UDK – 528.88(474.334.2)

A. CELMS[1], I. REKE[1], V. PUKITE[1], P. KOLODIY[2], J. LUKSA[1]

[1] Latvia University of Life Sciences and Technologies, armands.celms@llu.lv;
[2] Lviv National University of Agriculture in Dublany

POSIBILITIES OF USE OF REMOTE SENSING TECHNOLOGIES IN THE CASTLE ISLAND MEASURING PROCESS IN JELGAVA

New technologies come into area of surveying more rapidly. By them work can be done safer, faster and in more interesting way and one of the newest technologies is laser scanning, result of which is point cloud, from which diverse three-dimensional models can be created. By combining photogrammetry and laser scanning methods, it is possible to obtain many-sided digital material of high quality, which is used for purposes of designing, project supervision, thus people's work is facilitated and made easier, in particular in places, which have difficult access or access can be life-threatening. The digital material, in this case relief model, allows performing above-mentioned activities remotely. For the achievement of the aim, following tasks were set: to study the available information on historical development of photogrammetry and laser scanning and principles of functioning of them; to research, analyse and describe strategy and program of sustainable development of Jelgava City; to analyse the situation of the planned Northern Flyover; to obtain spatial data for location of the planned Northern Flyover; to perform spatial data processing.

Key words: laser scanning, relief model, photo visualization

Introduction

Already long ago, humanity was interested in the shape of the Earth. Best we can look to it from satellite images. These images give visual insight into shape, relief of the Earth, location of diverse objects. As well as new technologies come into the branch of land surveying more rapidly. Work can be done by them safer, faster and in more interesting way. One of the newest technologies is laser scanning, result of which is cloud of points, from which we can form diverse three-dimensional models. By combination of photogrammetric and laser scanning methods, it is possible to obtain many-sided digital material of high quality, which can be used for purposes of designing, project supervision, thus making people's work easier, in particular in places, which have difficult access or access can be life-threatening. The digital material, in this case relief model, allows performing above-mentioned activities remotely.

As territory of creation of relief model, the northern part of Jelgava City – place, where it is planned to perform construction of new transport corridor over Lielupe River is selected. Aim of the publication is to consider creation of relief model for the territory in the northern part of Jelgava City. For the achievement of the aim, following tasks were set: to study the available information on historical development of photogrammetry and laser scanning and principles of functioning of them; to research, analyse and describe strategy and program of sustainable development of Jelgava City; to analyse the situation of the planned Northern Flyover; to obtain spatial data for location of the planned Northern Flyover; to perform spatial data processing.

Materials and Methods

Remote sensing is obtaining of information on object or phenomenon without physical contact with object to be studied contrary to field studies. In present understanding, remote sensing is connected with application of aviation sensor technologies in order to detect and classify objects on surface of the Earth, in atmosphere and in oceans, by use of electromagnetic radiation emitted from satellite, aircraft and then reflected and accrued from the object or diffused Sun light. The instruments used are usually installed on the satellites, planes or unmanned aircrafts. Remote sensing as branch of science studies data processing methods, by which from the image obtained from the instrument, it is possible to obtain the useful information [http://virac.eu/petnieciba/petniecibas-virzieni/talizpete/tradicijas/].

Data processing methods of remote sensing are gradually developed for several decades, still the practical application is often difficult. In countless potential application spheres, remote sensing data are not used in practice due to hard to interpret results. For obtaining of useful, practically usable results, it is optimal, if in the study, remote sensing experts, which know all nuances of image processing methods, and experts of other natural sciences, which know end application branches, cooperate.

Laser scanner uses laser light, in order to estimate distances from the sensor to the object systematically. Aspect of measurement of distance – range depends on laser light, in order to carry out this measurement. Measurements of measurement range are obtained in such way, that strongly collimated laser energy, i.e., light is deflected in diverse directions.

In order to measure the distance between the sensor system and target, diverse principles can be used. They

differ with accuracy, but all have justification for certain range. The greater range can be checked, by use of impulse flow time measurement principle, obtaining cm accuracy. Shorter distances, for example, up to 100 m, by phased measurement method can be carried out faster and more precise. Diverse range principles are described in details by "impulse back and forth", also aspects, which concern all laser range principles, included.

