FULL-WAVEFORM LIDAR DATA

BASIC PRINCIPLES AND PRACTICE

Mgr. Miroslav Holubec
YMS, a. s., Hornopotočná 1, 917 01 Trnava, Slovensko
miroslav.holubec@yms.sk

Ing. Peter Bobáľ, Ph.D.
YMS, a. s., Hornopotočná 1, 917 01 Trnava, Slovensko
peter.bobal@yms.sk

Abstract – *Nowadays, LIDAR is one of the most progressive methods for spatial data acquisition. This technology goes through the rapid development from its formation, which brings the quality improvement and more possibilities of using the data. Oldies discrete laser scanners are replaced with full-waveform scanners, which represent different, more sophisticated way for spatial data acquisition. This article examines the possibility of use and the basis principles of full-waveform scanners.*

Key words – LIDAR, Laser Scanning, remote sensing, Full-waveform

INTRODUCTION

LIDAR (Light Detection and Ranging) is an active remote sensing method, which finds application in various fields and disciplines. It is a technology similar to radar, but that the collection of information instead of radio waves using laser beams. LIDAR principle consists in measuring the distance between the laser scanner frequently placed not on board the aircraft and researched object. The results of these measurements are called. "3D point cloud" representing objects in space.

Collecting data via LIDAR provides over other methods of benefits. The biggest advantage is the high level of accuracy, where the resulting data may contain up to several geo-referenced points per m2. Vertical accuracy of the readings achieves ± 15 cm. In addition, this technology allows for data collection during the night and shoot the ground surface in forested areas, which is a big advantage compared with photogrammetric methods.

The first aerial LIDAR-s systems for commercial applications have emerged in the 90s of the last century. It was a discreet laser systems that are technologically capable of capturing either as a discrete reflected beam or the first and last beam reflected from the subject. Since the early 21 century began to use commercial lidar systems allowing capture up to 5 reflections on the one posted pulse.

In recent years, come to the fore a new generation of so-called full-waveform (FW) laser scanners. Historically, the first FW lidar system was created already in the 80s of the last century for the purpose of monitoring areas of water bathymetry. In 1999, NASA developed the first operating system called FW LVIS (Laser Vegetation Imaging Sensor). It was created for the purpose of mapping the vegetation cover and also also had the potential for monitoring ground surface located under the vegetation. The first FW lidar system for commercial purposes was introduced in 2004, which was associated with the development of laser devices with narrow track beam. This allows to record pulses with high sampling rate (typically 1 GHz). By now, most companies engaged in the technology of LIDAR (Riegl, Leica, Toposys, ...) provides a system for recording the entire course of the reflected signal.

FULL-WAVEFORM LIDAR

Compared to discrete laser system, FW scanner can record the whole course of the reflected signal as a function of time. Based on these data can subsequently be obtained in addition to 3D point clouds and additional and more detailed information on the structure of the scanned surface. This is the width (range) of the reflected pulse and amplitude. Amplitude provides information on the intensity reflectivity of the target object. Varies depending on the radiometric and geometric characteristics of the subject. Beam Echo is an indicator of inequality and inclination sensing surface and can be used for example to distinguish vegetation from buildings. This additional information will provide end users more control over the process of interpretation of measured data. Principle FW liadrových systems following figure (Figure 1).

FULL-WAVEFORM DATA MANIPULATION

Processiing of FW lidar data allows users to manage the process of extraction points and makes it more efficient. Currently, the most widespread strategy of processing full-waveform lidar data is the decomposition of the set of components and to characterize different objects captured by a laser beam. The aim of this approach is to extract 3D point clouds with the greatest density and accuracy.

One of the most common method of this type is gaussovká decomposition. Allows FW lidar data as a set of Gaussian functions, making it possible to determine the amplitude and width of each echo. In various studies indicate that its use can lead to good results only in 98% of cases FW lidar data. There are different implementations Gaussian decomposition, which vary depending on the algorithm used for transforming the data to the file FW Gaussian functions.

