ANALYSIS OF DATA ACCURACY OF LITHUANIAN SPATIAL INFORMATION PORTAL TOOL "SET ALTITUDE OF POINT ON LOCATION"

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Abstract
Geoportal.lt is a Lithuanian state information system whose scope is to allow all data users to freely access geographic data, maps and e-services. The portal also allows drawing relief altitude profile and set the altitude of point on location. It is performed by applying the tool "Set altitude of point on location". It is one of the newest tools of geoportal.lt website, whose accuracy has not been analysed, and which, according to the information provided by GIS Centre, complies with the requirements set for 1:50000 scale maps. This tool is selected as an object of research, while the aim of the research is to analyse the accuracy of data provided by Lithuanian spatial information portal tool "Set altitude of point on location" in case of different land covers. The following methods of investigation have been employed: literary analysis; the analysis of cartographic material; field measurements and data processing; comparative analysis of data. The data is processed using Geomap and Microsoft Excel programmes. After the analysis has been carried out, it was established that the most common errors in all types of land covers are from 0.5 m to 1.5 m. Such errors comprise 70 per cent in forest areas, 35 per cent in built-up territory, and 53 per cent in thin land cover. Taking into consideration that the website geoportal.lt operates on the basis of orthographic map whose accuracy is 1 meter and the discussed tool shows the altitude of the nearest known point, it can be stated that the obtained presumptions are permissible. To summarise the obtained data, the tool is reliable. The reliability of the data is 91 per cent in thin land cover, 86 per cent in forest area, 75 per cent in built-up area. To compare it with topographic maps of analogous format, where the errors of altitudes may reach up to 10 meters, the tool is reliable even in case of major errors.
Keywords: *Lithuanian spatial information portal (geoportal.lt), laser scanning (LIDAR), altitudes*

Introduction

Two main methods based on central and orthogonal projection are used for cartography. In the majority of cases, both of these methods are joined and the location cartography is performed by using the combined method (Balevicius, Gudritiene, 2014). Each method has its advantages and disadvantages. Mostly, the size of objects and their spatial position is determined by performing the distant (photogrammetric) measurements. Laser scanning (LIDAR), which has been discovered recently and is already being used in Lithuania, allows collecting information not only on natural, but also on man-made surface objects as well as heights of land surface (altitudes). In Lithuania, the data of distant cartography is publicly accessible to the users on Lithuanian spatial information portal (Geoportal.lt). This website presents to the users the simplified tools, which allow carrying out the analysis of spatial object without the use of complex software (Papisiene, 2014). One of such tools is "Set altitude of point on location". The tool is created by using LIDAR data. The Lithuanian Orthographic map (ORT10LT) is used as a spatial basis. According to the specialists of GIS centre, this tool complies with the requirements set for the 1:50000 scale maps. A lot of Lithuanian authors analyse the accuracy and application of available LIDAR data, however, the functions of the product created on the basis of such data have not been thoroughly analysed, therefore this investigation has been carried out.

The main motif for applying the LIDAR method is its capacity to obtain a lot of information on land surface objects in a short period of time. The data gathered by LIDAR includes not only information on geodesic heights of land surface, but also natural and man-made objects (Kalantaite et.al., 2010). However all measurement methods and systems have errors. A lot of scholars have been investigating the accuracy of this method; in his article Zachary argues that the accuracy of LIDAR data ranges from 1 to 2 meters, and the mean squared error – from 15 to 20 centimetres (Zachary et.al., 2007). According to Zalnieriukas, the *LIDAR* laser beam measures the distance to solid surface with 1-3 cm accuracy, while the real accuracy of height scanning reaches 10-15 cm in urban territories. Ruzgiene claims that the accuracy of measurement is mostly dependent on the flight altitude. According to her, the accuracy of LIDAR data is approximately 15 cm. Kraus provides the conclusions of his research, stating that the vertical accuracy in forests in 0.50 m and 10-15 cm in streets (Kraus, 2008). According to A. Zalnieriukas, the accuracy of the location scanning depends not only on the flight altitude, but also on the features of the scanner, the width of the scanned sector, errors of scanner positioning on GPS and orientation, the frequency of laser beams and their dispersion, atmosphere conditions and especially the features of the reflective surface and other factors, therefore the accuracy of the data varies (Zalnieriukas et.al., 2009, Kraus 2008, Zachary 2007).

