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Systematic Use of the Laser Scanner

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ABSTRACT:The modern stage of economic development of any country requires much more spatial information about the region. This article describes the purpose of laser scanning, laser visualization of the area and obtaining initial data, the process of visualizing the area in three-dimensional form.

KEYWORDS: attributive information, classification, coherence, decoding, monochrome, NURBS, overlay process, photographing, projection, representative points, TIN, visualization.

I. INTRODUCTION

The objective of laser scanning is to create a three-dimensional geographic information model.This process is based on the results of the spatial analysis of laser scanning data, which is the essence of the second important function of the system in question.For data analysis, appropriate models of the mathematical definition of objects and terrain are needed, so the third function is to model the terrain.However, the simulation requires source data, so the fourth function is for retrieving data, and the fifth function is for obtaining semantic information.Finally, the sixth function - the visualization application - is necessary for human control and perception of the results of spatial analysis.Creating digital cards is an additional, seventh function.In order to implement these functions in the technological process: from the survey of the area to the visualization of the results, we will consider in more detail.

Laser survey of the area and initial data collection.Laser tomography and initial data collection is a process of direct study of the area.[1] The process of direct terrain survey involves the measurement and identification of site object characteristics.In addition, the quality assessment of the obtained data should be included in this process, since only accurate, complete and detailed information is suitable for further processing.

II. MATERIALS AND METHODS

Laser survey is performed to obtain geometric initial data reflecting the spatial properties of terrestrial objects.The essence of all laser scanning methods is to measure the distance from the scanner to the ground object and the direction of propagation of the signal with a high frequency.When measuring distances using a scanner, the properties of a laser source of electromagnetic radiation are used, namely: signal coherence, monochromaticity, small propagation angle.[2]

According to the results of laser scanning, each point is a point with the following characteristics: spatial coordinates (X, Y, Z), the intensity of the returned signal.In addition, digital surveys are conducted to improve the quality of the point array in terms of quality, which allows you to obtain information about the real colour of the object for each point.The use of laser scanning data in combination with digital images facilitates the process of identifying and monitoring land types online.The measurement results are followed by the following initial processing:

- the transition from physically measured values to corresponding geometric values, i.e. calculation of spatial coordinates and various corrections to them;
- filtering data, i.e. eliminating "false" measurements caused by the interaction of the laser signal with local objects and the environment under certain conditions;
- external and mutual orientation of the data, i.e. bringing the data into a given or unique conditional coordinate system.

In addition to laser imaging, field decoding, photography, video recording, abbreviation, geodetic satellite surveying, and other conditional or local information retrieval operations may be performed in the step of collecting information about location objects. These materials ultimately help in decoding the point array and creating a three-dimensional model of location objects, as well as in creating objects that are not reflected in the laser scan data.[3] The definition of non-spatial properties of spatial models is carried out by observing direct and indirect characteristics in a given range of properties of certain types of models, by measuring an array of points and other data.Indicators recorded in the resulting text or digital form generate conditional source data in a set with simulation identifiers.

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Contours (sketches) are calculated using data sources, such as photography, video shooting and geodetic satellite measurements, and serve to directly study the area.They can be applied in addition to direct learning outcomes.These sources of information are mentioned in the absence or insufficiency of laser scanning data.If it is not possible to obtain a complete set of initial data on the required objects from the array of points, then the study of the area is supplemented and tracked using clips and measurements determined by photo or video photography and satellite.

Visualize the territory in 3D view. As a result of the acquisition, initial processing, verification and completion of the laser scan data, the original data is presented as visual and processed information, which is formed by changing the original data and displaying it in one spatial information field. The geometric data is loaded into the processing program, during which the coordinates of the representative points and, if necessary, the height is calculated and aligned.[4] It uses source information in the form of coordinates and heights of datum points in a given coordinate system and map projection. Thus, geometric information (I_a) is obtained. From the schematic representation of the area, the data outline according to its geographical location and object description is topologically reduced to the form of a digital table (I_t). Topological information together with geometric information constitutes spatial information that fully reflects the spatial properties of objects. Conditional processing of data includes systematization, classification and coding of descriptions of non-phase properties of objects. This processing results in attribute information (I_a). Identification data is used in processing without changing other data, and it is implemented as an integral part of spatial and conditional information, ensuring that they are connected in the same sense for each object.

