BASIC PRINCIPLES AND USE OF LIDAR DATA

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Abstract *– Nowadays there are a lot of methods for obtaining information about the objects on the Earth surface. The special importance is on accuracy and reliability of this information. One of the active remote sensing methods which allow obtaining very accurate data about the Earth surface is LIDAR. LIDAR is usable in different areas and is an accepted method for data acquisition. This article examines the basic principles of LIDAR and the possibilities of utilization of this technology.*

Key words – LIDAR, laser scanning, DMR, DPZ, modeling

INTRODUCTION

The concept of LIDAR is an acronym of the English words "Light Detection And Ranging". In some literature, it is possible to meet even the acronym ALS (Airborne Laser Scanning) indicating the airborne laser scanning. It's a technology operating on the same principle as radar. However, instead of radio waves to gain information about objects using light radiation. It is therefore a method of active remote sensing (RS), based on the measurement of the distance between the object and studied alone with LIDAR, most often placed on aircraft, helicopters or drones. Since it is an active remote sensing method, it can be used to gain information during the night. Unlike radar, data acquisition through LIDAR is not possible during high cloud, rain or heavy fog.

HISTORY

The beginnings of LIDAR technology dates back to the 60s of the last century and are associated with the invention of the laser. At that time it was used mainly terrestrial LIDAR with static location, to monitor atmospheric and meteorological phenomena. Currently, LIDAR is a powerful tool for weather observations throughout the world (eg for Climate Change Research).

The use of ALS systems for the purpose of collecting topographic data started until 1980 and for commercial purposes has been introduced since the mid-90s. Development of ALS systems is associated with the introduction of GPS (Global Positioning System). Today, technology has had LIDAR widely used in various fields such as: hydrology, construction, forestry and the like.

LIDAR SYSTEMS DIFFERENTIATION

There are several types of ALS. Select type depends on the possibilities of its use and the specific needs of the project. Depending on the location of the device itself, it is possible to allocate two basic types: aerial and terrestrial LIDAR [2]. These can be further broken down - see the following figure.

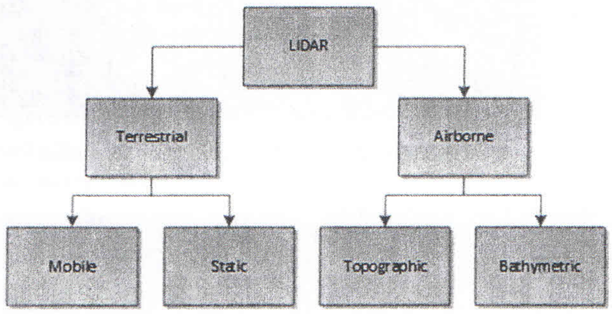

Figure 1 – Basic LIDAR typology

ALS, usually located on the aircraft or helicopters, can be divided into bathymetric and topographic. Topographic used primarily for modeling over terrain and can be used in various fields such as forestry, hydrology, geomorphology, etc. Bathymetric LIDAR systems are characterized by the fact that under appropriate conditions, can penetrate a portion of the water column. It can be modeled as the day of reservoirs, etc. Penetration depth depends mainly on the degree of turbidity of water and its flow. Most bathymetric LIDAR systems operating in two parts of the electromagnetic spectrum. The infrared spectrum is used to monitor the water surface. Green spectrum is characterized by excellent penetration and is used to monitor the bottom of water bodies. Combined topographic and bathymetric LIDAR systems placed on air carriers are often used to monitor coastal areas [3].

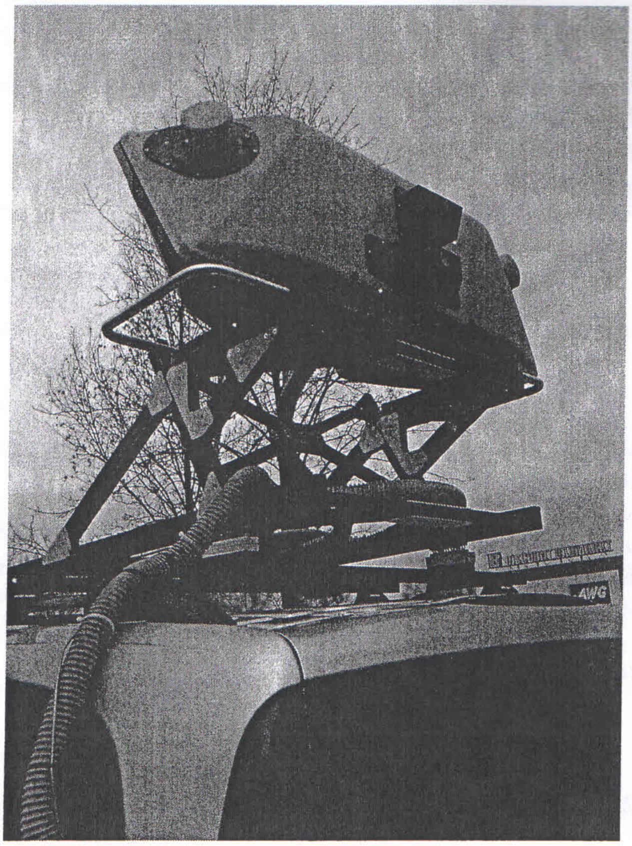

Figure 2 – Mobile lidar (photo by author)