Accuracy of distance depends mainly on accuracy of time measurement and precision of determination of back reflection. Under favourable conditions, it can reach cm accuracy, but for distances that are greater than 1 km, accuracy is sooner several centimetres. Increase of accuracy can be achieved, if measurements are performed repeatedly several times. Increase of range and accuracy can be achieved by increasing the radiated power, by increasing signal and noise ratio. However, systematic errors prevent high accuracy with this technique. When using in air, laser scanners can fly up to height of three or even five kilometres.

In order to obtain greater accuracy with laser scanning, the range is not determined directly, but by angular measurements. In triangular laser scanner, laser energy is expanded, in order to form plane, not light. With help of rotating shooter, this plane is put through space of the object. For one plane position – one angle of mirror, the crossing of plane with surfaces in the space of object goes back in one curve or several curves. Object space in the same time is depicted with lens on the plane of image. Image covers whole view. It can be obtained, for example, by calculating differences of two images. The first image is image without laser plane. The second image covers laser light curves. Curves of image plane form package of rays, which connect map of curves with projection centre. This crossing of node and laser energy plane gives place of points in the space of objects. This scanning method is restricted, because interdisciplinary quality decreases with range. This means that distance from emitter to camera field cannot be made too large. Therefore, scanners of this type are restricted with range of one or several metres. Accuracy usually is better than ± 1 mm. The described method measures not one point, but sequence of points along laser light curves in the objects in question. After several seconds, all field of vision can be scanned. Number of points depends on resolution of camera [Pfeifer Norbert, Briese Christian, 2007].

In order to be able to carry out tasks set by remote sensing, rather large technical support is necessary. Firstly, unmanned aircraft with camera is necessary, with help of which photo images are taken. They are processed and photo visualization is created. Likewise, unmanned aircraft with laser scanner is necessary, in order to be able to carry out scanning and to prepare relief model from the data obtained.

As relief model territory, opening territory of the planned Northern Bridge was selected. It was justified by necessity of construction of complementary infrastructure object – bridge, in order to reduce intensity of traffic in the central part of Jelgava City by redirecting freight transport to roundabout, thus also the technical condition of the main ways of the city is improved, also linkage between cargo carriers and producers is improved. The only bridge across Lielupe and Driksa, which connects both parts of the city, is situated on the main street of the city and is very loaded. Construction of Northern Bridge will encourage development of territories owned of municipality in the northern part of the city at the former aerodrome [Jelgavas pilsētas ilgtermiņa attīstības stratēģija, 2007].

Flyover (bridge) across Lielupe and Driksa River in Jelgava City has connections to Arch Highway, Kalnciema way, as well as perspective section of Atmodas street (see Fig. 1).

Spatial data are data that indicate location of an object; this means that data shall be attached to specific coordinate system that is LKS – 92 TM in this case.

For preparation of relief model of territory comprising the object, laser scanning data requested and received from Geospatial Information Agency of Latvia were used as base. In order to obtain spatial data by method of photogrammetry, it was necessary to receive permission from Council of Jelgava City to obtain photo images with unmanned aircraft equipped with passive sensor – photo camera. It was planned to carry flights 3 times– 1 January, 2019, 2 and 3.

March, 2019, as well as 30 and 31 March, 2019. On 2 and 3 March, 2019, flight of unmanned aircraft was not possible due to inappropriate weather conditions – rain, strong wind. In planned flight of 30 March, 2019, reference points or marks were not installed, because flight was carried out with unmanned aircraft DJI Phantom 4RTK, which provides flight in real time, thereby accuracy of photo images is to 1 cm.

As one of most important preparation stages is preparation of flight route. Route is created in Drone Deploy application. All flights were performed in height of 120 m, which is the height permitted in regulations of the Cabinet of Ministers [5]. Calculated time of flight is 47.10 minutes, area covered by flight – 167 ha, totally, unmanned aircraft with photo camera will take 944 photo images and 3 batteries are required in order to carry out flight. As in the specific day of flight (30 martā) wind speed was a little greater than advisable, more batteries were used than before predicted, because unmanned aircraft had to overcome greater air resistance. Likewise, two remaining routes were compiled – one for Arch Highway, the second – for area of Atmodas Street. As they are linear objects, flights were planned according principle forth back and once more forth, thus the required coverage was provided and resources were saved.

