



BIM creation using point clouds

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Abstract: The report examines the technology of laser scanning objects using laser scanners, the accuracy of the collected spatial data and its application in the process of creating a Building Information Model (BIM). The aim of the study is to present the technology to efficiently create 3D object-oriented digital models from scanned data. The results obtained can be used in measuring, modeling and certification in construction sites, monuments, civil engineering structures - bridges, tunnels, linear objects, cuttings, embankments and other.

Keywords: laser scanning, point clouds, object-oriented modeling, BIM, visualization

I. Introduction

BIM is abbreviation of Building Information Modeling. Using BIM we create and manage digital records for a project throughout its life - from the earliest concepts and designs of the architects, in the design solutions of the engineers, through the work of the builders and then the maintenance and management of the building during its service life and eventual destruction.

The concept of BIM has existed since the 1970s.. For the first time the term was used in 1992 in an article by G.A. van Nederveen and F. P. Tolman [2]. However, the term Building Information Modeling (including the acronym "BIM") became popular when Autodesk released an article entitled "Building Information Modeling" in 2003.

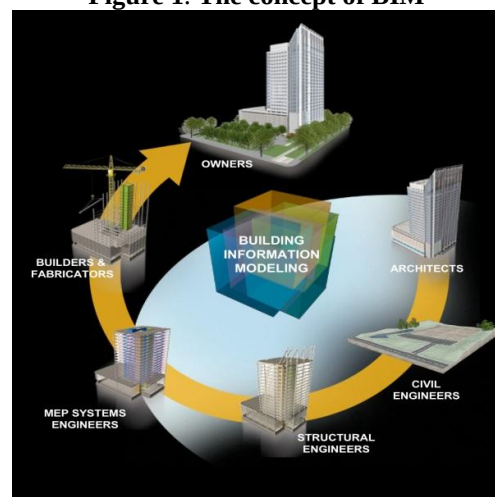
II. BIM nature

A. The concept of BIM

In an article for the CIO magazine, 2013. [3] Dr. Arch. Boyan Georgiev explained that BIM is an acronym that combines three different but interrelated concepts (Fig. 1):

- Building Information Modeling is the process of creating and exchanging data on the building (structure) during its design, construction, use, maintenance and destruction, that in its lifetime. BIM allows participants in these processes access the same information through the interaction of different technological platforms.

Figure 1. The concept of BIM



- Building Information Model is a digital description of the physical and functional characteristics of the building (structure) that serves as a shared source of data and information. It forms and maintain a reliable database for decision-making during its existence.

- Building Information Management provides organization and control of business processes using information from the digital model to permit the exchange of information throughout the lifecycle of the facility. The benefit of this is the presence of a centralized and visualize information, pre-study opportunities, sustainable solutions, effectively design, integration of disciplines and systems, complete construction and technical documentation and more.

B. BIM benefits

Here BIM is seen as an object-oriented digital model (OOCAD) with full database. To create models in a graphical environment no longer work but with lines and types of objects to which is associated attribute information [4]. Each created BIM model of a building or facility can be regarded as a GIS application for managing the design, construction and its service period. Its capabilities include:

- The **engineers** used BIM for complex analyzes of the efficiency of the building structure and systems of the building, and ultimately create construction documentation and significantly reduce the time for calculating and drawing. Creative work focuses on the design;
- **Builders** use BIM for more efficient management of resources needed for the project (type and quantities of materials, personnel and equipment).
- **Investors** make quick financial analysis for their investment, saving costs by the lack of conflicts, accelerated development and effective maintenance of the building.
- Introduction of **5D BIM** - a concept widely used in the CAD industry, which refers to the relationship between 3D graphic components of the model and defined time schedules and information related to the cost of various activities and materials.

C. BIM development

In recent years [3] in the UK BIM concept is the basis of public policy. At the beginning of 2008 was published standard BS 1192, which is applicable to all parties involved in the preparation and use of information during the design, construction, operation and demolition.

Leadership of the United Kingdom reported positive by the European Commission. In late October 2013 a conference was held to discuss the EU Directive on the application of BIM in the EU. The first step in this direction has already been made. From the end of March 2013. applies ISO 16739:2013 - Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries.

In the Netherlands in 2012 was published a second version of the standard defining the parameters of the documentation and formats for the implementation of BIM in construction.