Terrestrial LIDAR can provide very accurate data characterized by a high density of points. Thus enabling the creation of accurate, realistic 3D representation of roads, buildings, bridges, dams. They can be either mobile or static. Mobile LIDAR dwell placed on moving media, such as cars, trains, ships eventually. The design of these systems is similar to that of air LIDAR. They can be used for example to analyze road infrastructure, monitoring of potholes on roads, and the like. Still LIDAR systems consist of collecting information from a static location (tripod). They can be used outdoors as well as indoors. Commonly used in mining, archeology, but also in other areas. The next section of the text we will deal mainly air LIDAR [3].

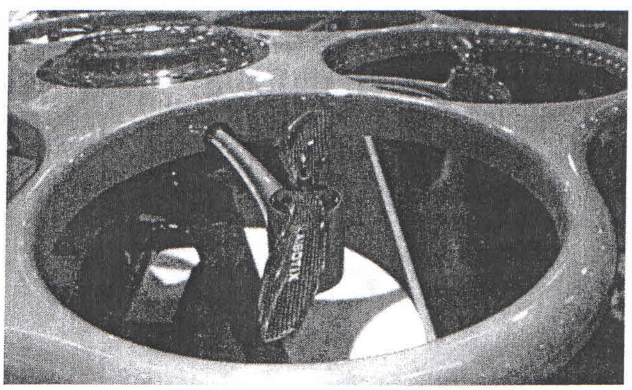

Figure 3 – Drone – a modern technology of lidar a photogrammetry data acquisition (photo by author)

PRINCIPLE OF OPERATION

The construction of LIDAR consists of laser, optical and mechanical system, the detector of the reflected electromagnetic radiation and precision clock measuring the time between sending a beam and capturing them through the detector. LIDAR units placed on mobile carriers (airplanes, satellites, cars, etc..) require the device to determine the exact position of the vehicle and its orientation. For this purpose are used GPS and IMU (Inertial Measurement Unit).

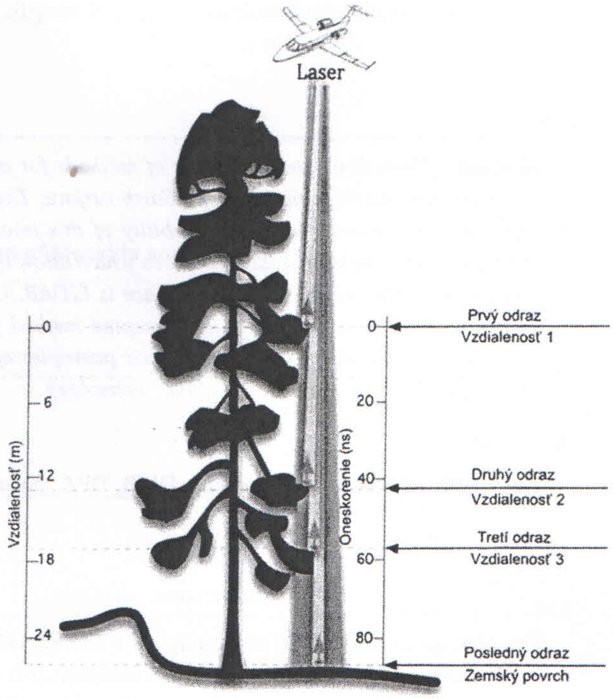

Figure 4 – Basic principle of lidar data acquisition (source: http://ucanr.org)

The basis of the system itself consists of a laser, which is a source of laser radiation. There is now a large variety of laser devices. Their use is dependent on both the power and also the wavelength at which the laser operates. LIDAR can operate in the ultraviolet, visible, infrared and infrared - the proximal portion of the spectrum. For some laser devices can be done to complete the conversion from one wavelength to another. In these cases it is necessary to carry out a set of electromagnetic radiation detector to enable them to radiation in the part of the spectrum capture. Lasers in LIDAR s work mostly in pulse mode [4].

LIDAR principle is quite simple. The optical system focuses the laser pulse generated by a very narrow beam. This beam is then deflected by a mechanical device across the line of flight of the carrier. Shift of the beam in the longitudinal direction ensure the movement of the carrier. After sending a light pulse computer records the time of posting. Together with the time of posting shall be recorded and information about the position and orientation of the vehicle and also the angle of the beam mechanical systems. Beam reflected from objects on the Earth's surface (vegetation, buildings, surface ..) is recorded by the detector and the time of arrival and intensity of the reflection. From the above data and knowledge of the speed of light is finally possible to determine the position and height of the point at which there was a loss [1].

