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Laser radar – LIDAR utilization for 3D data acquisition

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Abstract

This article aims at 3D data acquisition by scanning. It describes a device located in a unique workplace of the University of Zilina – University Science Park**. It is a mobile laser LIDAR designed for** 3D data acquisition. First part of the article reveals information about the history of LIDAR device utilization, as well as its first commercial use. Nowadays, there are many kinds of LIDAR on the market, depending on a type. The potential of the equipment is mainly in its very precise output that can be used in different branches. Transport is certainly one of the most interesting ones, but also terrain surfaces mapping both inside and outside municipalities. That is why its utility potential is huge in these areas.

Keywords: LIDAR, screening, topography

Introduction

Beginning of surface and area scanning dates back to 1970, when the first moon screenings were used with the technology based on laser ray use. The expression LIDAR was derived from words "light" and "radar". Later on, the scanning entered a period when the basis was created by „light radar ", its aim being the surface scanning. Today the expression LIDAR stands for Light Detection and Ranging. It is the most modern form of sensor technology used mainly in data collection in a given area, or specific objects. Until the mid-nineties, LIDAR served only as a scanner for individual altitudinal elevation and objects. During the second half of the nineties, the precise GPS system was integrated to LIDAR that brought a revolution in scanning area. Nowadays, it is applied in various branches and science disciplines, where the objective is to detect the examined surface as precisely as possible, considering negative impacts during the scanning. The measured data acquired from LIDAR can be used in many applications, for example during road, railway and airport constructions, but also in international pipelines or gas line constructions. [1][2]. Also, this progressive technology is very often used for height data collection such as measuring and registering the purpose of topographic 3D surfaces mapping for space modelling.

Figure 1 – LIDAR [8]

Measuring Principle

LIDAR is an advanced technology using three basic lights:

- Ultraviolet
- Visible
- Infrared

The device radiates light on scanned object where a part of light is absorbed by the given object, and a certain part of this light is reflected back depending on the surrounding environment. The LIDAR consists of four basic parts:

- Precise calibrator with laser ray and precision from 400 to 1300 nm.
- Scanner with supplementary optics.
- Receiver, e.g. photodetector.
- For GPS system position and description determination [1].

As for given object scanning and speed, many scanning systems exist for display image acquisition. There are four existing basic scanning systems for image acquisition:

- Moveable mirror
- Rotational mirror
- Nutational mirror
- Fixed optical scanner

The photodetector serves as a detector of electro-magnetic radiance. During a real-time visualisation, the photon incident at photo detector causes a signal, which aims at amplifier, or is brought into the amplifier. Thus the change appears from the current signal to voltage one. In the final phase, it is transmitted to digital one that is treated by numeric circuit afterwards. Navigation system is a very important part of LIDAR, as its greatest functionality is used mainly by mobile scanning device. The GPS system utility is important mainly in real environment portrayal, or more precisely in topographic terrain mapping. Multiple detection is used in individual object´s height detection, which enables a precise determination of scanning object model in further modelling or backgrounds´ creation.

Measurement Methods

There are many types of LIDAR on the market that differ from each other in dependence on type. Data needed for image acquisition can be gained from:

- Aviation.
- Terrestrial.

In the picture number 2, there is a basic principle of data acquisition described during the aviation screening. The device placed in aircraft transmits a ray towards a measured object. The chronometer is also activated during ray transmission, measuring the time needed for ray to return back to the measured object after reflection. The speed of light is known together with total time from transmission to accepting the information. We are then able to calculate the distance. As mentioned above, for precise position determination of measured point, the combination of global navigation system (GNSS) is used together with equipment that determines precise position and speed of the aircraft (IMU). Not having the combination of this information would make it impossible to determine the precise position of the plane in a moment of transmission and accepting the laser ray, calculating thus the position of measured point. Calculating the distance based on time needed for light to achieve the destination, and back in combination with precise GNSS and IMU data, enables to localize the measured points with precision of 10-15cm in both horizontal and vertical direction. Scanning is very fast and in one second the device measures 200 000 points. It can fly from 300 to 5000 meters during the aircraft surface scanning. In this height there is a guarantee of a very precise measurement in detail [5].

