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APPLICATION OF LASER SCANNER FOR COLLECTION OF DATA ON VARIOUS SIZE OBJECTS

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This paper shows areas of implementation of airborne laser scanning (LIDAR), terrestrial scanners and submillimetre scanners. Basic components of scanning systems, possibility of data logging and processing are also presented. This paper shows examples of products which can be deliverable to customers.

Introduction

Modern laser scanning techniques enable logging data about various size objects. They enable scanning of whole towns, railroads, power lines and the other linear objects by use of LIDAR systems. Big areas can be scanned with the aid of terrestrial topographic scanners. Industrial objects, industrial installations and devices, engineering objects are scanned by terrestrial laser scanners (TLS) designed to engineers tasks. This type of scanners are also used for documentation of architectural monuments, sculptures and the other objects where high object geometry is necessary. Another group of scanners include submillimetre scanners for high resolution and high accuracy scanning of small objects. Each of these technologies has its advantages, restrictions and characteristic possibility of data processing for customers.

Principle of laser scanners operation (excluding some submillimetre scanners) is quite similar to the one of no-mirror range-finders applied in tacheometers. There are both, scanners based on pulse range measurement (e.g. Trimble GX, Leica HDS 3000 and other) and scanners based on the phase difference method with modulating wavelengths (e.g. Z+F Imager 5006, Leica HDS 6000). The difference between these methods in the speed of data collection. Results of scanning measurement are recorded as clouds of points with 3D coordinate (X, Y, Z) for each point. Additionally laser scanners register power of reflected return signal from objects. Measured quantity of this signal is registered as integer value, that could be displayed as greyscale of points.

Airborne lasers

Airborne lasers LIDAR (Light Detection and Ranging) are quite new and dynamic developing technology of data collection about terrain surface. Even though it needs professional equipment for measurement and lot of free space on the data banks for data register, LIDAR gets more and more customers. It results from the possibility of making various analyses based on obtained data and on the speed of complete data collection.

At present there are several LIDAR systems characterized with different parameters like density of point clouds, scanner parameters or accuracy.

Airborne laser scanning system has two segments: aerial segment and ground segment.

Aerial segment includes:

- long-range laser scanner;
- Global Positioning System (GPS);
- Inertial Navigation System (INS);
- forward- and down-looking video cameras;
- two high-resolution, calibrated digital cameras;
- register data module;
- fly control system.

Ground system includes:

- ground reference GPS stations;
- software for data processing.



Photos: upper left: FLI-MAP components prepared to assemble on airfield; upper right: system prepared for work; down left: assembling control module on helicopter; down right: ground reference station;
 Source: *Materials of "DEPHOS" and "FUGRO" company*

Benefits of laser scanning

- high speed of data collection;
- no control points in corridor;
- low weather dependency;
- flexible operation;
- direct 3D coordinates (X,Y,Z) of terrain and objects;
- high accuracy;
- high density ;
- penetration of vegetation surface;
- synchronization with digital images of high resolution;
- synchronization with registered video image;
- low investments data processing.

