ASPECTS REGARDING 3D LASER SCANNING SURVEYS FOR ROAD DESIGN

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Abstract. This paper aims to present implementation of modern land survey using unconventional technologies namely 3D scanning technology and the advantages of its use in her area of terrestrial communication ways. 3D scanning provides a closer perspective to reality on the Earth's surface. Development of technologies for collecting and processing information currently allows achieving lifelike models as spectacular as it is useful. Currently 3D scanning technique is pervasive in most areas but especially in engineering for modeling of land surfaces, roads, urban space etc.

Keywords: 3D scanner, GPS, TIN, kinematic surveys, communication lines

INTRODUCTION

As is known one of the the important stages, in the design of terrestrial communication lines is to achieve a topographical support namely obtaining a more faithful modelto the real situation on the ground in digital format so as to be used by the design software for roads and railways.

In this context, this paper aims to present some methods for topographic survey using unconventional technologies namely, 3D scanning technology and the advantages of its use in the area of terrestrial communication lines.

Surveying instruments have seen a major development in the last two decades, primarily due to the technical developments in electronics and computer industry. Classical equipment and technology were replaced by electronic devices (total stations with EDM (Electronic Distance Measurement), GPS receivers (Global Positioning System), portable data collectors, automatic laser levels) and unconventional technologies. In addition to this rapidly evolving hardware elements has been made significant leaps in tools and software solutions for surveying. Technological development has enabled the surveyor access to new tools to complete the surveying work (surveying, area and volume calculations, preparation of plans, stakeout etc.) in a much shorter time with high accuracy and even with reduced costs. But, with few exceptions, these new technologies did not changed methodology, algorithm of work or good practice of the surveyor.

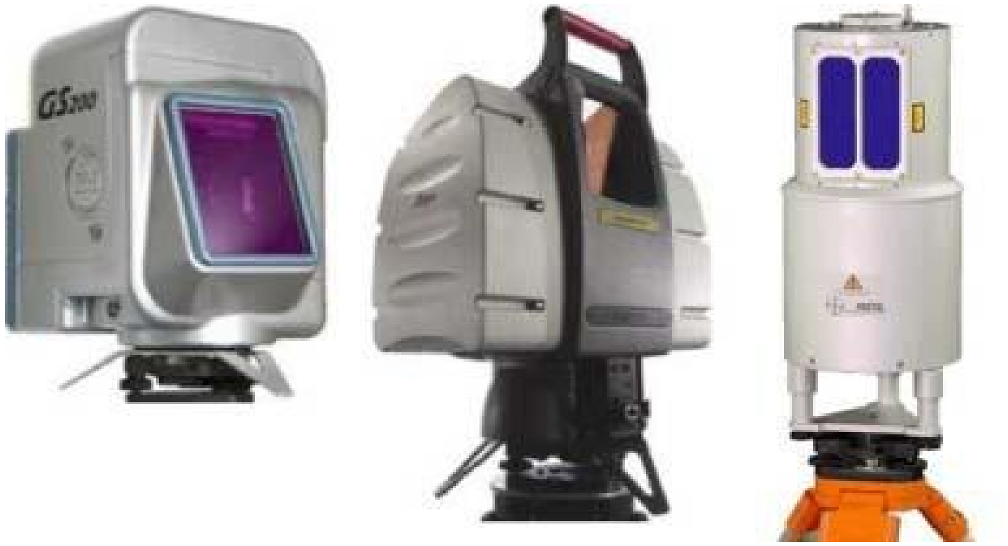
MATERIAL AND METHOD

Terrestrial 3D scanning is a relatively new technique used in surveying. There is a wide range of laser scanning systems, but the technique used for topographyc-geodesic measurements is of type "time-of-flight" or "laser range finding." In geodetic and land surveying measurement, 3D scanners can be used stationary or mobile.

