver sensitivity and surface properties is scanned. Usually, the manufacturer indicates distance measurements together with the value of the reflection coefficient.

Reflection coefficient is defined as the ratio of the radiation flux reflected surface to the radiant flux incident on a surface. Depending on the physical properties of the material that is scanned, the maximum distance will vary removal device. For example , the scanner Leica HDS8810 (Figure 9), with a coefficient of reflection of the laser beam 80%, is able to scan the surface at a distance of 1400m , while the reflection coefficient of 10% - 500 m [8]. Also, with the change of the distance to the location of the object and the instrument will change the coordinate determination - Leica HDS8810 scanner when scanning at a distance of 200 m yields results with an accuracy of 8 mm , and at a distance of up to 1000m - 20mm.

Figure. 9. Land laser scanner Leica HDS8810

Established that one of the highest reflection is silver (95%), Whatman (76-82%). Some of the lowest - red brick (8.10%), crude steel (5-10%), glass (0.08%) [23]. The value of the reflection coefficient also depends on the distance at which the removal is carried out, and the angle of the light beam hitting the surface. Given the importance of the reflection coefficient, each point is assigned a color scan of the selected range of colors (Fig. 10).

Figure 10. Assigning colors to black and white range based on the values of reflection coefficient

Speed and density of scan

Speed measurement depends on:
- The number of measurements per unit time;
- Resolution of measurement;
- Accuracy of measurement;
- Distance measurements;
- Capture the real color areas.

The advantage over traditional laser scanning survey is the number of measurements. To achieve the reproduction of the real state of the object in the form of dots in the shortest time, a laser scanner must be fast enough to carry out measurements. This is the main parameter of the scanner, which depends on the amount

of time spent on field work. Stonex X9 (Figure 11) is able to hold up to 1,016,027 points per second, making it one of the fastest scanners. The rate of rotation of the mirror optical system is 50 revolutions per second [12]. The accuracy of the scan will depend on the parameters set by scanning and scanning reflectivity of objects. For example, when measured at a distance of 10m accuracy is 0.5 mm (reflection coefficient 14%) or 0.3 mm (80%). When measured at a distance of 100m, it is possible to achieve precision scanning of 2mm (80%) to 10 mm (14%). Because scanners of this type can be regarded as the most versatile of their application is more wider.

Figure. 11. Land laser scanner Stonex X9

The timing of the scan depends on the parameters set by the device. Given the necessary result of scanning and terrain, the chosen instrument required level of resolution and quality (precision) of measurement. Some new scanners, such as Trimble TX8 (Fig. 12), have the function of variables in one scan. It is used for a more detailed measurement of a certain object and less thorough removal of other parts of the area.

Figure .12. Terrestrial laser scanner Trimble TX 8

Other settings

Land laser scanners and may differ in other avilable and use. These parameters are:

- Digital camera;
- Plam;
- Orientation sensors scan;
- Data transfer and communication;
- Physical dimensions and weight;
- Temperature operation .

Each pulse of the laser rangefinder provides information not only on distance but also on the color of the object in grayscale range, which is reflected in the ratio of reflectivity of the surface. But many customers do not want to work in psevdokolorah . To assign points scanning real colors created Photopanorama areas. The proper combination of pictures and point clouds requires that the camera was at the same point as the measuring system unit. Making pictures with the same range as given in the scanner, scanning all the points you can assign the appropriate color.

Some scanners are usually models of previous years, to capture the color , you could use external digital camera (Figure 13). The advantage of this method is the ability to adjust quality settings and pictures. A major drawback - the process of combining photography and point cloud , which is very time-consuming [13].In the model range , most modern 3D scanners are equipped with an internal digital camera , which simplifies processing of point clouds. But through an automated process pictures, real color of the object may be distorted.

Figure 13. Terrestrial laser scanner Faro Photon 120

Plummet is used to establish a scanner on a specific point. Since not all scanners are equipped with this device, the orientation of the scans can sometimes be difficult.

By targeting sensor scans installed in laser scanners include altimeter (altimeter) , compass, inclinometer , GPS receiver. These sensors help the automatic processing of scans by providing information about the height of scanning orientation to the north , the deviation point clouds from horizon coordinates of the location of the device. All sensors, except the GPS-receiver comprises a laser scanner Focus3D X 330 (Fig.14) [14]. The accuracy of the angle of inclination of the scanner is 54 "in the range of the 5 °. Altimeter in this scanner operates on the principle of electronic barometer. Single-frequency GPS- receiver is also equipped with a scanner Riegl [6].

Fig.14. Terrestrial Laser Scanner Focus3D X 330

These scans are often recorded on the internal hard drive or an external flash drive. There are also solutions write data to a memory card standard SD. Since the output of an intensive process of recording information, the best use of memory cards in Grade 10 and above. They provide the data writing speed not less than 10Mb / s. General Standard for the transmission of data is Ethernet, WiFi or USB 2.0.

Very important when choosing a scanner can play size and weight of the device. One of the smallest scanners considered Trimble TX5 with dimensions of 240mm x 200mm x 100mm. [15] The mass of the device is 5.0 kg. A larger supply of the laser scanner Leica ScanStation C10. It is 13kh with dimensions of 238mm x 358mm x 395mm [8].One of the best temperature ranges work with scanners Riegl VZ- 1000 [6]. Their use is possible at temperatures from - 40 ° C to +40 ° C.

The conclusion

The analysis was considered modern, the most common terrestrial laser scanners leading manufacturers . According to the material , these devices should be characterized by the following paramteramy :

- Method of measuring distance;
- Laser parameters ;
- Accuracy of measurement of the distance and angle ;
- Angle ;
- Measuring range ;
- Speed and density scan;
- Other settings.

In this paper, examples of the application of modern terrestrial 3D laser scanners and their scope , such as:

- Scanning of small architectural objects using triangular scanners
- To carry out geological studies recommend the use of long-range scanners , such as Riegl VZ- 6000.
- Scanning of industrial plants useful scanners that are equipped with assistive devices orientation , such as scanner Faro Focus3D X 330.
- When removing buildings settlements appropriate to use universal scanners mid –range and high accuracy measurement

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Analysis terrestrial laser 3d scanner and their scope

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This article classifies the various types of terrestrial laser scanners and examines the principles of their work. Author's classification is designed to explain the peculiarities of scanners in various areas and help in selecting optimal models, depending on the goals