In Lithuania, LIDAR technology has been applied twice. In 2007, the photos of the centres of ten biggest Lithuanian cities have been ordered by the National Land Service under the Ministry of Agriculture. The density of points on location is 3–4 points/m^2, the average distance among points is 0.5 m, vertical accuracy is ± 15 cm and horizontal accuracy is ± 30 cm. Another surface scanning has been made in 2009–2010. These measurements scanned the whole territory of Lithuania, thus forming a digital spatial model of land surface. The density of points in this scanning is no rarer than 1 point in 2 m^2, when the vertical accuracy is not greater than 30 cm and horizontal is not greater than 60 cm. When processing the data, the reflections with blurry signal, reduced by thick vegetation, have been removed. Therefore, the layer of points may vary in different Lithuanian territories (Zalnieriukas et.al., 2009).

To check the accuracy, the geodesic measurements, being the most accurate method of setting coordinates, have been employed.

The aim of research – to analyse the accuracy of the data provided by the Lithuanian spatial information portal (Geoportal.lt) tool “Set point on location altitude” in case of different land cover.

To reach this aim, the following objectives have been set out:

- To set the altitude of points by employing two different methods of GPS receiver and tool provided by geoportal.lt;
- To set the errors of data and the dispersion of the obtained errors in case of different land cover.

Methodology of research and materials

The object of research – Lithuanian spatial information portal (Geoportal.lt) tool “Set altitude of point on location”.

When performing the analysis, the following methods have been applied:

- literary analysis;
- analysis of cartographic material;
- field measurements and data processing;
- comparative analysis of data.

When carrying out the literary analysis, the results of the data of analyses carried out by other authors as well as the accuracy of available laser scanning data in Lithuania have been discussed. During the analysis of cartographic material, the topographic plans, which have been drawn by the co-author during the production work, have been selected. The measurements have been performed by using GPS receivers (TopCon GMS and Trimble R10). The altitudes of the points measured by GPS devices were compared to the altitude set by the geoportal.lt tool “Draw relief profile and set altitude of point on location”. The mean squared error M has been calculated by using the formula (1) for every difference of land cover altitudes (Živatkauskas, 2013):

$$M = \sqrt{\frac{M_1^2+M_2^2+..M_n^2}{n}} \text{(m)} \quad (1)$$

Here: $M_1^2 + M_2^2 + .. M_n^2 -$ error of measurements of separate points,

n – number of points.

The data is processed by using GeoMap and Microsoft Excel programmes, the charts informative pictures have been provided.

Results and discussion

Geoportal.lt is a state information system, whose scope is to allow all data users to freely access geographic data, maps and e-services. Currently, 38 organisations use this system to provide 289 services of spatial data review and download. The users can find, review and download various maps, data sets, compare them, use measurement and data analysis tools (Lietuvos..., 2015). Complex map tools, which allow analysing the data accessed through Geoportal.lt are proliferating. The drawing of relief altitude along the line drawn by the user or setting the altitude of point on location is provided to the users of this portal. It is performed by using a tool “set altitude of point on location” (Zemes..., 1015, GIS... 2015).

The information obtained by using this tool is based on LIDAR data, whose accuracy and collection methods are still a topical novelty in the cartography of the Earth surface objects.

The research has been carried out in Marijampole district. It employed the point altitudes measured by GPS device and altitudes of the same points measured by using geoportal.lt tool. The measurement data is selected from 10 not interrelated topographic plans in order to cover larger territory.

The measurement data has been divided into three groups:
First group includes points located in flat territories with thin land cover (farm land, natural fields);

- The second group consists of points in built-up territories (near buildings);
- The third group includes points in forest areas (among trees).

