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3D modelling using terrestrial Leica C 10 Scanstation

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Abstract: This paper has as goal, beside its educational purpose, the presentation of methods and materials specific for terrestrial laser scanning technology that are in close connection with surveying engineering and have to be used for 3D – and terrain modelling. The value of this paper lies in stressing the importance of the terrestrial 3D laser scanners and the practical applications they have in many domains, such as: historic conservation by means of assessment and monitoring of churches, part of cultural heritage, architecture, land surveying, archaeological studies, bridge structures, assessing the risk of slope instability along transport corridors and highway surveys.

Keywords: 3D modelling, laser scanning, point cloud, scan station.

1. INTRODUCTION

3D modelling (also known as meshing) is the process of developing a mathematical representation of any three-dimensional surface of object via specialized software. The product is called a 3D model.

In the last decade, more and more engineers all over the world started exploring 3D modelling instead of using the traditional two-dimensional drawings.

For instance, designing a dynamic framework for planning and development, based on 3D models can help to create the master plan of any populated area [1].

A 3D model incorporates components, materials, layers that make up a complex structure.

Apart from enabling the visualization of all components of an object, 3D modelling facilitates a separate visualization of the scanned object's parts. The components and the materials have properties called visualization properties such as contrast or albedo that can be easily highlighted.

3D modelling offers multiple advantages, namely correcting heights, interconnecting the object's components, creating a new product based on the primary elements. Thus, the designing process is facilitated together with an effortless manipulation of the complex data.

Terrestrial 3D laser scanners – a new class of survey instruments – have recently become very popular and are increasingly used in providing as-built and modelling data in various applications, including land surveying, mobile mapping, roads/tracks, monitoring, city modelling, facility management, archaeological studies, architecture, cultural heritage conservation, mining, industry,

geology, civil engineering, bridge structures, and highway surveys [2].

The purpose of a 3D scanner is usually to create a point cloud of geometric samples on the surface of the subject. These points can then be used to extrapolate the shape of the subject (a process called reconstruction). Like cameras, 3D scanners have a cone – like field of view and they can only collect information about surfaces that are not obscured. While a camera collects colour information about surfaces within its field of view, 3D scanners collect distance information about surfaces within its field of view. The “picture” produced by a 3D scanner (Figure 1) describes the distance to a surface at each point in the picture, by either the time of-flight method (TOF) or comparison of the transmitted and received wave form of modulated signal. These scanners measure thousands of data points (each point includes distance, angle, and reflected return signal power) per minute and generate a very detailed “point cloud” data set. The point cloud can then be post-processed to create an exceptionally accurate and detailed 3D Computer-Aided Design (CAD) model.

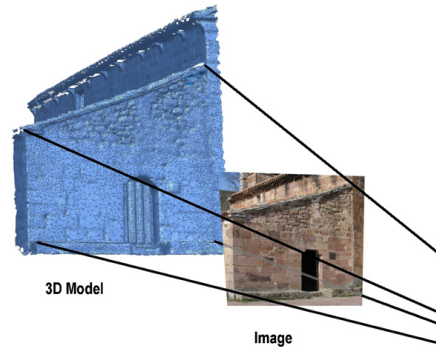


Figure 1 The camera point – projection

Consequently, model information, such as relative angle and length dimensions, can be extracted from the resulting 3D surface CAD model. Some of the data available with 3D laser scanners are difficult or impossible to measure using traditional surveying instruments. Laser scanners provide thousands of times more information than this traditional approach, and field-work time drops dramatically.

For most situations, a single scan will not produce a complete model of the subject. Multiple scans, even hundreds, from many different directions are usually required to obtain information about all sides of the subject. These scans have to be brought in

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a common reference system, a process that is usually called *alignment* or *registration*, and then merged to create a complete model.

Time-based scanners are active scanners that measure a time frame between two events. In general, there are two time-based scanning principles: Pulse based (Time-of-Flight) and Phase based scanners [3].



Figure 2 Commercially available TOF Laser Scanners

In Figure 3 some commercially available phase based scanners are shown. The most widely known companies are: *IQSun*, *Leica*, *Z+F* and *Faro*.



