3D IN GIS

NAGY Gábor, assistant professor, University of West Hungary, Faculty of Geoinformatics, Department of GIS, ng@geo.info.hu
SZEPES András, associate professor, University of West Hungary, Faculty of Geoinformatics, Department of GIS, a.szepes@geo.info.hu

Abstract: *The laser scanner is an powerful and modern technology of the geodesy survey. The University of West Hungary, Faculty of Geoinformatics has bought an Leica ScanSctation C10 instrument by subsidy, for use this technology in the education and in the research.*

The one of the uses of this new instrument was an survey in downtown of Székesfehérvár. We surveyed an given part of the historical city centre, and processed the recorded data. The work was completed by the teachers and the students of the Faculty.

1. Presentation of the results of the scientific and technical contents

The project was limited to a relatively narrow activity: we aimed to acquire a laser scanner and the software process the measured data.

Nowadays more and more rapid progress being made in all areas of life. This development can not be left out in the field of geodetic surveys, either. This development could not be left out in the field of geodetic surveys, either. One result of this development is the 3D laser scanner. With this instrument we can measure millions of points over a few minutes with the accuracy of conventional geodetic surveys. This large amount of measurement is very efficient and cost effective alternative to conventional processes in building industry and road constructions.

The laser scanner based on its operational system is an instrument which records the spatial location of the object point by measuring distance, horizontal-, and vertical angle, and by processing it in its own coordinate system based on emitted and reflected laser signal. Depending on the settings the density of the measured points (resolution of the measurement) can be varied in a large interval, determined by the given task. This value with 100m object distance can be even 1cm but then the size of point cloud increases rapidly.

The resolution of the instrument can be given to the objects between the minimum (5 m) and maximum (300m) distance. During the surveying it is possible to set, that if the distances are greater than the previously planned not to record, because these values can’t give realistic data anyway.(eg. in case of a 100m distance with 2cm resolution a reflected signal from 300m can’t have better resolution them 5-6cm)

The laser scanner we purchased - the C10 ScanStation ™ - is a compact "all-in-one" system, completely new instrument without any trade-off. This instrument includes the 3d laser scanner, a tilt sensor, batteries, control unit, data storage, video camera, laser plummet.

It has also introduced innovative solutions such as. the new X-Smart Mirror ™ rotating mirrors, which can create in minutes a fully domed recording. Thanks to its extraordinary power of the C10 ScanStation it makes the High-Definition Surveying™ (HDS™) so profitable that makes its use very economycal.

The ScanStation C10 offers range of capabilities of the platform, and the best value in use of a scanner. The user can choose between user-friendly, almost totalstation-like, built in

instrument control and data storage (81 GB HDD), or use of laptop, which provides subsequently more spectacular view, and also rapid on-site processing.

The ScanStation C10 combines the ease of portability and geodetic measures (traverse, freepoint, orientation, etc) in order to the qiuck as possible field work. In addition, the complete (360 º x 270 º) field of vision, high accuracy, high operating range (300% @ M90) and an incredible speed (50,000 points / sec) makes the ScanStation C10 a versatile scanner.

In order to achieve maximum efficiency the mirror responsible for directing laser light cho0se automatically spinning mode for quick and full 360° dome measuring, and oscillating mode for ## measuring just limited areas. Thereby its outstanding that measuring “full dome” it can be done 10 times faster than with the predecessors.

A general 360°or focused scanning, the initiation, station relocating become significantly faster, so we get the transformed point cloud much faster than before. The Smart X-Mirror is also responsible for the camera with auto targeting that allows a fast and accurate point cloud textures. Also the X-Smart Mirror is responsible for the built in camera’s automatic targeting that allows a fast and accurate point cloud textures.

The handling is very simple it is almost identical to the former total stations because of the similar intuitive interface, and color touch screen. This solution allows the gradual development, use of totalstation batteries, and the fewer accessories necessary to buy. This all contribute to reducing the costs dramatically.

Finally it is important to note its compatibility to the general geodetic instruments. Attach handles with Leica GnssS SmartAntenna or prism holder, or use without handle for unobstructed overhead scans. A built-in laser plummet and tribrach mount provide added compatibility with standard field procedures and accessories. [1]

The laser scanner has wide scope. We can fin numerous examples in the field’s literature.

2. Industrial equipment on the point cloud an in the reality

The reconstituted three-dimensional models serve as accurate and attractive basis for geographic information systems, primarily for industrial pipe fittings and installations line or linear installation records.

The laser scanner - such as their names suggest - obtains information by laser emission, about the targeted 3D object position and shape, similar to laser distometer. The instrument defines in its own coordinate system the direction of the beam and its distance by measuring time between the emission and the arrival of the beam.

By diverting the vertical beam thousands of points can be measured every second, and moving in a horizontal plane - up to 360 degrees interval in smaller scale - of the terrain scanning.

