SOME CONTRIBUTIONS TO DERIVING TOPOGRAPHIC FEATURES FROM AIRBORNE LASER SCANNING DATA

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ABSTRACT:
The airborne laser scanning data are one of the most promising source data for deriving different spatial data. This method is widely used in urban environment and forestry, while use for deriving topographic features is still rare. Slovenia has a crucial problem of regular updating of topographic data at different levels. At the moment the largest scale map which is regularly updated is National topographic map at scale 1: 50,000, but again without any detailed data capture in wooded areas. Therefore some tests about possible use of ASL data for that purpose were made. Set of small areas on different parts of Slovenia was chosen, representing different types of terrain, and therefore significant diversity was achieved.

Keywords*: topographic data, airborne laser scanning, terrain features.*

1. INTRODUCTION

Topographic maps and topographic databases are the basic parts of spatial data infrastructure. Every administration needs regularly updated spatial data for administrative tasks, environment monitoring, for spatial management and many other purposes. Although the Slovenia, as relatively young country, has been recognised as one of the most progressive EU countries, status of regular updating of topographical topographic data at different levels is far from ideal (*Petrovič, Duhovnik, 2009*).

The Slovenian National Topographic Map at the scale of 1: 25, 000 (DTK 25) is the largest scale map of Slovenia, presenting the entire territory on map sheets at the unique scale (*Petrovič, 2006*). The 198 sheets of the map were published from 1994 to 1998, as a remake of former Yugoslav's military topographic map, last updated in 1985 and 1986. Due to limited financial resources unfortunately the design modifications had the priority over the updating of content. Thus the degree of updating was mostly limited to only the inclusion of new connecting roads and railroad tracks, larger groups of new objects or larger individual objects, and the inclusion of new water-storage reservoirs. The marginal content with the legend, the mathematical elements of the map, explanations and colophon were indeed completely re-designed. DTK 25 boasts an extremely accurate height representation of the terrain, high legibility with high density of displayed information and good positional accuracy of all the displayed objects. Some segments of state administration (especially military) would be interested to update it, but according to budget possibilities the Mapping and Surveying Authority decided that at the moment the largest scale map which is regularly updated is National topographic map at scale 1: 50,000, but again without any detailed data capture in wooded areas (**Fig. 1**). Although not completely updated, user familiarity with the map DTK 25 should be a reason, why such out-of-date map is still widely used for spatial planning and especially for orientation and navigation on the terrain (at boy scouts, for mountaineering, for marathon orienteering, adventure races, etc.)

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Fig. 1 Slovenian national topographic maps: insert of DTK 25, covers of DTK 25 and DTK 50

In the late 1990s the project of establishing a basic national topographic database (DTK 5) started. The essential purpose of DTK 5 was the linking of the existing topographic records and the minimal addition capture from the cyclic aerial survey (CAS) images. In the period between 2002 and 2010, about 2000 3-km × 2.25-km sheets (out of 3258 DTK 5 sheets which cover the entire territory of Slovenia) were captured (**Fig. 2**). The created sheets cover all the bigger settlements and it can be estimated that the DTK 5 encompasses no less than 80 per cent of the population. But, the capture of DTK 5 for the rest of country territory was stopped and even already captured data haven't been updated in last years.

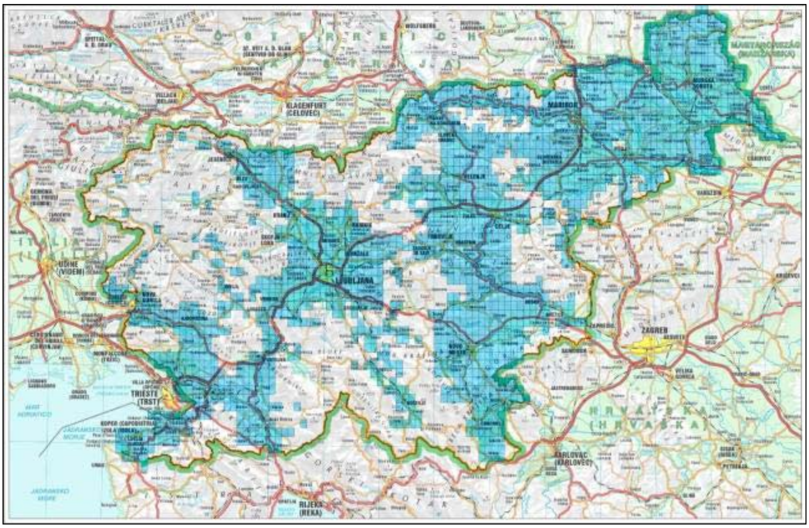

Fig. 2 Territory of Slovenia, covered with basic topographic database DTK 5

In the last decade, some ideas were promoted to assure regular updating of topographical data, like official collecting of data from companies responsible for public infrastructure or attempt to updating official topographic data by users (*Petrovič, Kovačič, 2008*). None of them brought any significant result.