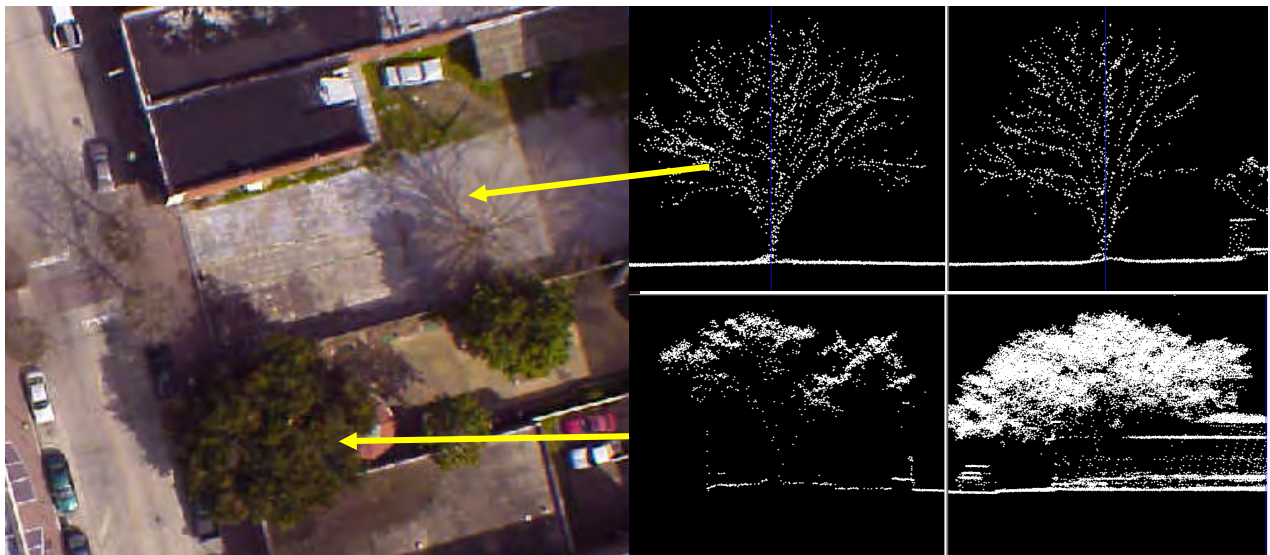


Fig.1: Vegetation influence on point clouds. (Source: Materials of “DEPHOS” and “FUGRO” company)