Precision servomotors drive the rotation. In order the maximum efficient data recording the scanning procedure controlled and managed by software installed on a laptop. As the outcome of the measure a set of point is created contains millions of points. The measuring range is covered from about two meters to 300 meters, up to 5 mm measurement accuracy. Most of the instruments available on the market can be equipped with high-resolution professional digital camera.

To each point of the point cloud, color information can be related based on photos taken. Thus we get true color -photorealistic- point cloud. Measurements carried out on different stations can be joined to a single local coordinate system by using artificial (reflectors) and natural control points. The resulted model can be walked around. Since the elements of point cloud are logically independent of one another it is impossible or difficult

connect database to them. With post-processing, the spatial three-dimensional objects have to be represented or substituted by TIN or primitives.

For modeling process there is a very broad spectrum of software are available, supports the automatized recognition of simple shapes. Such as fitting cylinder to the point cloud while modeling pipes using mathematical, and statistical operations. [2]

3. Uses of 3d laser scanner in road construction

This new technology can be applied for all phases of road constructing. Before the work begins it is necessary the accurate surveying of the terrain. Both the preliminary and the actual planning process have to be highly accurate and detailed survey, which includes terrain elevation data as well. Using laser survey it is not necessary to visit the targets with prism. Using the 8-50 thousand points collected in every second the contours of the surface or the 3D terrain model can be produced locally. The surveying and the data processing requires just a short period of time, which means high degree of time savings, thus results cost reduction. In case that a need arises to draw a cross section, where it is not previously planned, it is not a problem.

There is a post processing option to produce cross section at any point, which allowed by high dot density. So it is not necessary to repeat the field survey.

4. Reverse Engineering

In many cases there is a need to make technical drawings, models or documentation about already constructed buildings or facilities. The main reason of it that it often turns out during renovation or reconstruction that the original blueprints are missing.

Often there is no time for a full detailed survey, not to mention the costs and the ongoing work in the building which makes the surveying work almost impossible.

The documentation shall include the following elements:

- orthophoto,
- cross-sections,
- 3D point cloud,
- 3D Model
- 3D simulation run in the model space
- panoramic photo,
- 2D CAD drawings
    - combined with visual design
    - cross sections,
- geodetic measurements (angle, distance, volume, surface).

Due to the results of the 3D measurement at hard to reach parts documentation can be prepared even from hard to reach parts where with conventional methods would not be possible.

Built, and completed objects' surveying and 3D modelling. A 3d model made of the measured objects which is therefore suitable for example for additional planning and for making visual planes. Vectorising lines and columns can be easily measured. From the model it is possible to make any required 2d cross section. [3]

5. Measurements of city modelling

Based on the course and experimental measures the basis of a new technology idea has been formulated. The final material can be finalized only after processing a higher amount of measurements. To do this we are planning to calling for TDK and theses, in which student can acquire the usage of this instrument and the data processing methods, based on which the technology description will be finalized. Possible topics of thesis includes surveying Romkert of Fehérvár, surveying an urban church inside and outside, partialy the town square, and a small residential building.

6. Laser scanner survey in downtown of Székesfehérvár

We have surveyed a part of the historical city centre of Székesfehérvár with laser scanner, in a project CT-GUIDE (3D városkalauz projekt – BAROSS_KD_INTEG_07-2008-0062).

The work was done by a Leica ScanStation C10 instrument. The most of the surveys was in 13 march, 2010. We need additional surveys latter, because exist incomplete parts on the point cloud, which was discovered during the processing.

We started the work at 7:00 PM. because this time the traffic in the downtown is not too heavy. The work was started in the square of the town hall, and later contained in the less busy streets of the workspace.

The laser scanner set to point cloud resolution of 10 cm. We didn't select scanning interval, made full survey in each station, because we plan the survey of the full city centre of Székesfehérvár, and we can use this data.

Fig. 1. The workspace of the survey in the ortophoto with the places of stations.

The survey contained several stations. We made measures to HDS targets in every station for the registration of different stations (different model spaces). The laser scanner scanned the neighbourhood of the targets, and the locations of the HDS targets are determinable from the scanned point clouds.

An typical work in a station is this: After the set of the instrument and set the point cloud resolution, the C10 done the scanning and photographing full automatically, during 15-20 minutes. Following this surveys, we observe to the targets. This task needs some contribution from the operator of the laser scanner, because he need point to the HDS targets before the target scanning. The total time of the work in one station was 30-40 minutes.