2. AIRBORNE LASER SCANNING (ALS)

The technology of laser scanning has importantly affected the principles of spatial acquisition of topographic and other physical data about the environment (*Shan and Toth, 2009, Kraus, 2007*). Frequently the synonym expression LiDAR survey or short LiDAR is used. The very important advantage of LiDAR capturing is its speed; it allows capturing large area in a short period with high density (**Fig. 3** left). The main results of airborne LiDAR survey are clouds of georeferenced points containing data on the reflection order and the intensity of the returned pulse (**Fig. 3** right). The airborne laser scanning data therefore seem to be a promising source data for deriving different topographic data and for quick, non-expensive regular updating of topographical maps and databases.

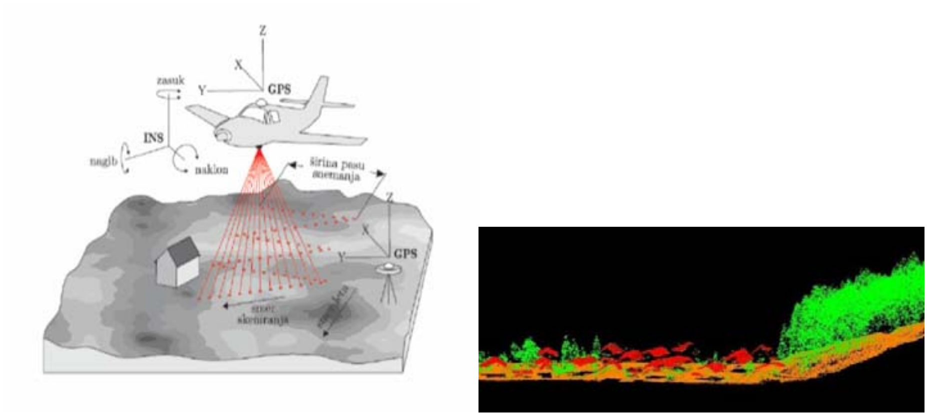

Fig. 3 Principle of LiDAR capturing and classified point cloud as a result of LiDAR

To collect and classify topographic contents from the LiDAR point cloud, the recognition of individual objects and phenomena and the definition of the edges between them (i.e. edges defined by buildings, roads, etc.) are required. The success of recognition depends among others also on the LiDAR point density per surface unit (*Triglav Čekada et all, 2010*). Recognition of objects, phenomena and edges is very attractive and intensive research topic. There are already some results in automated deriving data from ALS: edge detection and building extraction mostly in urban environment; or forest type, density, three-heights in forestry. But, for the most nature made ones, small water objects, relief features, etc. such automated methods are not performed yet. For those features at the moment manual recognition of objects in different derived presentations (eg. hillshading) is still the most efficient method.

3. ANALYSES IN TEST AREAS

The Slovenian National Topographic Map at the scale of 1: 25, 000 (DTK 25) represent about 300 different feature types, DTK 50 and basic topographic map DTK 5 have more reduced content. To assure complete regular updating of all topographic data (maps and databases) all 300 feature types should be captured. Therefore our first goal was to analyse, how each feature type should be recognised in LiDAR data. Initially set of three small areas in Slovenia were selected to analyse possibility of deriving topographical data. Slovenian landscape is very diverse and there wasn't problem to find three areas representing different types of terrain (**Fig. 4**).