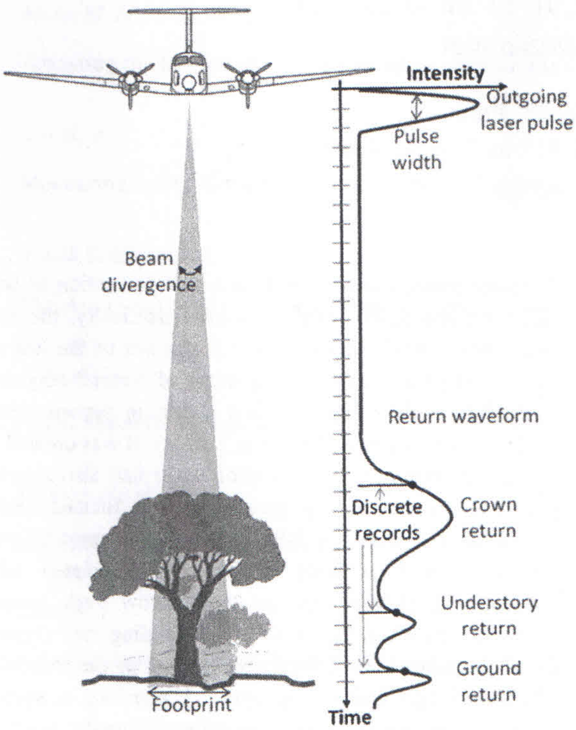

Figure 1 - *Principle of lidar imaging (source: www.imagingnotes.com)*

Another part of the processing lidar data is their classification , at which the points are classified into several categories (landscape, buildings, low vegetation, high vegetation, etc.). Points can be classified on the basis of height ratios on the point, according to the intensity reflectivity, depending on the direction of inclination of neighboring points etc. In most cases, first performed is automatic data classification. There is a large variety of classification algorithms. Their use depends on the specific objectives of the project . Later, in the case of misclassified points in the automatic classification can be performed manually using the correct classification . It should be noted that the classification process in order to achieve higher-quality data can be time-consuming and requires a considerable amount of supporting data. Either it is already on existing data or can be obtained during the actual scanning .

USE OF FULL-WAVEFORM DATA

FW LIDAR provides benefits primarily for applications that require the detection and differentiation of vertical objects. To capture the whole course of the reflected beam provides more detailed information on the vertical structure of the monitoring area. Close the laser beam incident on the surface (about 0.3 to 1 m at an altitude of 1 km) turn allows vertical objects differ from each other.

FW lidar technology finds application mainly in forestry applications in order to provide the most detailed description of the structure of vegetation. There are many treatments for FW data to estimate the characteristics of the forest. Their influences range as the size of the monitored area, forest type, level of leaf area , etc.

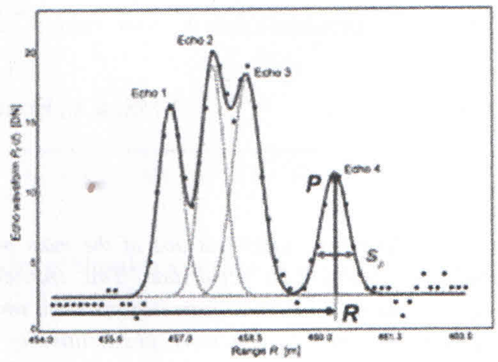

Figure 2 – *Typical full-waveform curve (source: http://geo.tuwien.ac.at/)*

FW Lidar is characterized by narrow beam footprint and high density of trapped points allows modeling of vegetation with higher accuracy. However, also requires more time for mapping of the study area, as opposed to a wide track lidar beam. FW lidar laser beams with a narrow track can penetrate through the treetops and reach the ground. It is essential to measure the height of trees. The ratio between the number of reflections from the surface and from vegetation depends on the level of leaf area and the density of the cloud of points. The ability of laser beams penetrate the canopy LIDAR gives the possibility to model the course of terrain and in wooded areas. The resulting digital terrain model can then be used as the modeling of environmental processes (hydrological modeling, erosion modeling) . In addition, FW LDAR is suitable to determine the width of the treetops, canopy structure, classification trees by species or to estimate their other specific characteristics. Information on species composition and vegetation structure are then fed as for planning, monitoring and evaluation of the risks of changes in forested areas .

When using FW lidar data in built-up areas is seldom an increase in the density of points obtained in comparison with discrete LIDAR. Compared vegetation, laser beams pass through surfaces such as roads or buildings. Multiple reflections can occur, especially at the corners of buildings. Use of FW lidar in built-up areas is based mainly on the ability to distinguish buildings from vegetation, ground surface and possibly other kinds of objects.

CONCLUSION

The commercial potential of full waveform lidar systems is large, as demonstrated by several studies. There is still only to improve these systems, but also to the creation of new applications, methods and software products, so that it is possible to extract from the data obtained the best possible information. Currently these software products is still fairly expensive, but the prospects of the development of more open-source products that will be useful for processing purposes FW data.

Also important is the question of storage and management of huge amounts of data (big data), which full-waveform lidar systems recorded during the recording process.

References

[1] DOLANSKÝ, Tomáš. Lidary a letecké laserové skenování. Ústí nad Labem: Univerzita J. E. Purkyně, 2004. ISBN 80-7044-575-0. Available from: http://wvc.pf.jcu.cz/ki/data/files/160lidaryweb.pdf

[2] National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center. Lidar 101: An Introduction to Lidar Technology, Data, and Applications. Charleston,: SC: NOAA Coastal Services Center, 2012. Available from: http://csc.noaa.gov/digitalcoast/_/pdf/lidar101.pdf

[3] WANG, Jun; Jie SHAN. Segmentation of lidar point clouds for building extraction. In: ASPRS 2009 Annual Conference. Baltimore, 2009. Available from: http://www.asprs.org/a/publications/proceedings/baltimore09/0101.pdf

ACKNOWLEDGEMENT:

This paper is published as one of the scientific outputs of the project supported by EU: „**Broker Centre of Air Transport for Transfer of Technology and Knowledge into Transport and Transport Infrastructure**" ITMS 26220220156

Operačný program VÝSKUM a VÝVOJ

Európska únia