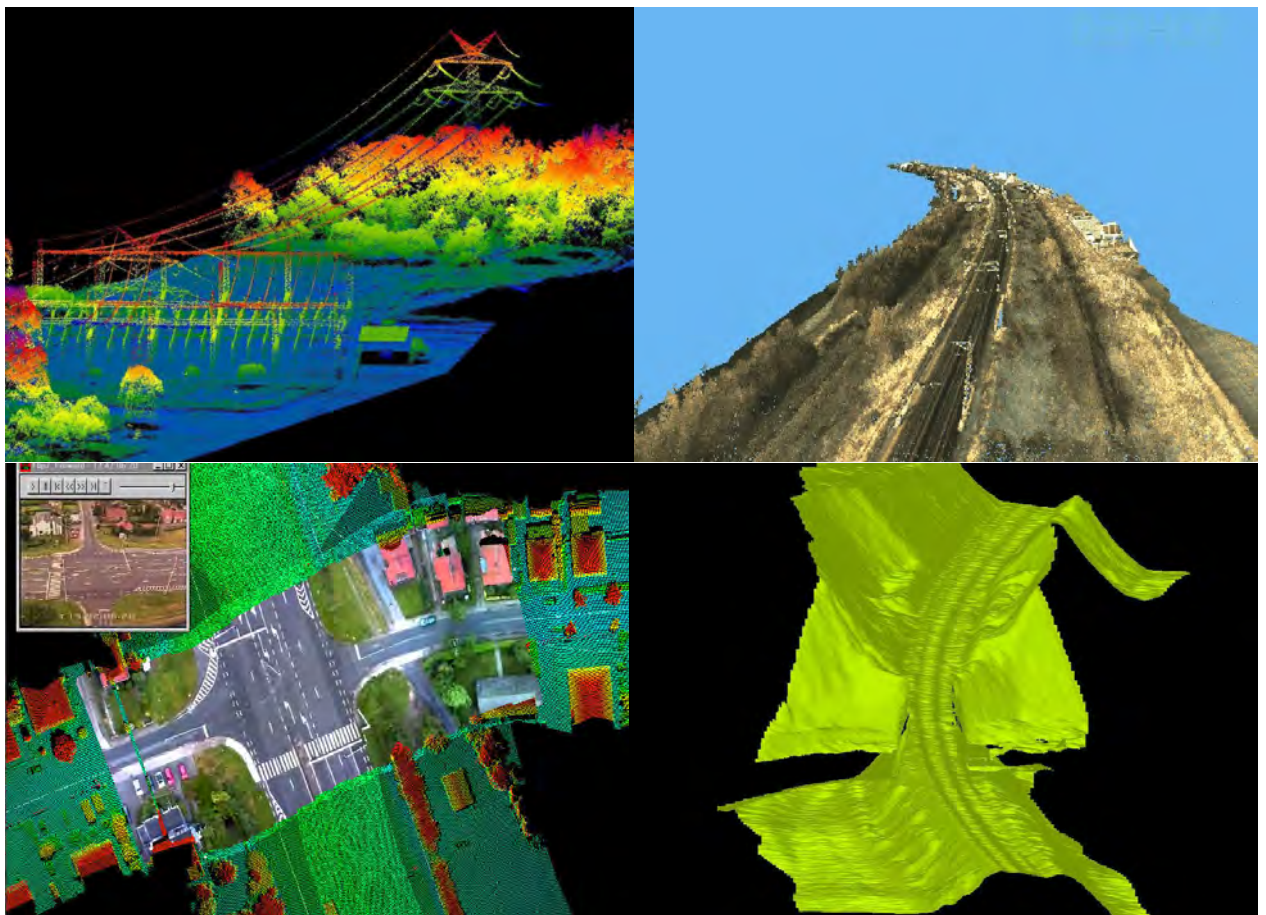


Figure 2: upper left: Power lines documentations (hipsometric view), upper right: railroads documentation (colored point cloud), down right: integration of various data types, down left: visualization of Digital Terrain Model (DTM)

Source: Materials of “DEPHOS” and “FUGRO” company

LIDAR technique is successively implemented for various measurements:

- 3D models of urban area;
- designing and monitoring of roads and highways;
- designing and monitoring of railroads and related objects;

- management of natural resources;
- geomorphology process monitoring;
- studies about flood threats, and monitoring of hydraulic engineering objects;
- seaside zone monitoring and seaside zone dynamic change analysis;
- strip mine monitoring;
- determination of range of telecommunication antennas ;
- high voltage power lines monitoring;
- and the others.

Products:

The following documents may be based on data collected by the LIDAR systems:

- plans;
- ortophotomaps;
- profiles in any location and any direction;
- digital terrain models (DTM);
- digital surface models (DSM),
- 3D models;
- visualizations of objects.

Data from airborne laser scanning may be also applied as source to make various analysis depending on customers requirements.

One of the major assets of airborne laser scanning is completely data acquisition from the whole registered area, and thus the possibility of making analyses and documents in any location, without need for making additional surveys.

