Integration of GIS and a complex of three-dimensional laser scanning

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Abstract. The need for a qualitative presentation of data becomes more and more obvious every year. The ability to dynamically display information, the information relevance, the maximum efficiency of management decisions with minimal labor costs - it is on these principles that modern GIS should be built to manage the large enterprises. This article discusses the most promising way to create a GIS based on laser scanning data for enterprise management. The method of creating a GIS considered in the article, the advantage of the 3D model as the GIS basis, 3D scan data conversion availability, the economic investments analysis and the example of the pilot version of the 3D GIS allow to evaluate all the advantages of integrating GIS laser scanning technologies. We have studied the materials from foreign sources, affecting the possibility of such technologies joint use. The research purpose in this article is to substantiate the possibility of creating a 3D GIS based on laser scanning data. Conclusions are also made about the main advantages and disadvantages of working with such systems.

Introduction
The modern level of GIS development is coming to a new level thanks to the four-dimensional information representation concept at present, - now it can be not only displayed, but also predictable [1]. This is achieved by the artificial intelligence technologies introduction and expert systems in GIS [2]. The second development direction is fair to point out the new ways to get geo-bases for creating GIS - moving away from paper carriers as a source of data for creating GIS to technologies that allow getting actual, easily convertible data to scanning systems [3].

Unfortunately, the availability of using GIS applications that include an artificial intelligence component remains low, because it requires large investments (not every enterprise that uses the GIS platform for management purposes is advisable for such technologies’ implementation).

Creating a GIS based on laser scanning data (especially for GIS in order to manage a large industrial enterprise) is much more affordable and profitable on the investing money part.

Methods of obtaining spatial information by laser scanning are already firmly established in the field of engineering and geodetic surveys, but not only as a source of initial data for GIS [4]. Although
the data obtained by this method has a number of advantages that are most important for all the ‘functions’ of the created 3D GIS implementation - high quality visualization of the scanned area due to its volume image, the ability to build a 3D model of complex technological objects or engineering structures and high data convertibility (Software to work with laser scanning data have many output formats).

Article 132 of the Civil Code, which considers an enterprise as a single immovable complex, “an enterprise as a property complex includes all property types intended for its activities, including land, buildings, structures, equipment, inventory, raw materials, products, rights of claim ... and others exclusive rights, unless otherwise provided by law or contract ”[5], puts forward a number of tasks that will allow considering the enterprise as a generalized information structure for such an enterprise GIS [6].

These tasks include the following:
- The need to account for a large number of objects with different characteristics;
- The need for relevant information at the time of creating databases and accounting systems;
- The need for constant information updating;
- The need to make quick management decisions.

Research into the GIS and laser scanning technologies integration is also considered among foreign authors of scientific articles; however, they do not affect the possibility of using them for managing the large enterprises [7, 8, 9, 10].

**Material and Methods**

The stages of creating a 3D GIS based on laser scanning data do not differ from the stages of creating traditional 2D GIS. An exception is the method of obtaining and processing source data - directly carrying out field work with a laser scanner and creating a model for a cloud of points in various computer-aided design (CAD) systems [11].

To understand the need to introduce such three-dimensional systems, attention should be paid to the GIS modeling main drawback by processing raster images and scanning cartographic materials - a possible information irrelevance.

Speaking about the creation of a GIS for a large industrial facility, the relevance of information display is the main concept of using GIS as a whole. The technological objects schemes are often stored in enterprises in the paper media form. As previously discussed, paper mapping materials do not contribute to the 3D GIS main objectives achievement - the effective creation, implementation and use in production.

Without obtaining a realistic model of a technological object or an engineering structure, it is not possible to create a 3D GIS itself. And creating such a system based on paper cartographic materials (plans and schemes) is difficult even with the most advanced CAD systems [12], since the resulting model still will not be able to repeat exactly all the design solutions or existing defects and inconsistencies with the existing mechanisms and structures drawings (which is important for working with a dynamic GIS).

Laser scanning methods make it possible to obtain the most highly accurate data in the shortest time possible compared to the obtaining data other methods (the same drawing of cartographic materials or the shooting of objects with electronic total stations [13]).

The complexity of the integration of GIS and laser scanning is a choice of software platform that supports the ability to create 3D views - the resulting cloud of points will be transformed into a 3D model, then we need software that supports the 3D data format as much as possible - the data should not be distorted [14].