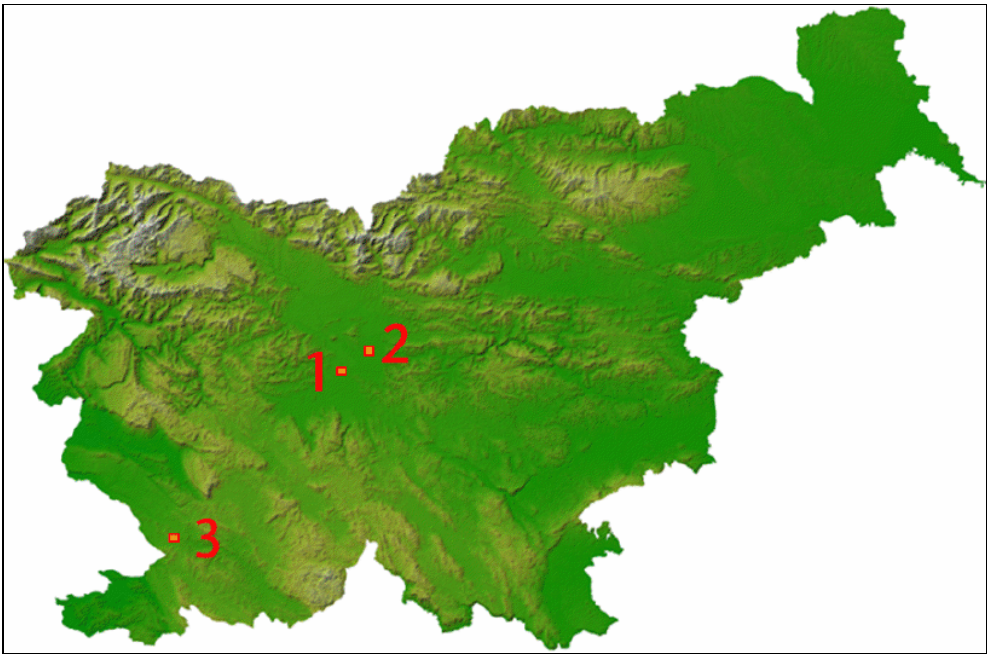

Fig. 4 Test areas for feature type recognition

Area 1, very close to the city center of Ljubljana is a steep continental relief with water objects, a lot of man-made objects, tracks and paths, very well-known and usually occupied by residents. Area 2, near Domžale is also a city recreational area, but terrain type is steep and carsty – surface rocks, depressions, pits, and no water objects appear in the area. The third area is typical moderate carst terrain near Lipica in Karst plateau.

As a reference data with all presented feature types DTK 25 was used, however due to its obsolete content there could be some discrepancy with LiDAR data. Therefore another reference dataset were used. The maps, presenting territory much more detailed as DTK 25 are orienteering maps (O-maps). All three selected areas are covered with corresponding O-maps at a scale 1: 10,000. LiDAR data for all three areas were slightly different in resolution. To enable manual visual interpretation and recognition of objects and phenomena LiDAR data were converted to 0.5 m GRID and presented as hillshading image with standard parameters: slope shading, azimut 315° (north-west), declination of the light source 45° and exaggeration factor 2.

In the initial part of analyse we were not able to systematically check all 300 feature types yet, so we focused mostly on the amount of objects that could be recognised and classified. **Fig. 5** show the first area. It's clearly visible that ALS hillshading shows much more objects that are presented on DTK 25, even more that on orienteering map.

Orthophoto on the other side couldn't be used for any feature type capturing except large buildings, roads or open areas between forest.