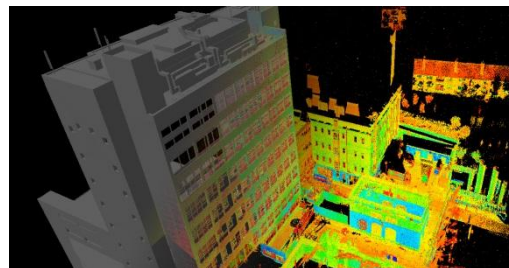
In the United States without a special institution or organization dealing with the use of BIM, the big design companies are actively pursuing this type of technology. Among them are the leading software companies that use the concept of BIM and actively assist private companies and government institutions for implementing it. Asian countries also noted the development of their attitude to BIM. In Singapore adopted regulations for the mandatory introduction of these technologies. South Korea follows the same route. India is developing high potential of export firms manufacturing these technologies to help industrialized countries.

III. BIM & 3D LASER SCANNING

The application of the technology of laser scanning (Fig. 2, 3 and 4) is popular in surveying and GIS environments for many years. However, recent advances in hardware technology and development of BIM help usher in a new level of data use of laser scanning in the construction industry.

Scanning for the purpose of construction is most often applied to existing sites (eBIM or existing BIM), but appear and applications related to new construction and design. Scanning technology is becoming an essential step to complete the integrated BIM cycle and plays an important role in the process.

Figure 2. From scanned "point cloud" to BIM documentation for future applications



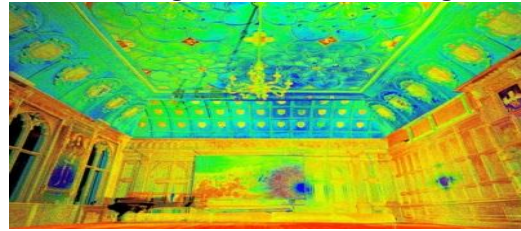
Many of the companies producing laser scanning instruments (laser scanners) have issued guidance on how the scanning technology can be applied in the BIM workflow and construction [1]. Scan technology can be used for

optimizing the building process at the same time reduce the risk of the project, the cost and the time of its completion, respectively realization. The objective is to understand the practical application of the laser scanning, as regards the object-oriented modeling and integration in BIM.

Figure 3. Exterior scanning



Figure 4. Interior scanning



The essence of the process of laser scanning is as follows. Scanners send laser beams with high density scanning the object and perform measurements to determine the position of a lot of points. The hardware of the scanner measures the time of elapsing the distance from the scanner to the reflecting surface and back to its adoption by the scanner (in pulsed scanners) or the phase difference (in phase scanners). Thus the distance and spatial angles between the scanner and scanned object for each his point is measured. Contemporary scanning technology has the ability to send thousands of beams per second, resulting in a huge amount of collected spatial data, known as „point cloud „. Many scanners can identify and record the RGB (Red, Green, Blue) value or intensity of each reflected point from the object. As a result, point clouds include millions or even billions of data, which describes the scanned area maximum realistic.

Figure 5. 3D model of a metro

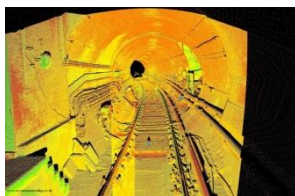
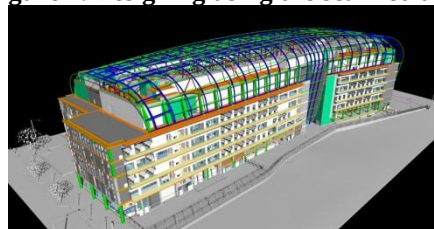


Figure 6. 3D model of a bridge construction



3D object-oriented design process presented on 3D terrain can be called 3D vertical planning. Combining the design of the building or facility with real property serves to create realistic models of the designed object, illustrating the investment intentions

Figure 7. Designing using the scanned area



IV. Laser scanning data processing in Revit

A. Introduction of point cloud and its application to a local coordinate system

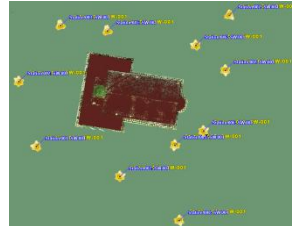
Scanned data converting into BIM model is a classic process of data transformation. First is performing the scanning process scans from required number of stations. Second, the collected data from different stations is combined into one, which is commonly known as post-processing, or the step of registration. Figure 8 shows the unified and processed point cloud of a church [7] in 3D view visualization mode. The scan process is accomplished with Leica ScanStation C10.