One of emitted laser pulse can return to the detector as well as multiple reflections. Width of the beam incident on the earth's surface can reach several tens of centimeters (depending on the altitude of the carrier). Therefore, there are still a fact that the beam reflected from a number of different objects. First reflections captured taking with it usually represents the highest element of the surface, such as the top of the building. Recent reflections captured the detector is characterized majority of the ground [2].

The process of obtaining data from LIDAR is a network of highly accurate georeferenced points (cloud points) representing objects located in space. This data is prior to actual use for a specific purpose, yet necessary process. For this purpose, various methods are used filtering and classification.

USE OF LIDAR DATA

According to the preceding text, LIDAR technology is currently widely used. Is primarily used for production of high-precision digital elevation model (DEM), which can then be utilized in various fields. Besides high accuracy due to the high density of scanned points, the immense advantage of the possibility of application of this technology in forested areas. Small width of the beam emitted from the laser makes the assumption that a certain portion of the beam is able to penetrate well below the treetops. This can be used to obtain information about the terrain under forest cover. Digital elevation model, characterized by high precision, can be of great use for example in modeling of environmental processes (hydrological modeling, erosion modeling)[4].

***Figure 5** – Digital elefation model (DEM) obtained by LIDAR (source: http://web.cs.swarthmore.edu)*

Repeat the same area scanned by LIDAR can be applied to produce highly accurate differential models. DEM created at different times give the opportunity to examine the changes that have occurred in the area of interest for a certain period of time. Thus, it is possible to evaluate the intensity of erosion processes such as the area, monitor changes building, quarrying, carrying sediment, or even to evaluate the changes of snow cover, which can be of great benefit to modeling rainfall-runoff processes in the catchment area [1].

Another possibility of using LIDAR is the creation of 3D models of buildings. Process to detect the points representing the building separated from the building points representing the surface of the ground or other objects in the space (trees, roads, etc..). , A relatively comprehensive problem dealt with a range of publications, such as: [5], [6].

LIDAR has a wide area of application in forestry, where it is possible to use multiple reflection beam emitted from LIDAR and get information such as the amount of vegetation, leaf area or canopy structure. Represents a contribution to forest management, forest inventory (monitoring vegetation characteristics), or in the planning of technical operations in forests (logging planning, silviculture activities) .

As already mentioned in the preceding text , LIDAR has a wide application in the field of hydrology. Bathymetric LIDAR systems allow, under certain conditions pass water column and get information about the terrain contained underwater. In addition, accurate DEM obtained from LIDAR is suitable input for modeling floodplains using hydrodynamic models or to generate drainage networks for rainfall - runoff modeling .

In addition to the above-mentioned possibilities LIDAR applications, the technology is also used in other areas , such as: agriculture, geology, mapping over power lines, road infrastructure mapping, mapping leaks, mapping of natural resources and the like .

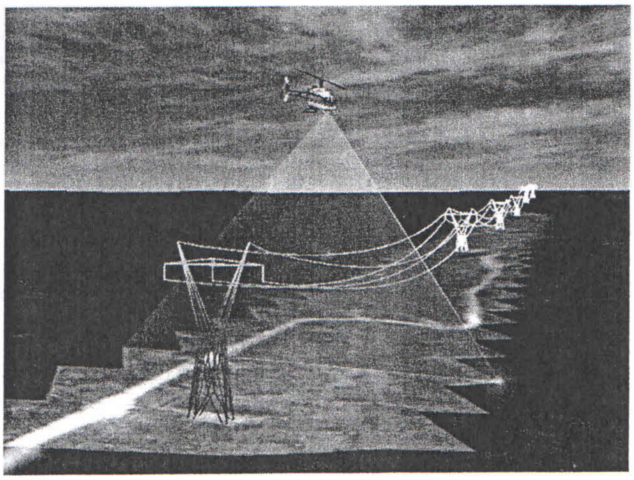

***Figure 6** – Corridor mapping principle (source: http://www.geoinformatics.com)*

PROS AND CONS OF LIDAR TECHNOLOGY

Laser scanning technology provides over other methods of obtaining spatial information several advantages. This is particularly the following benefits:

- High level of accuracy - high density of points (up to a few points per m2) to simulate the course of terrain with high precision (vertical accuracy of ± 15 cm)
- The ability to scan large areas in a relatively short time

- Ability to provide detailed information on the vertical distribution of vegetation
- Data can be obtained even at night
- Detection of ground surface in forested areas

The main drawbacks of this technology are:

- Inability to pass through very dense vegetation
- Very much data-intensive processing
- A relatively high price
- Inability to obtain data during high cloud, rain or heavy fog

Conclusions

LIDAR is a relatively new, rapidly evolving technology that has a wide application in various disciplines and sectors. Data collected by LIDAR provide high reliability and accuracy, which will be in the future with improving the technology has increased. Despite some limitations to LIDAR major assumptions of the future for its further use and development.

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