Most of the points, i.e. even 65 points were chosen for comparison in open, flat areas, since they comprised the majority in the mapped territory (Fig.1).

Fig.1. Examples of points selected in open areas

Coordinated points are completely in open areas, there are no buildings, trees, shadows or other objects that may influence the accuracy of LIDAR data near them.
The dispersion of deviation in altitudes based on size when comparing the GPS measurements with NTVA data is provided in percentage (Fig. 2).

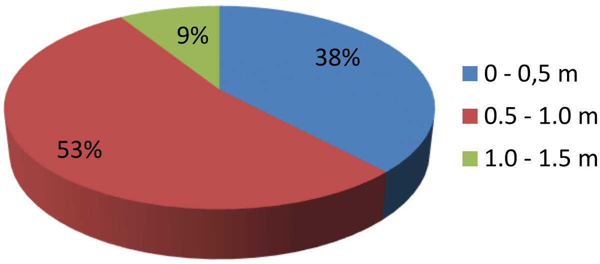

Fig. 2. The dispersion of deviations according to size

The measurement discrepancies were divided into 3 groups: altitudes with 0-0.5 m accuracy, altitudes with 0.5-1.0 m accuracy and altitudes with 1.0-1.5 m accuracy. It was determined that the discrepancies whose altitude difference ranges from 0.5 to 1.0 m comprise the largest percentage share, i.e. 53 per cent of all the discrepancies in flat land cover. A minor percentage share crosses the one meter limit, however, taking into consideration the fact that the tool is created on the basis of LIDAR data for 1:50000 cartography, the assumption can be made that this error does not exceed the maximum limit.
The second group of the selected altitude points is in built-up territories, i.e. near buildings. 20 coordinated points, whose altitudes have been established by performing geodesic measurements and using Geoportal.lt tool, were analysed in this group (Fig. 3).

Fig. 3. Examples of points located in built-up territories

Taking into consideration the error of every point, the mean squared error is 1.6 m and 1.30 m when calculating the mean squared error arithmetically. When comparing the data of built-up territories with the data of points with thin land cover, it can be observed that the differences among altitude and mean squared error vary more than two times. According to the obtained differences in altitudes, two coordinated points, whose errors exceed 3 m can be observed. The photos of the points are provided in Figure 4.


1. 2.

Fig. 4. Major errors in built-up territories: 1 – 3.5 m difference, 2 –3.6 m difference

These points have the biggest error when comparing the data obtained using the tool to the GPS device. The error of the first point may have been influenced by the fact that the point is measured in close proximity to the building, and in the second photo, the measurement is performed in case of being near the building, whose shadow may have interfered with the beam.

The altitudes measured in built-up territory have various deviations grouped according to size and presented in percentage (Fig. 5).

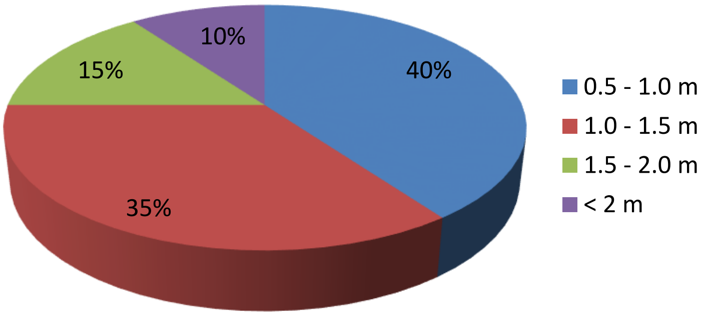

Fig. 5. The dispersion of deviations according to size

The errors were divided into 4 groups: errors with 0.5-1.0 m altitude difference, the second group includes 1.0-1.5 m altitude difference, the third - 1.5-2.0 m altitude difference while the fourth – 2 m or greater difference.