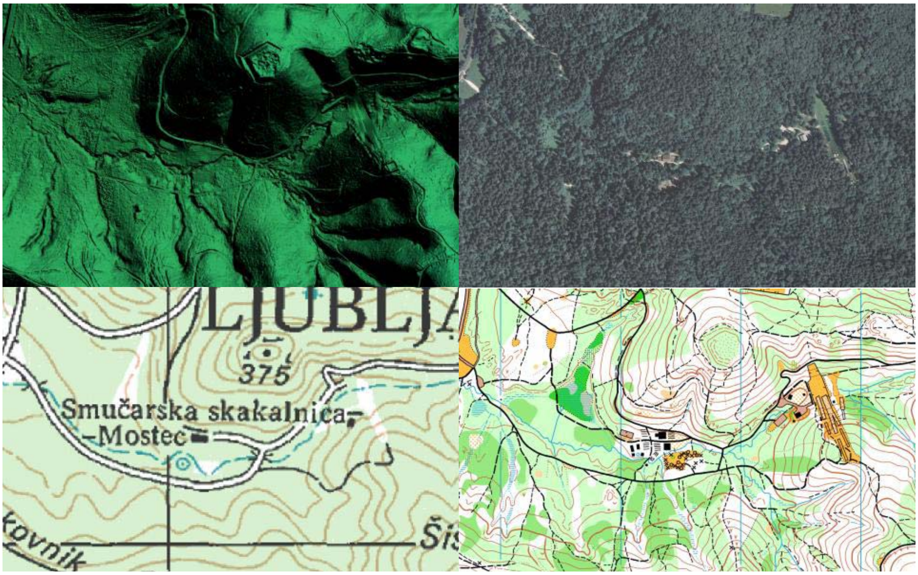

Fig. 5 Test area 1 – ALS hillshading, orthophoto, DTK 25, O-map

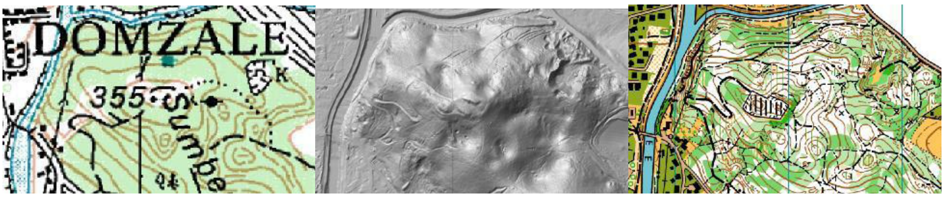

Fig. 6 Test area 2 – DTK 25, ALS hillshading, O-map

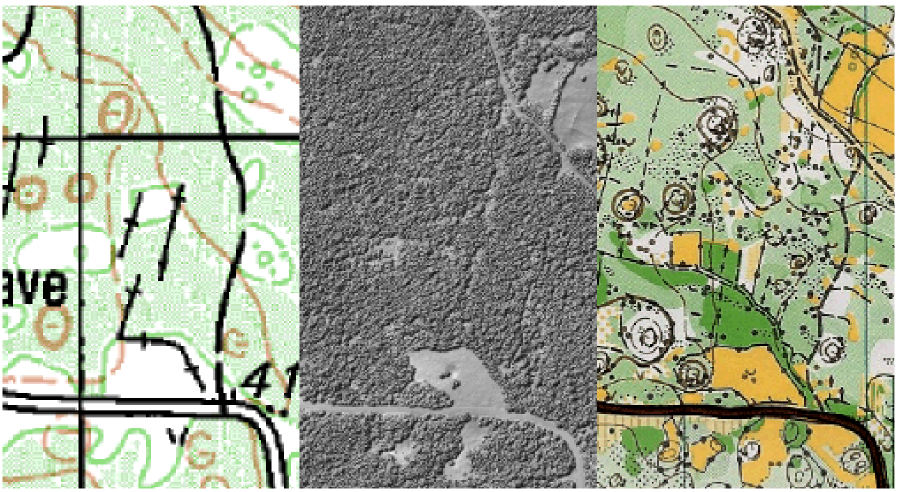

Fig. 7 Test area 5 – DTK 25, ALS hillshading, O-map

Fig. 6 show area 2 near Domžale. The conclusions can be the same as at area 1, but in this case in carst type of relief some typical carst phenomena, especially depressions, are clearly visible. Even cliffs along the river and steep walls of abandoned quarry can be easily recognised.

The third area was selected in basic carstic area, near famous horse-riding farm Lipica. The area is relatively flat and in this case we decided to analyse first echo model, which shows vegetation (**Fig. 7**). Comparison to orienteering map shows, that also small open or semi-open areas in the forest can be recognised, but due to canopy overlaying on the edges they often look smaller as they are in reality.

In the last test we did the opposite procedure. Upon experiences in the previous tests we tried to capture features from hillshading made from LiDAR data. The test was done in the neighbouring area to the test area 1, near Ljubljana. Initially all recognised point or linear type shapes in hillshading image were captured. Some shapes were so specific that we managed to define the feature type, for the most of them field check was necessarily. The result of the test was small orienteering map, presented in **Fig 8**. Although the field check was essential for exact feature recognition, the test showed that less than half of time was used in comparison to traditional terrain data capturing for orienteering maps.

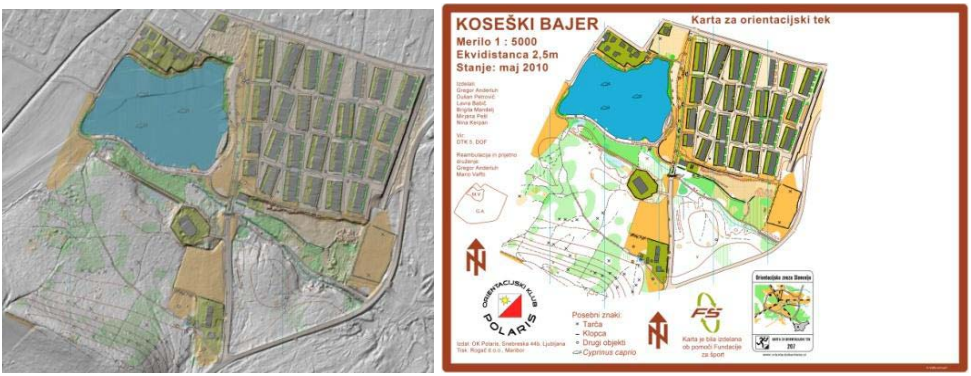

Fig. 8 Orienteering map made mainly form LiDAR data

4. CONCLUSION

The main goal of entire project is to create the procedure, which enable capturing all necessary data for establishing and updating Slovenian topographic maps and databases. Presented analyses were only the triggering tasks that gave us only basic impressions about the possibility of capturing topographic features from LiDAR data. In general it was obvious, that according to the others so far used mass capturing source datasets (eg. orthophoto) much more features can be derived. A detainee of available derived features is sufficient for all basic topographic datasets and also for orienteering maps. But, with described tests we also realised some problems. Some terrain features look too similar in LiDAR data and sometimes abandoned, overgrowth terrain object can't be distinguished from the regular used ones (eg. tracks in forests). Therefore it seems to be necessary to perform some field checking, too. But, with following tests we would try to recognise specific appearance of as many topographic features as possible, also on other areas, different form the test ones. Finally we would try to automate recognition and feature deriving procedures.

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