Further processing of cloud of points is carried out in Bentley MicroStation program, which is equipped with TerraSolid program plugin. Microstation is 3D modelling tool for architecture, construction, cartography, engineering communication and many

Fig. 1. Linkage of streets of Jelgava City and planned flyover with ways of state and regional importance

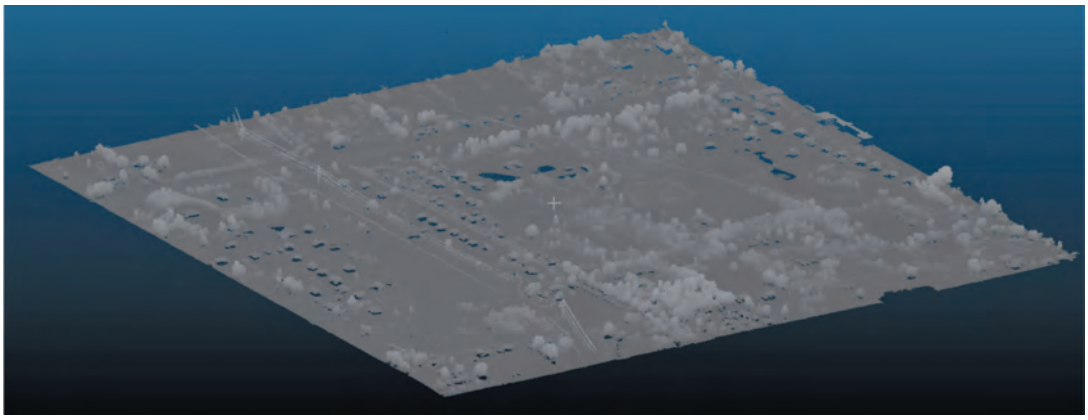

Fig. 2. Point cloud from laser scanning data of Geospatial Information Agency of Latvia (Source: created by the authors)

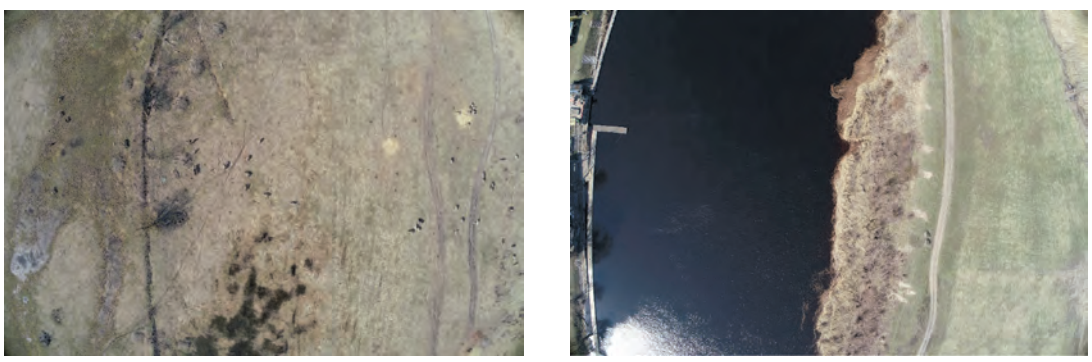

Fig. 3. Photo images obtained by photogrammetry (Source: created by the authors)