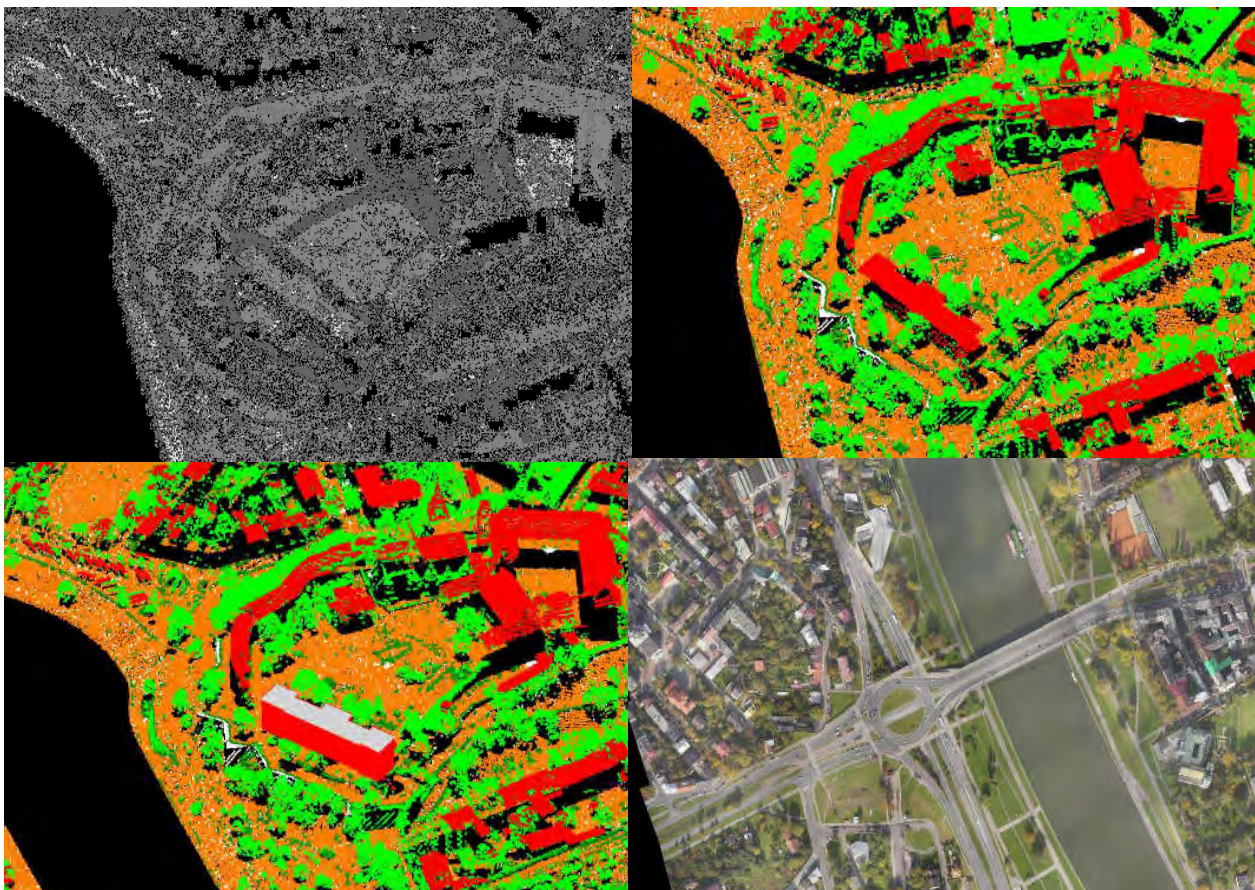


Figure 3: upper left: Wawel Hill – point cloud; upper right: Wawel Hill – object classification; down left: Wawel Hill – modeling; down right: the Grunwaldzki Bridge – orthophotoplan.

Source: Materials of “DEPHOS” company

Terrestrial Laser Scanners (TSL) for engineering use

Due to specification of work and way of data acquisition, terrestrial laser scanners for engineering use can be divided into two main groups:

- scanners with pulse range measurement;
- scanners based on the phase difference method with modulating wavelengths.

Scanners with pulse range measurement are characterized by longer range of work (up to 300 meters), while scanners based on the phase difference method with modulating wavelengths up to 70 meters). However scanners based on the phase difference method with modulating wavelengths are quicker (acquire up to 500 000 points per second, e.g. Z+F Imager 5006) then scanners with pulse range measurement (acquire up to 5 000 points per second, e.g. Trimble GX 200).

Choice scanner type depends on object characteristic that is going to be developed. It depends on wideness of object, its geometry or availability as well as required accuracy parameters.

The area of terrestrial application of laser scanning is very wide, and together with popularity of this measurement technique acquires new domains of implementation. It should be noticed that it is quite new, developing technology and possibilities of its application in many areas is in the stage of research.