Figure 8. Unified and processed point cloud of Holy Trinity church, Sofia, Bulgaria



Scanning can be time-consuming initiative, leading to a very large and / or complex data sets, so it is recommended each team that applies this technology to plan very carefully their efforts (Fig. 9). The desired outcome of the scanning process should be clearly defined. In many cases, the desired result is to accurately determine the location (X, Y, Z coordinates) for the physical surface of the object. In other cases, the required information can be information 4D (3D + time schedule), and cost information, 5D. Last but not least, creating models can be supplemented with the management of the facility.

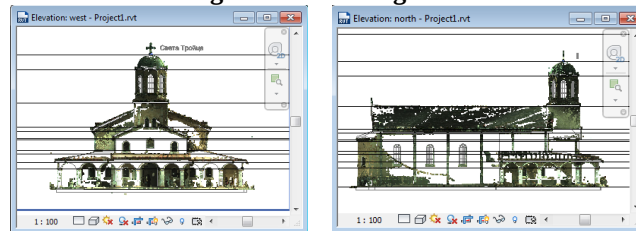
Figure 9. Scheme of the location of scanning stations



B. Defining levels

With Level tool we can identify the main sections. A level of any desired height is created by the designer of the building (e.g., the first floor, the upper part of the concrete wall, etc.). Adding levels takes place in elevation view visualization mode (Fig. 10).

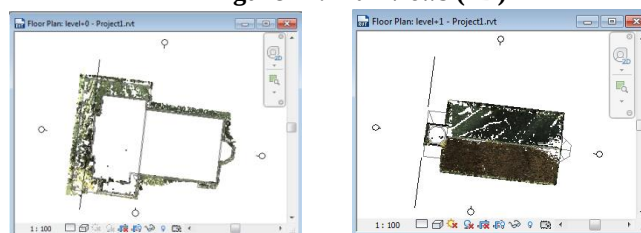
Figure 10. Defining levels



C. Plan view

By defining the existing levels of the building or facility shall be established and their respective plan views (fig. 11). The main part of the design work is accomplished in plan view visualization mode.

Figure 11. Plan views (2D)



D. Constructive components (walls, floors, roofs, rooms)

The software supports a high level of topology and performs continuous monitoring of the underlying structures (fig. 12). An interesting issue is the accuracy of the attachment of a defined structural element to a specific set of points from the cloud. The research about the accuracy of the selection of smoothing straight lines and planes is subject of a future work.

Figure 12. Basic constructions /roof/

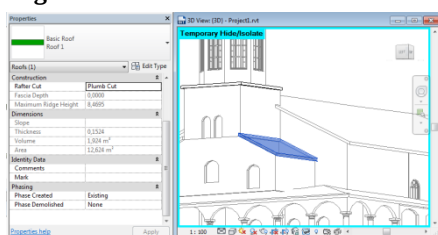
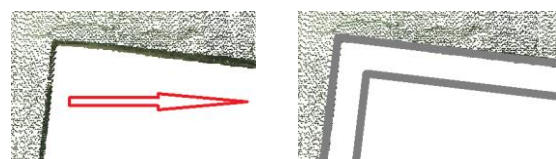


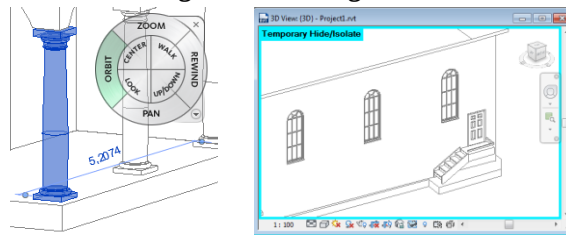
Figure 13. Basic constructions /wall/



E. Adding families and edit them

The different kind of objects like doors, windows, columns, etc. are loaded in the project from external libraries – files with extension .rfa

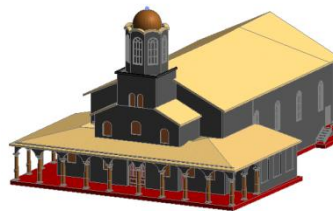
Figure 14. Adding families



F. Selection of suitable materials for the constructive components

If in the attribute information of the constructive components is introduces information about the material they are made of, the project is well illustrated in realistic view visualization mode.