After the model is loaded into “3D accessible software”, it is necessary to choose the data information structure - layer-by-layer binding or object-oriented. If we are talking about complex, unique on the structures’ part and technological enterprises purposes, it would be advisable to use the second option. This is due to the fact that the resulting data array cannot simply be divided into layers - each of the received 3D objects has the features inherent only in its structure and content. In this
case, for successful work with 3D GIS, it is necessary to use a “separate” object display in the environment. For simpler enterprises and engineering complexes, layer-by-layer binding will suffice [15].

In comparison with the obtaining graphic information method using the drawing of a topographic base (topographic plans, aerial photographs, etc.), the object laser scanning method requires a much higher cost: the larger and more complex from the point of view of the construct, the enterprise is built, the higher the cost of both field and cameral works.

The more GIS performs the functions, the more complicated its “internal” device. This means that the user, when working with such a system, needs knowledge in the field of software, a GIS device not at the level of an ordinary user.

The complexity of the device DBMS, a large number of system components, advanced tools for performing tasks can be implemented with the help of expensive, limited in distribution and software use. The more complex the structure and specification of the enterprise itself, for which the GIS is created, the more complex the device of the platform on which such a GIS will operate.

Results

For the successful implementation of such fairly expensive projects, it is necessary to work out a mechanism for creating 3D GIS from the initial stage to its implementation in production. In other words, when developing any GIS, a “pilot project” is needed.

As a prototype, it is possible to develop a pilot GIS for one of the campus buildings, since its 3D model has been created based on laser scanning.

Summary

Summarizing, we can say that the two relatively recent technologies integration - GIS and laser scanning, can yield successful results with proper use of software, equipment and creating GIS intricacies knowledge. It is the simultaneous (or rather, sequential) use of GIS and laser scanning that makes it possible not to separate, and besides based on the previously stated concept of building GIS for enterprise management - the ability to dynamically display information (create a 3D model), the relevance of information (a highly accurate 3D model) [16], the maximum efficiency of management decisions with minimal labor costs (a highly accurate 3D model containing all the necessary attribute information for fast and efficient Board Governance)

References

[1] Gribkova I S, Popova O S 2016 Municipal geographic information systems: problems and solutions (Electronic network polythematic journal “Scientific works of KubGTU”) 11 143-154.
[2] Verbitsky M V, Gribkova I S, Osennaya A V 2018 Prospects for the use of expert systems in the development of urban planning documentation (Development and Innovations in Construction - a collection of articles of the International Scientific and Practical Congress) 48-51.
[3] Khashpakyants N O, Gribkova I S 2017 Application of laser scanning in land management and cadasters (Electronic network polythematic journal “Scientific works of KubGTU”) 9 27-35.
[4] Shevchenko G G, Gura D A, Serikova A A 2016 The use of laser scanning to create geographic information systems (Electronic network polythematic journal “Scientific works of KubGTU”) 15 57-68.
[5] Ivanikova E A, Gribkova I S, Lamanov P I 2015 Experience of using GIS for land property management using the example of schools (The science. Equipment. Technologies (polytechnic messenger)) 4 99-102.
[6] Gribkova I S, Autumn A V, Gribkova L A 2015 Criterion for the development of land and property complexes of universities on the example of the Kubt (Regional aspects of the development of science and education in the field of architecture, construction, land management and inventories at the beginning of the III millennium, Scientific readings in
memory of Professor V. B. Fedosenko, Materials of the International Scientific and Practical Conference 378-381.

[7] Heather Richards-Rissetto 2017 *What can GIS + 3D mean for landscape archaeology* (Journal of Archaeological Science) **84** 10-21.

[8] Harley A S, Fotopoulos G, Hall B, Amolins K 2017 *Augmenting the GIS environment and the GIS environment* (Computers & Geosciences) **103** 152-163.

[9] Wei Huang, Min Sun, Songnian Li. *A 3D GIS-based Interactive Reality System* (Expert Systems with Applications) **55** 48-58.

[10] Arianna Campiani, Ashley Lingle, Nicola Lercari 2019 *Spatial analysis and heritage conservation: Leveraging 3-D data and GIS for monitoring earthen architecture* (Journal of Cultural Heritage Journal of Cultural Heritage).

[11] Shevchenko G G, Gura D A, Petrenkov D V, Osennyaya A V, Chernova N V, Shishkina V A 2016 *Efficient construction of 3d terrain models for inventory purposes* (EUROPEAN RESEARCH collection of articles of the winners of the VI International Scientific Practical Conference) 48-52.

[12] Gribkova I S, Brovkova Y V, Gura D A, Shevchenko G G 2017 *On the creation of an information system for managing the property complex of an enterprise on the example of ensuring the reconstruction and arrangement of deposits* (Electronic network polythematic journal "Scientific works of KubGTU") **3** 20-28.