Figure 3 Commercially available Phase based Laser Scanners

2. LEICA C10 SCANSTATION

Leica Geosystems introduced today its fastest and most versatile laser scanning system, the Leica ScanStation C10 (Figure 4). This new high-definition surveying (HDS) scanner is designed to increase surveying productivity and accuracy in both routine surveys and large, complex projects. The Leica ScanStation C10's Smart X-Mirror, which can operate in either oscillating or rotating mode, eliminates the need for double window scans. Capable of scanning up to 50,000 data points per second. By using the ScanStation C10, surveyors can cut field time by 50% or more, enabling them to bid more competitively and increase profit margins [4].



Figure 4 Leica C10 ScanStation

The ScanStation C10 (Figure 5) features a dual-axis compensator, laser plummet, and rotating horizontal turret for quick setup over a known point. It can interface with standard survey accessories such as

TPS batteries, total station prisms, and even the Leica GPS Smart Antenna.

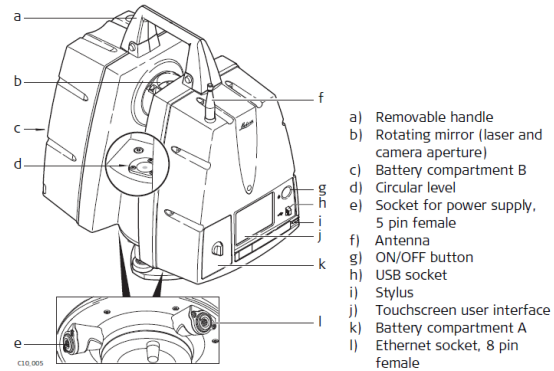


Figure 5 Leica C10 ScanStation components

The scanner has an easy-to-learn, surveyor-friendly onboard interface (Figure 6) with high-resolution, colour touch-screen and integrated, high-resolution zoom camera/vid. A 5M-pixel CMOS digital image sensor captures both single frames and continuous video.

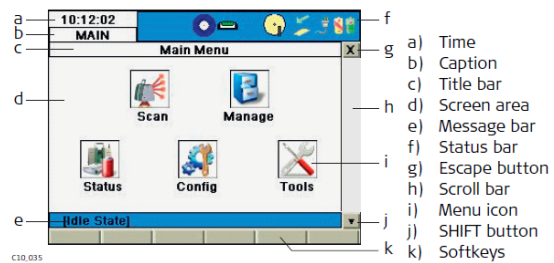


Figure 6 Description of the user interface

The characteristics of Leica ScanStation C10 are the following:

- max 50.000 points/second;
- 130-300 m range (depend the albedo of the surface);
- Leica Smart X-Mirror System, rating or oscillating;
- 270 x 360 degrees field of view;
- TOF (pulse – based) method;
- green color (532 nm);
- for a single measurement, the accuracy is:
 - position - 6 mm,
 - distance - 4 mm,
 - angle (horizontal/vertical)– 12”/12”.

Camera:

- 1920 x 1920 pixels;
- 17 x 17 degrees ;
- Leica Smart X-Mirror System, the opposite side of the laser beam;
- 270 x 360 degrees field of view (Figure 7);
- about 3-4 minutes for a full panoramic view (230 images).

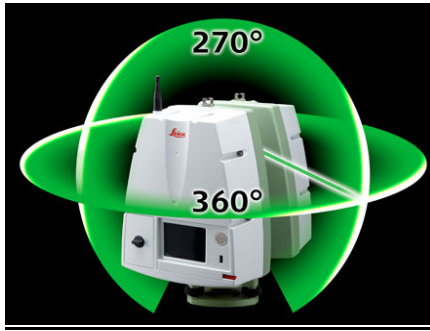


Figure 7 Field of view

Targets: when scanning an object using terrestrial Leica C10 ScanStation for creating its 3D model, two types of targets can be used (Figure 8).



Figure 8 Circular planar target (6") and square planar target (3"x3")

3. CYCLONE SOFTWARE

After the scanning phase, the data obtained needs to be processed. This can be done by means of the Cyclone software.