The built-up territory features no errors lower than 0.5 m, while the only and the lowest error of these measurements is 0.8 m. All the errors up to 1 meter comprise the largest percentage share i.e. 40 per cent, while the errors with 1.0-1.5 m deviation constitute 35 per cent of all the errors. Errors with deviation up to 2 m make up 15 per cent. In built-up territories 10 per cent of all the errors are the errors with 2 m and greater deviation, which may reach up to 3.5 m in some areas. Such errors are not acceptable even for 1:50000 maps. However when comparing them with the altitudes provided in topographic (analogous format) maps, which are established by using horizontals, it can be stated that the obtained data are more reliable, since the deviations in horizontals are up to 10 m (Gudritiene, 2013). Based on the obtained data it can be stated that the altitudes in built-up areas provided by geoportal.lt tool are of average reliability and can be used when there is no need for highly accurate data.

The third point group selected for altitude analysis is in forest area. Altitudes of 35 points have been analysed in this group (Fig. 6).

Fig. 6. Points selected in forest area

Having evaluated all the deviations of point altitude errors, the obtained square error is 0.99 m and the average point error calculated arithmetically is 0.64 m. The dispersion of point deviation varies with the smallest deviation being 50 cm and the largest reaching up to 2 m. The errors do not exceed the permissible limit.

The point altitude deviations in forest areas according to the grouped sizes are provided below (Fig. 7).

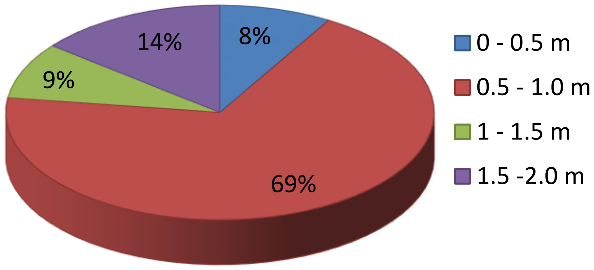

Fig. 7. Altitude deviations in forest area

The altitude deviations in forest territory were divided into 4 groups: the first group is from 0-0.5 m, the second – from 0.5-1.0 m, the third 1.0-1.5 m and the fourth up to 2 m.

Errors with altitude deviations up to 50 cm constitute 8 per cent of all the errors. Errors with deviations from 1 m to 1.5 m make up 9 per cent. The largest part is comprised of errors with deviations from 0.5 m to 1 m represented by 69 per cent. The largest group of errors (up to 2 m) comprises 14 per cent of all points. Since the data whose altitude error does not exceed 1 m dominates, it can be stated that the tool provides accurate data in forest territory.

Having compared all the data of tool accuracy analysis, the percentage of the errors of different covers (open, built-up, forest) are provided in the diagram below (Fig. 8).

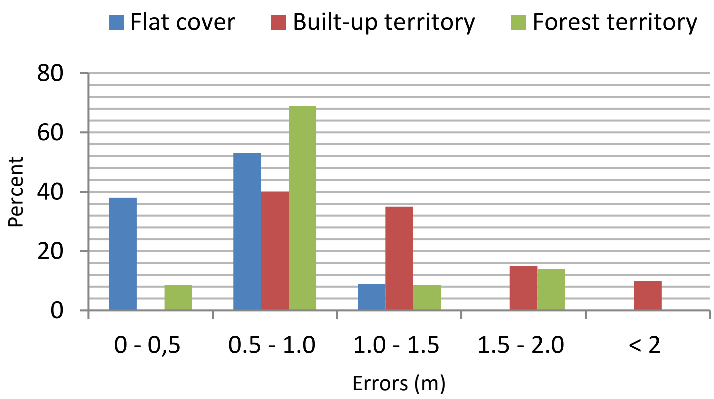

Fig. 8. Total review of territories in percent

The lowest percentage of errors up to 50 cm occurs in land covers where fields, greenlands, arable land and other lands prevail as well as in forest areas, where it reaches 10 per cent. Based on the research carried out by other authors and the results that they have obtained, it can be stated (Kraus 2008, Zachary 2007, Žalnieriukas 2009) that such errors comply completely even with the requirements raised by LIDAR and the obtained data is highly reliable. Such errors in thin land cover make up approximately 40 per cent and in forest territory approximately 10 per cent.