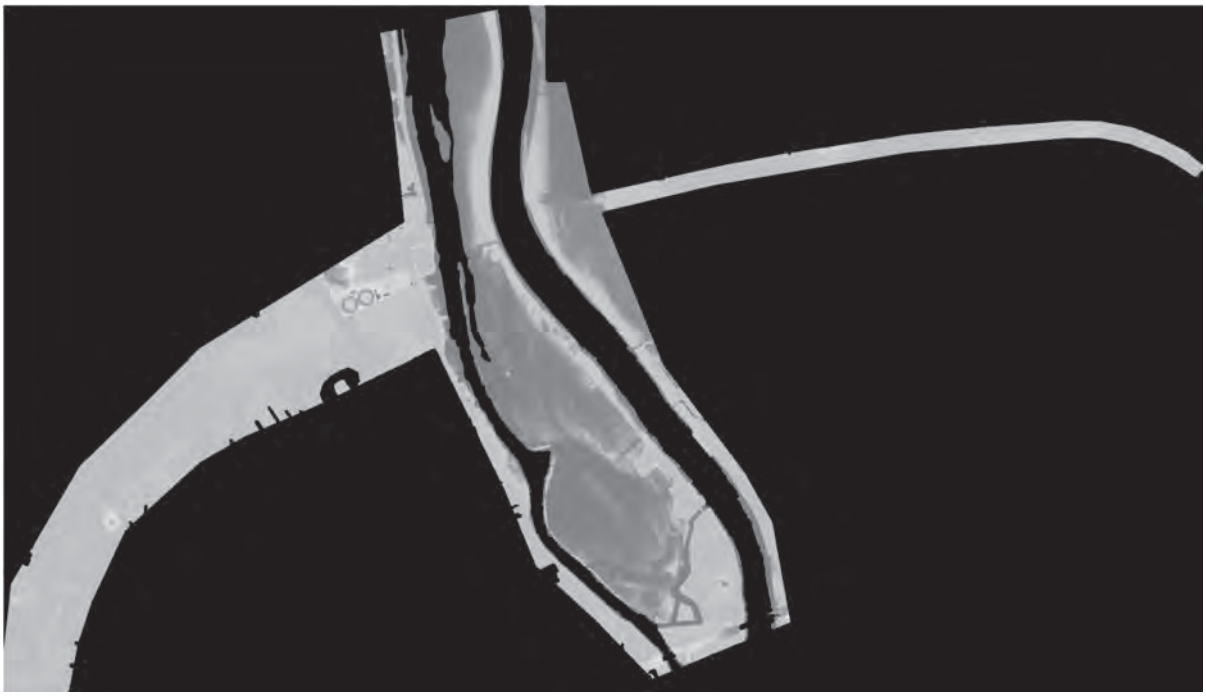

Fig. 4. The prepared relief models after alignment of points to control measurements (Source: created by the authors)

other branches [https://likumi.lv/ta/id/286823-kartiba-kada-veicami-bezpilota-gaisa-kugu-un-tadu-cita-veida-lidaparatu-lidojumi-kuri-nav-kvalificejami-ka-gaisa-kugi]. TerraScan is main application for Terrasolid software family, in order to manage and process LiDAR clouds. It offers import and project structuring tools, in order to process large number of points in laser scanning campaign, as well as the corresponding trajectory information. Incorporation of diverse classifications allows filtering of points of cloud automatically. Results of automatic classification can be improved by use of semiautomatic and manual classification tools together with many-sided possibilities of visualization of 3D point clouds [http://www.miko.lv/programmatura/bentley]).

Results and Discussion

In the result of laser scanning, point cloud (see Fig. 2) is obtained. It is formed as model of point cloud and attached to coordinate system (georeferenced) in the course of processing. Point cloud consists of millions points, each point contains information on coordinates of location and intensity of the reflected signal.

For the preparation of model of territory of the Northern Flyover, laser-scanning data obtained from Latvian Geospatial Information Agency – point clouds were used. In order to cover the entire required territory, 14 point clouds were used. Size of one point cloud is 1 km × 1 km.

In the result of application of photogrammetry, photo images are obtained.

As it can be seen in Fig. 3, on edges of image, picture is convex.

In order to create three-dimensional relief model, not only rather wide technical support, but also skills and knowledge in the area of data obtaining, processing and preparation is necessary. As base in the preparation of relief model, laser-scanning data received from Geospatial Information Agency of Latvia were used. From point clouds obtained in the result of alignment of photo images, information on relief points was selected and added to the laser-scanning data, thus data of point clouds of photo images are combined with laser-scanning data. Additionally, also photo visualization plan was prepared as visual aid that depicts situation in the specific moment in format of picture.

In order to prepare relief model with acceptable and appropriate accuracy, comparison of model points with carried out control measurements shall be done.

After the evaluation of these indices, decision was made to align relief model to mean difference of heights, thus preventing that model could be broken (deformed), which could have a significant impact on the end result.

When the original alignment of relief model is performed, relief model is created once more, but from transformed point of Earth (see Fig. 4). Relief model M 1:10 000 with height marks, which are located in square 70 m × 70 m, was prepared.

As in the preparation of the relief model, information from Geospatial Information Agency of Latvia was taken as the base, process of preparation was much shorter than

in case, if laser-scanning would be done by unmanned aircraft, to which the active sensor – laser scanner is added. In such case, equalization of flight trajectories, comparison of mutual coverage of flight trajectories, as well as number of other activities shall be done, which makes creation of the model more time-consuming and more complex.