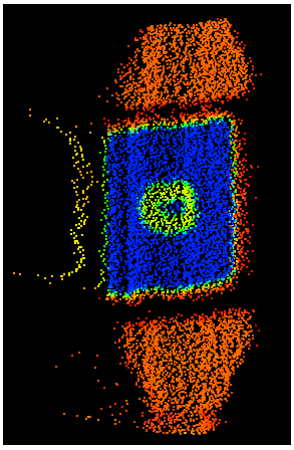

Fig. 2. The point cloud of a target scanning

The Leica ScanStation C10 allows two different methods for control of the survey. We can use the built-in computer of the scanner, or could control the survey by an computer, which connects to the laser scanner. The computer (typically a notebook) runs the Leica Cyclone software, and we control the laser scanner and storage the acquired data in this computer. The user can view the scanner data during the survey in this computer.

We needn't use the services, which are available only the Cyclone software running in an exterior computer. (For example we needn't use the advances limitation functions of measure field, because we survey the total interval.) The duration of the survey was longer than the time of the battery of an typical notebook. Because of this causes, we use the built-in computer of the Leica ScanStation C10 during this survey.

7. The processing of the measurement

We use the Leica Cyclone 7.0 software for processing of the measured data. This program storage the point clouds and other data in databases, which may be in the local computer or an other computer of the network.

Because we work with the built-in computer of the Leica ScanStation C10, the acquired data was in the built-in hard disc of the scanner. The first step we copied the data to an USB mass storage device (for example an flash drive), which was included to the USB connection of the C10. The second step we loaded the data from the USB flash drive to an Cyclone database.

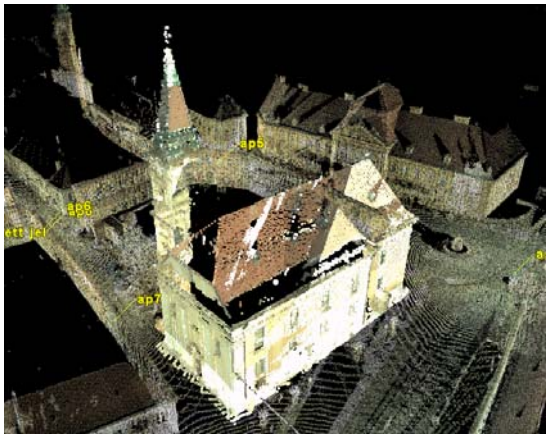

Fig. 3. The segmented point cloud of a building

Some preparation tasks followed the data loading. Applied MultiImages and estimated cloud normals in each station. This processes and the loading of the data need more hours.

The different stations have different ModelSpaces, but we need a joint ModellSpace with each point clouds. We created a Registration in the Cyclone, and added all of the stations. The connection between the ModelSpaces (every station is a ModelSpace) was provided the common targets (HDS targets measured from more station) and the Cloud Constraints, which was calculated from the overlapping parts of the two point clouds. We could make Cloud Constraints with some common picked points, and after the program can align with a process, which need some time.

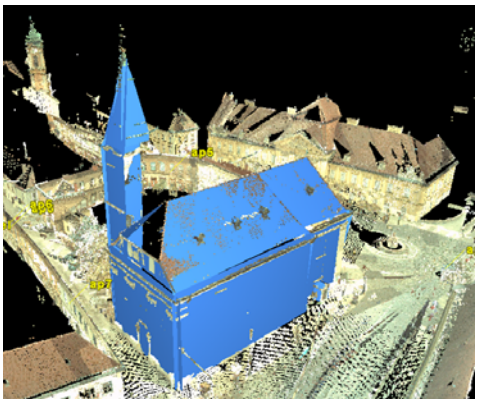

Fig. 4. The model of a building with plane patches

The program can calculate the registration by the Constraints and Cloud Constraints, and the Registration may be freeze to create a ScanWlord. The ScanWorld contains one joint ModelSpace with each point clouds of the stations.

We used various methods for process the point cloud data. The Cyclone can fit plane patch or other surfaces to the parts of the point clouds, which represent walls or roof planes of the buildings. We can make building models in a CAD or 3D modelling software from this surface patches.

We can segment the point cloud to different parts for the different buildings. The Cyclone provide several methods for segment the points clouds. We segmented the point clouds by the vertical location. Switch Top View and Orthographic projection, before draw Polygonal Fence to the building, and segment the point cloud with the Cut by Plane function.

8. Experiences

The registration is available by only the Cloud Constraints (for this work), because of we needn't observe targets, and can save time of the observing and setting the targets.

During the survey of close streets, must set more station; because of in the walls of the buildings have enough points in the cloud. This may be a problem in every case, when the surveyed surface locates in sharp angle from the station.

9. References

1. *http://hds.leica-geosystems.com/en/Leica-ScanStation-C10_79411.htm*
2. *http://www.leica-geosystems.hu/*
3. *http://www.laservision.hu/1_7*
4. *http://hds.leica-geosystems.com/en/Leica-ScanStation-C10_79411.htm*
5. *http://hds.leica-geosystems.com/en/Leica-Cyclone_6515.htm*