[13] Gura D A, Shevchenko G G, Kirilchik L F *Application of inertial measuring systems* **9 (SI 1)** 732-741.

[14] Kuzyakina M V, Gura D A, Mishchenko Y, Gordienko D A 2018 *Experimental analysis of SRTM model* (International Journal of Engineering and Technology (UAE)).

[15] Gribkova I S, Gura D A, Brovkova Ya V 2017 *Development of methods for creating information systems for the rational management of land and property complex* (Electronic network polythematic journal "Scientific works of KubGTU") **4** 221-232.

[16] Shishkina V A, Gribkova I S 2019 *Creation of a GIS for enterprise management based on data obtained as a result of laser ground and aerial scanning* (Scientific collection: Student work land management faculty. Collection of articles on the materials of the International Student Scientific - Practical Conference. Krasnodar) 173-176.

[17] Federal Law No. 223-FZ of July 18, 2011 “On Procurement of Goods, Work, Services by Certain Types of Legal Entities”: official text, Meeting of the legislation of the Russian Federation dated July 25, 30 (Part I) 2011, Art. 4571.

[18] Of the Federal Law of 31.12.2014 No. 488- FZ “On Industrial Policy in the Russian Federation”: official. text. // Collected Legislation of the Russian Federation of January 5, 1 (Part I) 2015, Art. 41.

[19] Federal Law of November 23, 2009 No. 261- FZ “On Energy Saving and on Increasing Energy Efficiency, and on Amendments to Certain Legislative Acts of the Russian Federation” (with amendments and additions): official. Text, Collection of the legislation of the Russian Federation of November 30, 48, 2009, Art. 5711.

[20] SP 60.13330.2016 *Heating, ventilation and air conditioning*. Updated edition of SNiP 41-01-2003. Moscow, Gosstroy of Russia GUP TsPP, 2017.

[21] DIN EN 215-2006 *Thermostatic radiator valves*, Technical requirements and tests 2007, p.41.

[22] GOST 30494-2011. *Residential and public buildings. The parameters of the microclimate in the premises*, Standardinform of Russia, Moscow,2013, 33 p.

[23] Resolution of the Chief State Sanitary Doctor of the Russian Federation of June 10, 64,2010 "On Approval of SanPiN 2.1.2.2645-10" (with amendments and additions) GARANT system: Information on http://www.base.garan.ru/12177273/#ixzz5kfZ0ocJx

[24] GOST 30815-2002. *Temperature controllers automatic heating devices for water heating systems of buildings*. General technical conditions, Standard inform of Russia, Moscow, 2002, 33 p.
[25] GOST 31311-2005 Heating devices. General technical conditions, Standard inform of Russia, Moscow, 2006, 7 p.
[26] Sasin V I, Prokopenko T N, Shvetsov B V, Bogatskaya L A 1990 Recommendations for the use of convectors without a casing "Accord" and "North" (SRC sanotechniki, Moscow).
[27] Kushnir V D, Sasin V I 1991 Hydraulic testing of heating devices in conditions close to operationa (SRC sanotechniki) 65 35 - 46.
[28] Bershidsky G A, Poz M Ya 2017 Some questions of the method of thermal testing of heating devices. Ventilation. Heating. Air conditioning (AVOK) 4 76-81.
[29] Antsiferov S A, Filenkov V M 2015 Testing of the experimental stand for determining the hydraulic resistance of a rough pipe (Herald of NGIEI) 6 (49). Information on http://www.cyberleninka.ru/article/n/aprobatsiya-eksperimentalnogo-stenda-dlya-opredeleniya-gidravlicheskogo-soprotivleniya-sherohovatoy-truby (appeal date: 01.30.2019).
[30] Antsiferov S A, Usmanova E A 2015 Analysis of the effect of internal corrosion on the operation of pipelines (Herald of NGIEI) 6 (49). Information on http://www.cyberleninka.ru/article/n/analiz-vliyaniya-vnutrenney-korrozii-na-ekspluatatsiyu-truboprovodov (access date: 30.01.2019).
[31] Rafalskaya T A, Mansurov R Sh, Efimov D I, Kosova E Yu 2016 Problems of energy efficiency of centralized heat supply systems (Izvestiya VUZ. Construction) 10 (11) 32-48. - ISSN 0536-1052. Information on http://www.izvuzstr.sibstrin.ru/uploads/vorotnikov/ # 10-11-16.pdf

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