Stationary 3D scanners

Scanning principle "time-of-flight" assumes a laser diode that sends a pulsed laser beam to the scanned object. Pulsed laser beam moving through a slit rapidly changing its horizontal and the vertical angle by means of movable mirrors from inside the instrument. Pulse is reflected diffusely from the surface of the object and a part of it comes back to the receiver. The time required for beam movement from the laser diode to the surface of the object and back is measured with high precision. Knowing the speed of light, and measured time , we can calculate the distance from the scanner to the object, also known vertical orientation and angle of each beam, so that the position of each point can be calculated where the beam was reflected.

The scan result is a set of digital data which is in essence a thick " point cloud" in which, each point is represented by relative coordinates X, Y and Z, in relation to the position of the scanner and the intensity of the reflected light beam. These points are specific points that define the objects in the field. From data obtained can be determined and analyzed the three-dimensional shape of any object in the environment. Very large and



complex objects can be scanned from several positions.

Fig. 1 - Three models of stationary 3D scanners, left to right:
Mens GS200, Leica (Cyrax) HDS3000, Riegl LMS Z210

Most software used for data processing allow stacking observations from multiple station points in a single point cloud. In this way, areas that could not be scanned from a point station are filled with scans from next station points.

The figure below shows the digital image of a point cloud consisting of 781 970 points corresponding to a scanned intersection. Since the intensity of each point in the cloud is mapped to the spatial position, the operator can easily differentiate the different area while viewing the three-dimensional design.

The most important advantage of this method is that it can be obtained a high density of points with an accuracy of 5 to 10 mm. This method allows to increase detail distance of about 200 meters in ideal conditions. The method is also very fast: a full scan at 360 ° can be achieved in less than 5 minutes depending on the scanner model used. Laser scanner is mounted on regular topographical a tripod and operated with a laptop that is used also to store the measured data. Most of the software used to operate the scanner allows the user to georeference the scanned data (X, Y, Z) in a local or global reference system. After georeferencing is achieved the point cloud for of the area.

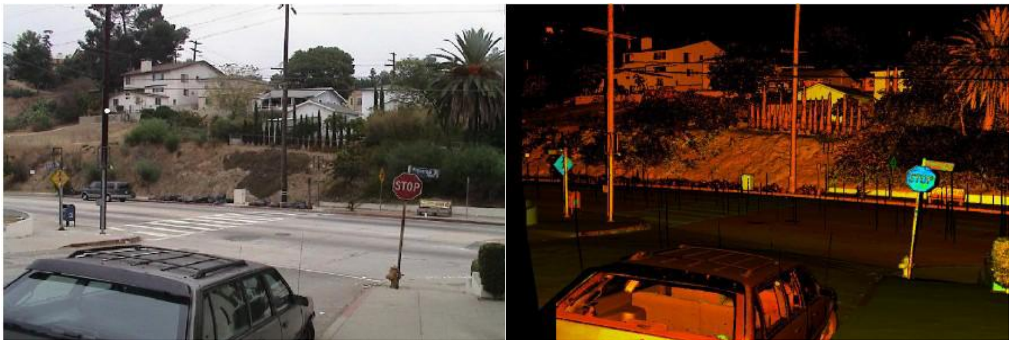


Fig. 2 - Picture of a crossroads and the correspondent point cloud
[Charles M. Coiner, Anthony P. Bruno-3D Laser Scanning for Common Surveying Applications]

Mobile 3D scanners

The construction and rehabilitation works for a road or railway requires reliable topographic surveys. Due to increasing traffic or degradation, the responsible authorities are required to pay special attention to the management and maintenance to ensure: traffic capacity, safety and comfort in traffic. Implementation of maintenance works creates negative influences (traffic jams, etc.) on the traffic is necessary to minimize these. Another drawback is the large amount of surveying required for designing these works.

To meet new challenges cinematic 3D scanning offers the possibility of precise topographic surveys. By applying mobile scanning technology time is relatively short, the effort to raise the necessary details for the rehabilitation of roads and railways is minimal, while the traffic is not significantly affected. This approach reduces both the costs and the risks posed to operators.

To meet all requirements for the accuracy and diversity of the recorded data, mobile 3D scanners are used in combination with other recording devices such as photogrammetric cameras, accelerometers, GPS receivers. All these equipments are mounted together on a mobile platform that can be a road vehicle, railway vehicle, aircraft and more recently with new developments in the miniaturization on drone or UAV (Unmanned Aerial Vehicle).