The organized set of geometric, topological, identifying and conditional data on the region and its spatial objects form a three-dimensional spatial information model (I) of laser scanning data,that is,

$$F_i : S \rightarrow I \quad (1)$$

here,

$$I = \{I_p, I_a\} \quad (2)$$

$$Ip = \{I_g, I_t\} \quad (3)$$

The 3D spatial information model reflects the final results and is used to address issues such as the radical improvement of our country's economy and the efficient and rational use of land resources. However, in practice, the 3D spatial information model is rarely used in terms of volume.A three-dimensional spatial information model can be used for the purpose of comprehensive representation of location information, obtaining some geometric parameters and qualitative characteristics of the designed object, monitoring the necessary design stages.In this case, using the spatial information model allows you to not only control quality indicators but also control permissible errors and subsequently change the study of the engineering project in accordance with the goal.Traditional control methods did not allow to study and modify these processes.The development and regulation of ground control processes allow you to constantly update and conduct virtual research using laser scanning technology.

Territory modelling. The presence of a three-dimensional spatial information model allows you to model the territory in particular, creating its three-dimensional geographic information model.The essence of the territory modelling process is officially consistent with the following expression.

$$F_m : I \rightarrow M, \quad (4)$$

There are two main approaches to the description of territory:

- structural, that is, representation of spatial objects with division;
- an expression in the form of cells in which the average obtained values of the characteristics of this part of the territory that is not structured are given.

Therefore, the set of M models, in turn, is a set of three-dimensional models for determining the region: primates (M_p), solids (M_t) and small sets in the form of TIN or NURBS surfaces (M_s).

$$M = \{M_p, M_t, M_s\}, \quad (5)$$

Use geometric and topological information to create a primitive terrain model.

These models are based on geometric primitives, that is, basic models of objects in a mathematical function (sphere, plane, cylinder, etc.).

A three-dimensional solid model is an interconnected set of complex mathematical models whose elementary appearance is geometric primates.Channels, double columns, parallelepipeds are examples of such solid models. Solid modelling is often used in technologically complex strategic areas and in construction work intended for

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agriculture.Modelling a TIN or NURBS surface-shaped region involves creating an object surface proportionally as an elementary step using triangles or spline functions.In this case, the element connection is merged into a single object.The three-dimensional vector model of the region includes models of objects and their relationships.Thus, spatial objects are models of regional relations in which processes, events, and events must be understood along with physical objects.

Geometric information obtained from measurements with certain accuracy does not allow you to create accurate models of spatial surfaces.Therefore, during the simulation process, the alignment work is carried out taking into account geometric information conditions.

This alignment work, firstly, allows you to find and eliminate gross errors in the processing of laser scanning data, and secondly, to create the right model.In equalization works, the movement of the surface of three-dimensional objects determines the limit of measurement error.Attribute information is not an independent model but complements the three-dimensional vector model of the terrain.At the same time, each spatial object can enter the description as a component or be in a single attribute database for the entire territory on which it is built. The connection of different parts of space objects in one system is ensured by means of identifiers.A three-dimensional model of territory will usually consist of thematic layers, which include spatial objects related to a single topic.The surface of the Earth is modelled by a separate layer.In this case, the features of limit heights or depths of the usual and non-classical structural type are used for modelling.Monitoring of the process and results of the territory modelling is carried out using auxiliary materials obtained during the information collection process specified in Fig. 1 of the sources.