The software (Figure 9) lets users automatically register scans together via inexpensive black-and-white paper targets, without the need to label scan targets. This not only eliminates any need to use uniquely labelled scan targets, but it also eliminates a time-consuming and often error-prone office process of reading target labels from scan data, manually typing these labels into the registration software, and then searching for and fixing any labelling errors. By using this new "position-based" target registration instead of label-based registration, users can achieve tighter registrations, faster.



Figure 9 Cyclone software used for modelling

Cyclone is Leica Geosystems HDS software composed of several modules, including Cyclone – SCAN, Cyclone – REGISTER, Cyclone – MODEL, Cyclone – PUBLISHER, Cloud Worx for MicroStation, Cyclone II TOPO, Cyclone-VIEWER Pro, and other modules, that stores all data (control points, LiDAR point clouds, and photos) in a database file with extension .imp.

Cyclone 7.1 also:

- supports registered scan data sets from ScanStation C10 that have been automatically registered in the field using C10 firmware v2.0's "Known-point setup" and "Backsighting" capabilities
- directly supports pcE data formats in the Cyclone SERVER module
- features products for use with Microsoft certification of all Cyclone Windows 7
- allows direct data export from Cyclone to Leica CloudWorx-VR for 3D Studio Max etc.

To start working with the scan data in the Leica Cyclone software, a connection between the scan database containing the scan data and Cyclone is required. In order to obtain the 3D model, a new database has to be created in Cyclone Navigator then, in this database the "Multi images" command should be applied, to colour the point clouds. Through the registration operation, the scans from different stations can be brought in a common reference system and then merged to create a complete model.

The Cyclone software uses the term "Scan World" for each scanner setup, meaning a new physical position and orientation of the scanner.

4. METHODS OF ACQUIRING AND PROCESSING THE DATA

Laser scanning survey performed with Leica C10 ScanStation may be divided into three phases: planning, scanning and registration and QA/QC (Quality Assurance / Quality Control). Only the scanning phase is required to be performed in the field. Thus, laser scanning survey generally reduces field time, but the office post-processing time is generally increased [5].

In the **planning phase** several objectives have to be considered:

- *the project requirements* – surface measurements instead of individual point measurements, 3D deliverable, complex surface structure, data record that can be used by a multi – disciplinary team for different purposes,
- *the project limits,*
- *the scope of work* – preparing a 3 D model.

Having in mind the objectives described above, one has to determine:

- *the number of scanning stations* – to guarantee a maximum coverage and accuracy while minimizing the number of setups and the appearance of low intersection angles,
- *the scanner station locations,*
- *the number of the targets,*
- *the type of targets* that are going to be used for a particular project (3" and 6" HDS targets),
- *target locations* (to be visible from the scanning stations).

When developing the scanner setup and control locations, the following issues should be taken into account: the scanner instrument's field of view (270 x 360 degrees), practical scan range (130 – 300 m), any blockage of line-of-sight to key features and control targets due to buildings, structures, and vegetation and also a weather forecast check (rain, fog etc.).

Scanning phase work includes setup and break down of the hardware.

In the **registration and QA/QC** (Quality Assurance / Quality Control) **phase**, the specialist has to download the data obtained in the scanning process and use the Cyclone software for the 3D modelling.

5. CONCLUSION

3D modelling permits the exportation of the data to different programs that are specialized on a certain field of activity, for example: designing, spatial and urban planning, tourism, real estates, security etc.

Among the benefits of 3D scanning with Leica C10 Scan Station, we mention:

- opportunity of real image acquisition with very realistic 3D models, that are applied in a large variety of fields;
- less time for field work, more time for data processing;
- less cost than airborne technologies on small – and moderate – size reaches;
- the scanner minimizes the probability of unscanned zones due to shadowing effect of roughness elements and overhanging zones due to proximity to the target and the possibility of scanning from different angles and overlapping the scanning results.

The 3D models can be used for publicity purposes as they are accessible and easy to understand because of the force of the visual impact.

6. ACKNOWLEDGEMENT

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