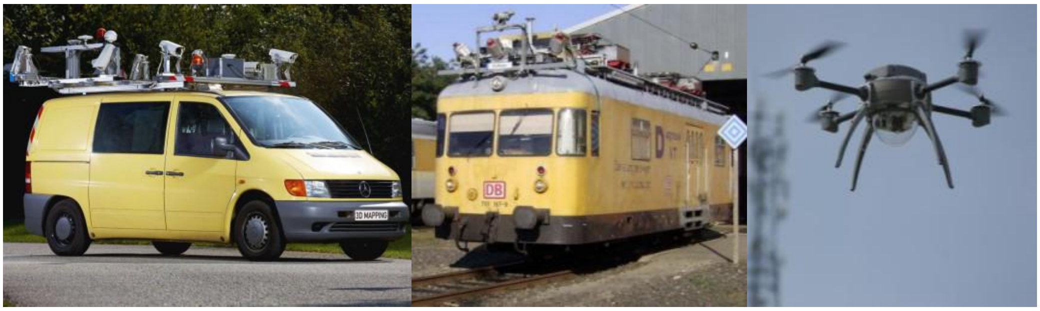


Fig. 3 - mobile scanning systems, from left to right:
Moses, Rail Mapper, MicroDrone

Mobile road mapping system (MOSES)

MOSES was designed as a multi-sensor measuring vehicle to capture all relevant road or rail details in a cost effective manner without obstructing traffic (Figure 3a) [Gräfe 2007]. The system was designed by the company 3D Mapping Solutions GmbH. MOSES combine measuring sensors with complementary features. Stereo-photogrammetric cameras and a number of 3D laser scanners are mounted together on a calibrated measuring platform. Multisensor devices cover a measured corridor of a width of up to 20m each part along the traveled path. External orientation for georeferencing collected data by all sensors is provided by a combined system, wich include IMU (Innertial Measuring Unit), DGPS (Differential Global Positioning System) and high precision odometer. Reliability and stability of trajectory module are the key ability of MOSES to serve high-precision applications [Gräfe 2007]. The system architecture is modular, so that it can be adjusted to various tasks using a variety of sensor configurations. Maximum coverage road corridor sensor is guaranteed by a variable number of cameras for documentation and photogrammetric measurement purposes, combined with laser scanners.

Fig. 4 - Example of "point cloud" obtained from a kinematic scan in Munich
[Kinematic 3D Laser Scanning for Road or Railway Construction Surveys – G.GRÄFE]

Laser scanner module combines two dimensional scanners with trajectory module. Prerequisite for kinematic laser scanning applications is that the scanner is able to operate in profiling mode. Scanners are mounted perpendicular to the direction of travel and thoughtful calibrated. Orientation scanners is flexible, so the field of view of 360 °. They also can be used as the fixed 3D scanners. The main feature of modern laser scanning is the enormous density of measured points combined with a measurement resolution of less than 1 mm. The frequency of profile in running direction varies depending on the speed of travel. At a speed of 10 meters per second, the average width of a road can be obtained up to 10,000 points per square meter. The following examples show the scanning capabilities of the kinematics system. Figures 4 contain images of 3D point cloud resulting from a demonstration in the center of Munich. Modern software packages enable operators to work effectively within these results, raw data, which may contain point numbers in the millions.

CONCLUSIONS

Kinematic scans with precision laser scanners open a number of new applications in the design and execution of communication lines. The quality of the results obtained so far by scientists and engineers around the world has been shown in normal working conditions.

Regarding the benefits of this technology, in addition to high speed data acquisition, high precision measurements and high resolution data collected are obvious, and also include minimizing the inconveniences during the works, reducing the risks exposed operators who work in traffic and many other related advantages.

Unfortunately, like any innovative technology, there are some drawbacks, mainly related to the cost of implementation and the lack of specialized personnel, but the disadvantages will disappear over time.

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