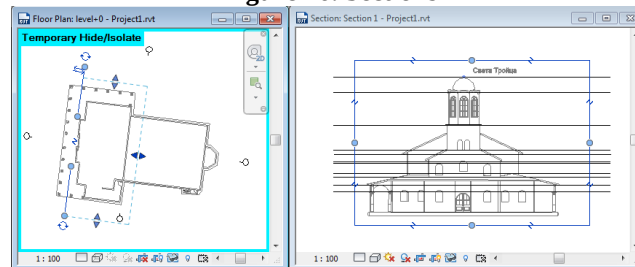
Figure 15. Realistic view



G. Sections

By defining different sections for the purposes of the geodetic practice we easily form an orthophoto image. In the design process sections and defined network design axes (grids) are part of the documentation required for the project. The axes may be defined as lines, arcs, or a combination thereof.

Figure 16. Sections



H. Statements of graphic and attribute database

One of the main advantages of this modern way of designing is the possibility of implementing fast and easy extracts attribute information attached to each object in the model (Fig. 17). For example, all the bill of quantities are displayed automatically. This saves time, effort and reduces the possibility of error admit in the calculations.

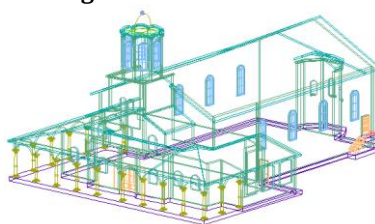
Figure 17. Table value of all walls of a given type

Тен стени	Площа	Еквивалентна площ на обект	Обект
Wall 1	100.36 m²	10.00	100.36
Wall 1	10.25 m²	10.00	102.51
Wall 1	7.91 m²	10.00	108.08
Wall 1	10.91 m²	10.00	109.14
Wall 1	11.02 m²	10.00	110.21
Wall 1	11.89 m²	10.00	118.87
Wall 1	5.05 m²	10.00	55.53
Wall 1	5.03 m²	10.00	50.26
Wall 1	32.05 m²	10.00	308.48
Wall 1	14.69 m²	10.00	146.77
Wall 1	4.03 m²	10.00	40.32
Wall 1	12.45 m²	10.00	124.50
Wall 1	1.70 m²	10.00	17.04
Wall 1	3.51 m²	10.00	35.15
Wall 1	5.38 m²	10.00	53.88
Wall 1	10.00 m²	10.00	100.00
Wall 1	3.50 m²	10.00	35.51
Wall 1	10.04 m²	10.00	100.41
Wall 1	5.79 m²	10.00	57.91
Wall 1	8.75 m²	10.00	87.53
Wall 1	13.05 m²	10.00	130.46
Wall 1	3.05 m²	10.00	30.47
Wall 1	4.98 m²	10.00	49.80
Wall 1	1.57 m²	10.00	15.69
Wall 1	53.58 m²	10.00	535.80
Wall 1	110.73 m²	10.00	1107.27
Wall 1	16.48 m²	10.00	164.81
Wall 1	10.22 m²	10.00	102.18
Wall 1	22.09 m²	10.00	220.97

I. Plot design and export to other formats

The software offers data export to other CAD applications (Fig. 18).

Figure 18. Vector model



V. Conclusions

The main features and benefits of BIM are discussed in the report. The disadvantages accompanying introduction of new software in the design and maintenance of buildings [4] should be noted too. First problems in documenting the final products of built BIM for existing country standards and practices accordingly. Introduction of national standards and libraries for graphics and documenting the final material supporting all design activities for the project. It is important that as BIM software system requires hardware platform with greater possibilities of commonly used at present. There is also a need for time and resources for training and utilization of BIM specialists in design and construction.

In conclusion, the modeling of the considered object and its transformation from a scanned point cloud in semantically enriched object-oriented 3D digital model in Revit software can be summarized that this modern approach of designing gives results in a high precision, detail and reality. It saves time and money, creates a product ready for use and subsequent upgrade by all other professionals working on its reconstruction, restoration, or external repairs and more.

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