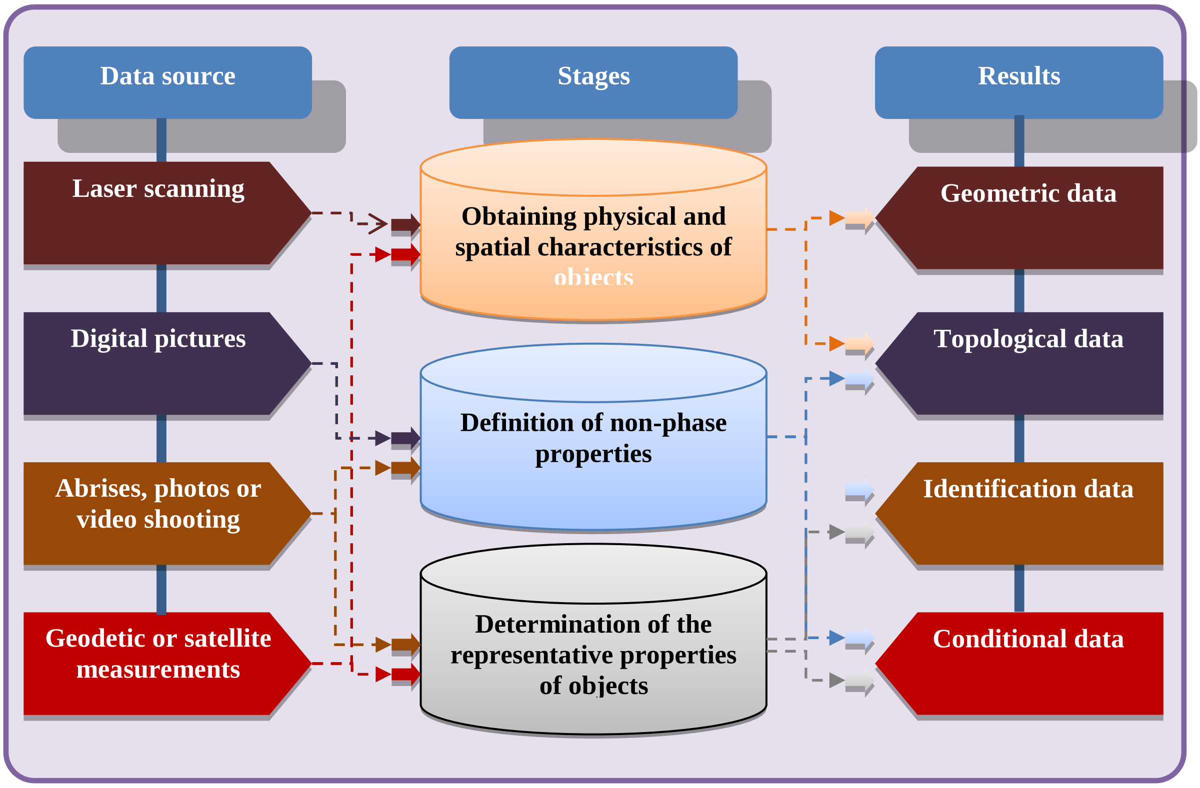

Fig. 1. Functional scheme of data acquisition in laser scanning technology.

A three-dimensional vector model of the region is used for spatial analysis performed using software that performs a number of functions of a geographical information system. These include programs that provide analysis of the location, relationships, and other spatial relationships of spatial objects, analysis of networks and objects, computational geometry and overlay operations, processing of digital relief models, and so on.

Analysis of facilities within buffer zones allows solving the problem of assessing the zone of influence of agricultural transport communications and similar existing or planned networks.The steps of computational geometry allow you to calculate the areas of polygons and the coordinates of centroids, the lengths of broken and curved lines, etc.

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The essence of the Overley process is to combine layers on several different topics and summarize the geometry of an object geographically, placing their attributes on top of each other.Processing digital relief models to determine the visibility or invisibility of morphometric data; three-dimensional images, longitudinal and transverse profiles along given lines, estimation of slope shape, calculation of positive and negative volumes, generalization of structural lines and important relief points, construction of isolines, separation of relief at different lighting, etc.
In addition to these features of the GAT software, special programs for predicting GAT applications are also used, based on the creation of deterministic and stochastic models for spatial analysis.As a result of spatial analysis, the area model (A) is supplemented with new objects, as well as qualitative and quantitative indicators of the area in one aspect or another.For example a comprehensive assessment of the use of the territory, an assessment of the convenience of transport, engineering, investments, documentation, etc.
Formally, the following expression corresponds to spatial analysis.