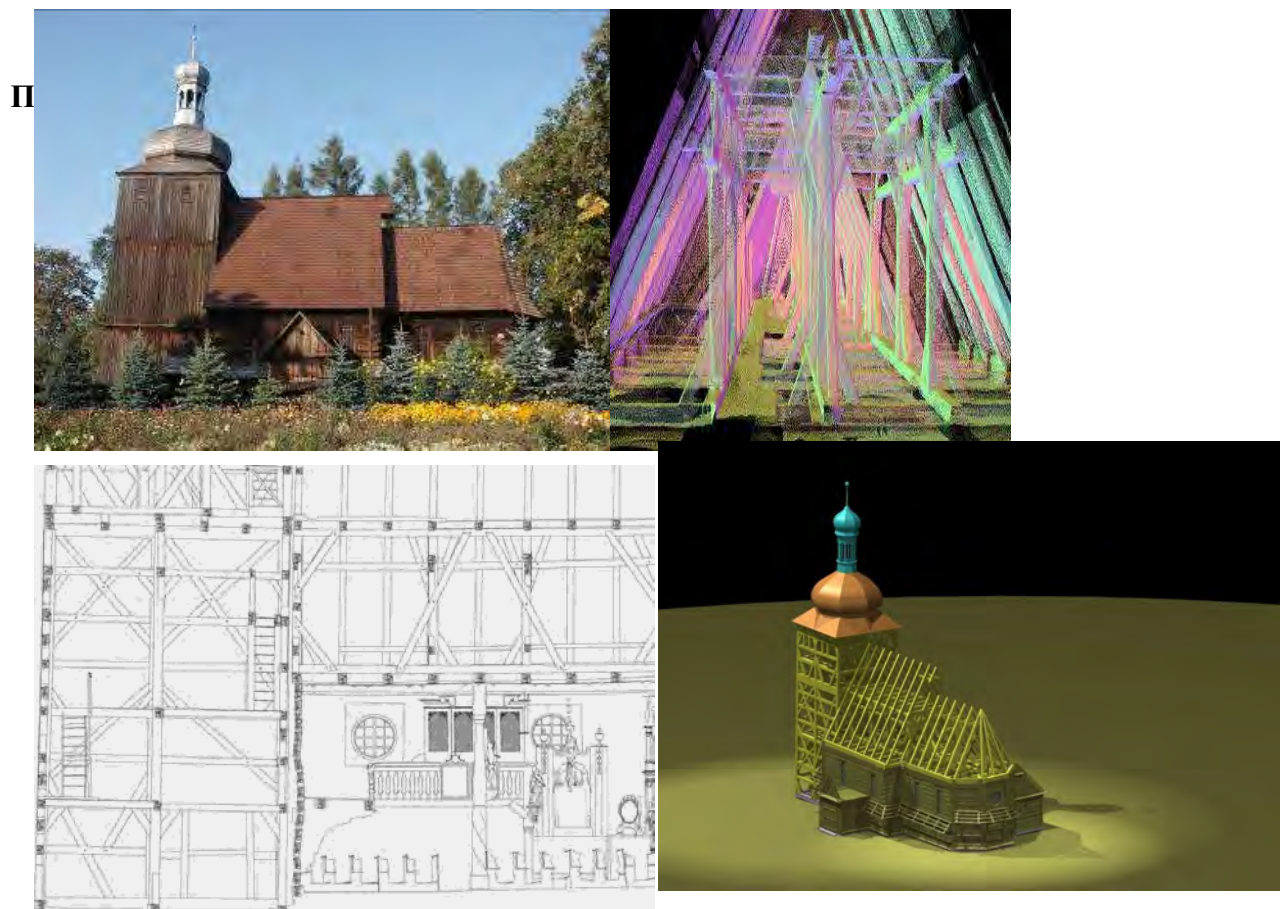


Figure 4: Old wooden church in Michallice: upper left: illustrative picture, upper right: scan of rafter flaming, down left: cross-section, down right: 3D CAD model;

Source: Materials of "DEPHOS" company

Terrestrial laser scanners are implemented in the following areas:

- inventory measurements of various type on industrial objects;
- buildings measurements;
- inventory of monument objects;

- archeology discoveries documentation;
- deformation objects analysis;
- crime scenes and accidents scenes documentation;
- and many others.

As the result of processing of data from terrestrial laser scanning, the following final products may be obtained:

- filtered and orientated point clouds (e.g. in ASCII format);
- grayscale orthophotoplans generated from point clouds;
- 3D surface vector models;
- plans, sections, views;
- contour lines models of surface;
- hypsometric models of surface;
- visualizations of deformation;
- 3D object models.

Submillimetre scanners

Third type of scanners, with increasing application allow to acquire point clouds with density and accuracy about 50 micrometer. This accuracy allow to prepare high precision documentation of museum collections, archaeology discoveries and industrial products quality control. Some restriction is their low operation range, from a few to tens centimetres, which makes scanning of big objects very strenuous and time-consuming procedure.

Due to way of acquisition data, submillimetre scanners can be divided into three groups:

- scanners with pulse range measurement;
- monochrome light scanners;
- white light scanners.