Relief model was prepared for 281.26 ha large area, which covers streets of the city covered by planned Northern Flyover – Arch Highway, area of Atmodas Street, also part of Pilssala island, where Jelgava Palace is situated. As in relief model colours depend on differences of heights, we can see that practically the entire Pilssala island is located lower (blue colour) than remaining territory, thus risks exist that in the result of large influx of water (heavy rain, flood, overflow), island will be located under water, thus habitats living on the island are exposed to risk. Analysis of the marks of heights depicted on the relief model, which are placed in 70×70 m large grid, allows drawing a conclusion that differences of heights are not very large, taking into account specific areas. They are within limits from 1.5 m to 2 m. Of course, if the entire territory is analysed, differences of heights are approximately from 0.06 m to more than 6 m. As the territory is rather large, from all above we can draw conclusion that relief in the selected territory is rather even and there are not sharp differences of height in specific areas of territory of the object.

All end products, which are obtained in process of processing of laser-scanning data, also relief model, have wide application: topography mapping, mapping and visualization of build-up territories, territorial planning, environment and nature management (monitoring included), inspection of infrastructure object (for example, power lines, pipelines a.o.), monitoring of mining sites, modelling of consequences of natural disasters (for example, modelling of flood), inspection of transport infrastructure objects (for example, evaluation of condition of railways and roads), information for planning of construction works, control of agriculture areas, forest management purposes, geology, hydrology and pedology, archeology, as well as in other areas, where geospatial information is necessary [http://www.terrasolid.com/products.php].

Conclusions

Remote sensing is a complex branch of science; nevertheless, it gives many-sided knowledge about geodesy, photogrammetry and other related branches.

Laser scanning gives multiform possibilities for the improvement of contemporary surveying branch, as well as for facilitating people's work, allowing performing work faster and safer.

Northern Flyover has significant importance in the development of the city, in order to reduce the intensity of the traffic in the main streets of the city, to improve mutual linkage between cargo carriers and producers, as well as to develop new industrial territories, improve well-being of inhabitants of the city by provision of new jobs, as well as by improving the economic condition of the city. Thus possibilities are created for city to develop also in other directions.

For preparation of relief model, additional knowledge is necessary in issues related with geodesy and in technical issues. Unfortunately, it is not possible to acquire this knowledge in the studies of the university.

Preparation of relief model is a time-consuming process, because it is not only task to summarize data, but all that begins with planning of flight and ends with preparation of end products, however all the same it is faster than only human work in the field.

There are several factors that can have an impact to end result, for example, weather condition – snow or wind speed, also magnetic fields, therefore it is necessary to take them all into account, avoid exposure to these factors as much as possible, when the planning part of flights is carried out.

Acknowledgements

We are grateful to the company A-GEO Ltd and land surveyor Andrejs Veliks personally for the selection of data used for this study.

References

Tālizpēte (without year). (Remote sensing) viewed 06.05.2018., available at http://virac.eu/petnieciba/petniecibas-virzieni/talizpete/tradicijas/ (In Latvian)

Pfeifer Norbert, Briese Christian (2007) Laser scanning – principles and applications. Available at https://pdfs.semanticscholar.org/f566/c9d2c90f471c63a4ac8802c49de9e9e4577b.pdf

Jelgavas pilsētas ilgtermiņa attīstības stratēģija 2007. – 2020.gadam (2013) (In Latvian)

The Procedures for Performing Flights of an Unmanned Aircraft or Movements of Other Such Type of Machine, which are not Classified as Aircraft available https://likumi.lv/ta/id/286823-kartiba-kada-veicami-bezpilota-gaisa-kugu-un-tadu-cita-veida-lidaparatu-lidojumi-kuri-nav-kvalificejami-ka-gaisa-kugi

Bentley (without year) viewed 02.05.2018., available at http://www.miko.lv/programmatura/bentley

Terrasolid Products (without year) [viewed 02.05.2018., available at http://www.terrasolid.com/products.php

Aerolāzerskenēšana (without year) viewed 25.04.2018., available at http://map.lgia.gov.lv/index.php?lang=0&cPath=4_5&txt_id=126 (In Latvian)