The most common errors are from 0.5 m to 1.5 m. Such altitude errors may occur in all three types of land covers. Based on the fact that geoportal.lt website operates on the basis of orthographic map, whose coordinate accuracy is 1 m, it can be assumed that such errors are permissible and the obtained data is reliable, since it complies with the requirements for 1:50000 scale maps. Such errors are most common in forest areas, i.e. approximately 70 per cent, approximately 40 per cent in built-up areas and approximately 50 per cent in fields.

The analysed tool works on a zooming principle, therefore it can be claimed that the errors from 1.0 m to 1.5 m are also minor, since the tool provides the altitude of the nearest known point.

The errors from 1.5-2.0 m are of average reliability. In built-up territories, errors reaching 2 m and more are unavoidable and constitute approximately 10 per cent. They may been caused by buildings and their shadows that interfere with the penetration of laser beam during the scanning process.

In conclusion in can be stated that the tool is reliable in open areas with thin land cover in approximately 91 per cent of cases. The reliability is also high in forest areas and constitutes 86 per cent, while in built-up areas the data of the tool is less reliable and make up to 75 per cent. It may be influenced by the shadows and the built-up land cover that may limit the penetration of laser ray.

The mean squared error has been calculated according to the formula provided by the methodology. The graphical results of calculations are provided in Figure 9.

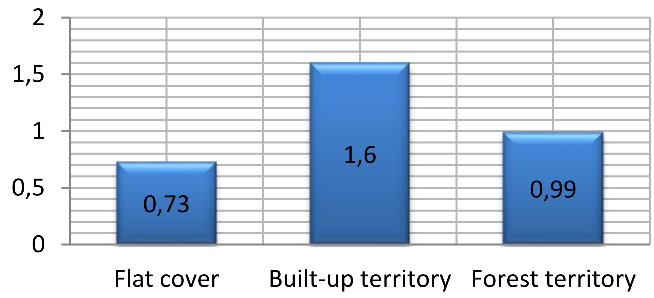

Fig. 9. The dispersion of average square inaccuracies of Geoportal.lt tool "set point on location altitude"

The largest mean squared error is in built-up territory and constitutes 1.6 m, in open area it is more than two times lower, i.e. 0.73 m, while in the forest territory it reaches 0.99 m.

Having checked all 120 analysed point altitudes and their errors and without excluding the land cover or built-up territory it can be stated that the most frequent error of the tool is up to 1 m. In total, there are 94 deviations of such kind, which makes up 80 per cent of all the analysed altitudes. However, even in case of major errors, the tool is useful since the altitudes on maps provided by using horizontals differ by up to 10 m (Gudritiene, 2012). Therefore, geoportal.lt tool is more beneficial for setting altitudes than old cartographic material of analogous format.

Conclusions

1. 120 points were selected for the analysis (65 of them are in open area, 20 – in built-up territories, 35 – in forest territories). The mean squared error of the data provided by the tool is: 73 cm in territories with thin land cover; 1.6 m in built-up territories; 99 cm in forest territories.
2. Errors up to 50 cm comply completely with the requirements of LIDAR, they usually prevail in territories with thin land cover (38 per cent), while in forest territories they make up 8 per cent. There are no such errors in built-up territories.
3. The most frequent errors in all the land cover types are from 0.5 m to 1.5 m. They constitute 70 per cent in forest territory, 35 per cent in built-up territory and 53 per cent in territory with thin land cover.
4. Taking into consideration the fact that geoportal.lt website operates on the basis of orthographic map with 1 m accuracy and the discussed tool shows the altitude of the nearest known point it can be stated that the obtained errors are permissible except for two cases mentioned in the analysis.
5. To conclude the obtained data it can be stated that the tool is reliable. The accuracy of its data in thin land cover is 91 per cent, 86 per cent in forest territory and 75 per cent in built-up territory. In

comparison with the topographic maps of analogous format, where the altitudes differ by up to 10 m, the tool is reliable even with the highest error.

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