$$F_a : M \to A \quad , (6)$$

This functional relationship indicates that the simulation process is associated with the resulting digital model.
Preparation of spatial solutions based on laser scanning.A spatial solution is a project of actions regarding spatial changes of a direct domain or processes that occur in it (G).The spatial solution is based on the project of changing the area under consideration.A change project is a model of the area in question that adds new elements to it as a result of spatial analysis, control design, or area change.Typically, several models are created to compare, justify, and select the best solution.
The process of preparing spatial solutions can be formally described as follows.

$$F_p : M \cup A \to G \quad , \quad (7)$$

Structural and functional model of systematic 3D geographic information support. The above set of implementation processes is reflected in the overall structure-functional relationships of the information components shown in Figure 2 and combines the elements and functions of geodetic support into a single system called a three-dimensional geographical information system.

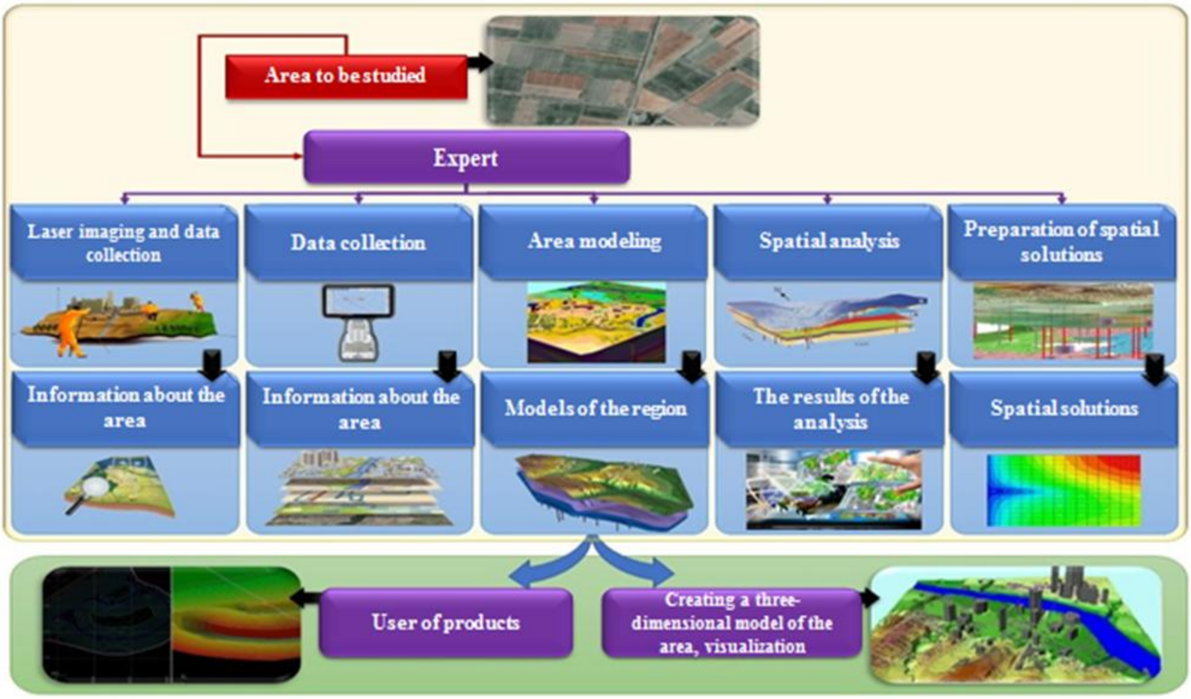

Fig. 2.Structural and functional model of the systematic presentation of three-dimensional geoinformation.

In special cases of using modern measuring devices equipped with computing devices, some processes can be carried out in real-time, providing the addition of processes, and not in sequence in time.Fig. 2 shows the interaction of processes from the initial data of the structural-functional laser scanning to the delivery of the final spatial project (solution) from the product to the user.The main and most important step in obtaining a three-dimensional geographic information model is to obtain laser scanning data.

III.CONCLUSION AND FUTURE WORK

System-based use of laser scanners provides accurate and high-quality information about the region.Also, as a result of laser scanning, a three-dimensional spatial information model of the terrain is created.This, in turn, will contribute to the use of innovative modern geodetic devices in all areas and the implementation of high-precision design developments.

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