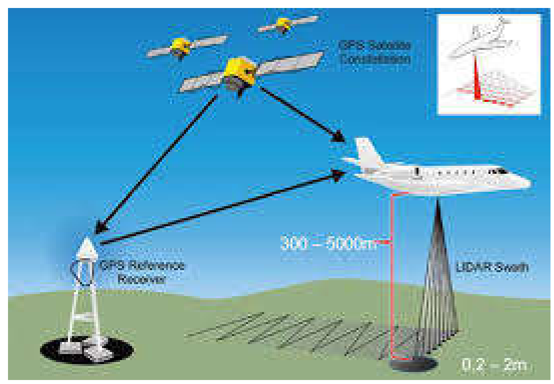

Figure 2 – Aircraft Scanning [3]

Terrestrial measuring can be done with some transport equipment or without (car) (figure 3). Measuring without the transport equipment is used mainly in detailed infrastructure screening. Terrestrial mobile measuring is used mainly in object scanning **or small segments of a country. The aircraft scanning is used for large areas and object complex scanning that is hardly accessible from the surface.**

Figure 3 – Car Scanning [4]

Therefore, the University Science Park as a unique workplace of the University of Zilina owns a mobile laser LIDAR used for 3D data acquisition. Its specifications are:

- **64 Channels**
- **120m range**
- **2.2 Million Points per Second**
- **360° Horizontal FOV**
- **26.8° Vertical FOV**
- **0.08° angular resolution (azimuth)**
- **<2cm accuracy**
- **~0.4° Vertical Resolution**
- **User selectable frame rate**

This radar is constructed for autonomous car navigation, mapping, examination, industrial automatization and many other ways of use. This mobile technology for research and development of information mobile systems is used for collection, analysis and evaluation of anonymous data based on GPS axis. This is determined by data collected thanks to mobile devices. Various situation evaluations are possible in terms of migration. Open platform enables analytic assignment administration over the collected data. It is also possible to create a combination of mobile terrestrial and aircraft scanning with highly modernized wireless quadcopter with accessories where various kinds of scanners can be placed together. The space has been made for full creation of images and post processing in practice so that the highest requests for a model creation for customers would be met. In case of further data elaboration, another possibility is open for research area from the point of view of information-communication technologies, with a possibility to use this data in technically advanced data centre of USP UNIZA.

Conclusion

LIDAR device has a huge potential in various transport assignments and urbanization as well. Its greatest advantage compared to photogrammetry is in possibilities of relief point detection as well as in forested areas.

Its speed in combination with high density of laser scanning brings a big potential. Data acquired from the device is used in visualisations which are later imported into the form of digital surface model or into the 3D building models and other objects. Having these results will make it possible to continue with another research and elaboration of examined subjects. The obtained data will enable to create a large space for another possible use. We can acquire some unique outputs that can be linked with other USP UNIZA equipment. This equipment will have important potential on both Slovak and foreign market.

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References

[1] LIDAR-UK, Blue sky International Limited, Online, Available: http://www.lidar-uk.com/.

[2] Course Outline – Lidar: History of Lidar Development. Geography, College of Earth and Mineral Sciences, Online, Available: https://www.e-education.psu.edu/lidar/l1_p4.html

[3] Lidar pořizovaní 3D dat, Online, Available: https://www.google.sk/search?q=lidar+skenovanie+zo+vzduchu+a+zeme&client=firefox-b&biw=1536&bih=755&source=lnms&tbm=isch&sa=X&ved=0ahUKEwji7oDp_ZzNAhWDGRQKHR2tB_IQ_AUIBigB#tbm=isch&q=3d+lidar+na+lietadle&imgrc=_SV1lDkjXBHsgM%3A

[4] Baidu-Autonomous-Car, Online, Available: http://ww1.prweb.com/prfiles/2016/01/15/13

214814/MOD-92968_Baidu-Autonomous-Car-Dec2015.jpg
[5] Lidar přizovaní 3D dat Online, Available: https://is.muni.cz/el/1421/podzim2012/AEA_73/Tencer__LiDAR__Porizovani_3D_dat.pdf
[6] Výsledky LiDAR prieskumu vo Vrátnej v časopise LiDAR NEWS Online, Available: http://www.yms.sk/press-1/clanky/vysledky-lidar-prieskumu-vo-vratnej-v-casopise-lidar-news.html
[7] 3D segmentation of single trees exploiting full waveform LIDAR data Online, Available: http://www.sciencedirect.com/science/article/pii/S0924271609000495
[8] Velodyne LiDAR Online, Available: http://velodynelidar.com/hdl-64e.html