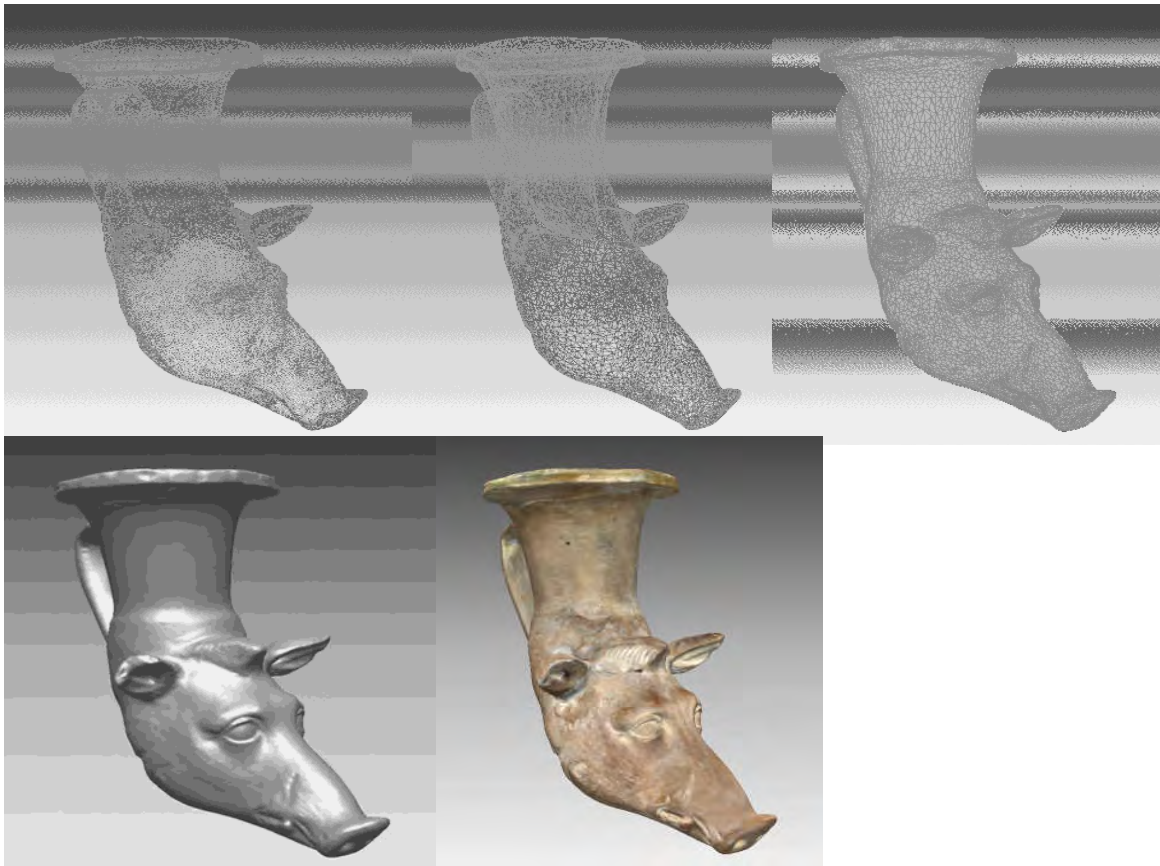


Figure 5. Example of stages of data processing for small objects – object from Museum Palace at Wilanow

Source: Materials of “DEPHOS” company

Applications:

- verification of compatibility with blueprint;
- industrial products control;
- small objects documentation;
- small objects 3D modelling;
- others.

Stages of processing

- data collection – scanning, taking digital photos;
- data processing – filtration, join point clouds, refilling data deficiencies;
- obtaining model of object in complete point cloud;
- make TIN object surface model;
- texturing 3D model.

Summary

Technology of laser scanning is dynamically developing domain of measurement and documentation of different kind objects. In many cases, when laser scanners become cheaper and more popular, they will replace standard surveys. Advantage of laser scanning is its speed of data acquisition, density of information, and high technically advanced data processing. This parameters allow adjust final product to expectations of customer.

Depending on size of analyzed objects and accuracy requirements, there is possibility to apply airborne laser scanner (LIDAR), terrestrial laser scanners for engineering tasks or submillimetre scanners.

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