CO-011

SOME EXPERIENCES IN MAKING ORIENTEERING MAPS IN SLOVENIA FROM AIRBORNE LASER SCANNING DATA

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ABSTRACT

Orienteering maps are thematic maps with very detailed content. Their production is due to extreme detainees of content very expensive, time consuming and it requires a lot of terrain work made by skilled mapmaker. In such situation the airborne laser scanning data seem to be one of the most promising source data for deriving different features and objects that should be mapped on orienteering maps. The paper describes historical development of orienteering map production in last decades and points out on most important technological improvements in production, concluding with use of LiDAR data. Different small areas with different terrain type were selected to compare existing orienteering maps with contour lines and hill-shading made form LiDAR data. Based on experiences derived from those comparisons two new orienteering maps were made with minimum addition terrain work.

KEYWORDS

orienteering maps, airborne laser scanning, terrain features

INTRODUCTION

Orienteering maps are thematic maps, specially prepared and made for use in orienteering competitions. Since the main task for athletes in orienteering competition is finding control points on the terrain, usually in quite hidden places, orienteering maps have to be very detailed, showing many terrain features and objects, also runability and all obstacles that influence competitor's speed. On the other hand, to assure fair circumstances for all competitors, content and map symbology have to be familiar to all. These leads to fact that orienteering maps are the most standardised maps of all map types in the world (Zentai, 2001). The production of orienteering maps is due to extreme detainees of content very expensive, time consuming and it requires a lot of terrain work made by skilled mapmaker. Additionally, all more important orienteering competitions should take place in the areas with new maps, preferable also on the new areas, which were not use for competitions before or at least not for the last years. The consequence of above described situation is large necessity for produce a lot of orienteering maps around the world. The situation is Slovenia in even more specific, due to a lot of very challenging and interesting terrains a lot of foreign competitors often take part in orienteering events in Slovenia and they prefer to compete on new terrains, thus lead to production of tenths of new orienteering maps every year.

Twenty years ago the first orienteering maps according to IOF standards were made in Slovenia. The production at that time completely based on analogue cartographic technology. The only available source data in Slovenia were basic topographic map sheets, covering entire territory of Slovenia mostly at scale 1: 5,000, while for less populated areas the map scale was 1: 10,000 with contour interval of 10 m. Around 60% of Slovenian's territory is karstic, with relatively small height differences, but extremely crumbled, with a lot of small depressions, hills, gullies and other features. Base maps with 10 m counters at those areas were not very helpful for mapmakers. Therefore mapmakers had to make almost all capturing at the terrain, using compass for directions and pacing for distance measuring. Figures 1 show the example of area, where the orienteering map was made completely based on terrain measurement, due to bad base map mapmaker used it only for defining borders of map (road and the river) and to determine height difference between lower and upper part of the terrain.

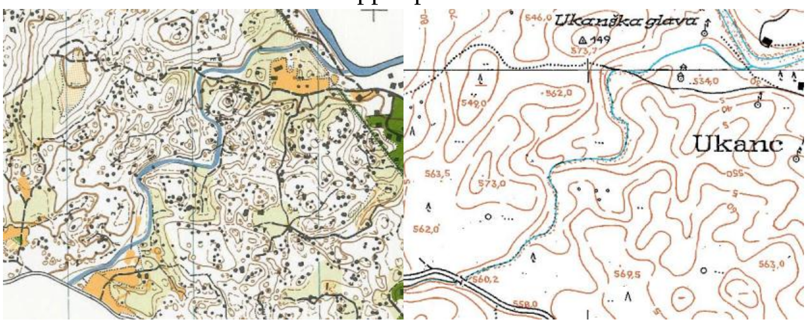


Figure 1: insert from O-map Ukanc and the same area on basic topographic map 1: 10,000

The only available technology that would enable easier and more accurate production of orienteering maps would be photogrammetric survey from aerial photographs. The official aerial survey in Slovenia was applicable mostly for open areas and for smaller scale maps, orienteering maps would require special survey; however price for such survey was much too high.

NEW POSSIBILITIES IN ORIENTEERING MAP PRODUCTION IN LAST DECADES

The last two decades brought a lot of significant improvements in production of orienteering maps. Computer cartographic technology gave many advantages, better graphical quality, assured the same symbology for all maps, enabled easier updating of maps, and finally easier combination of different data sources. The most popular program for orienteering maps became OCAD, which within those years overgrowths from simple CAD program for creating orienteering maps only to powerful cartographic software, that may be used for creation of different maps. The use of OCAD in education is very efficient, too. The other advantages came from available source data. Orthophoto images and high resolution satellite images became widely available for all areas. With ground resolution of 0.5 m or smaller a lot of objects can be recognised and captured directly from georeferenced image. Besides orthophotos, also basic national databases in vector form became usable, especially for build objects, roads, paths and other distinctive objects. Digital terrain models were mostly too less detailed to be used for orienteering maps. Even nowadays a lot of map makers are quite sceptic using national vector databases; in many cases they are too generalised to be used for detailed content of orienteering maps. The third important technology became GPS, enabling map makers to determine their absolute position on the terrain. Figure 2 shows the use of GPS track for mapping ski tracks on map for ski orienteering.

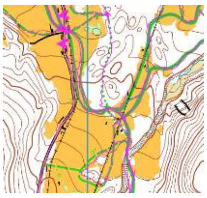


Figure 2: use of GPS track for mapping ski tracks on map for ski orienteering

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). The very important advantage of LiDAR capturing is its speed; it allows capturing large area in a short period with high density (figure 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 (figure 3 right). The airborne laser scanning data therefore seem to be a very useful source data for mapping different objects and phenomena, even vegetation or terrain feature in vegetation covered areas.

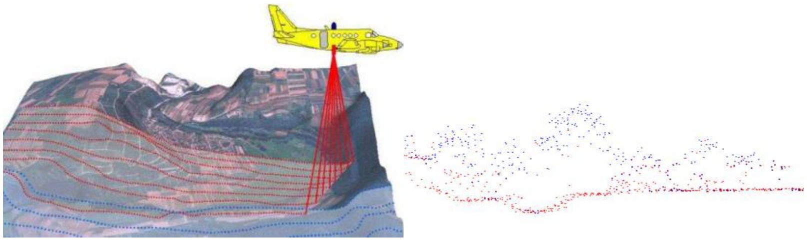


Figure 3: Principle of LiDAR capturing and classified point cloud as a result of LiDAR

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. For the most nature made ones, small water objects, relief features, etc. such automated methods are not performed yet, however some tests between orienteering map makers and also in topographic mapping field were done (Gartner at al, 2009). For those features at the moment manual recognition of objects in different derived presentations (eg. hillshading) is probably still the most efficient method.

Slovenia has no complete official coverage with airborne laser scanning data yet, however there are two firms making ALS for different private and public costumers. Thanks for their kindness we got a possibility to use some segments of their data for the purpose of testing possibilities of using those data for orienteering maps production in Slovenia (Petrovic, 2010). The territory of Slovenia in very diverse and the territories used for orienteering maps are extremely different, as well. Therefore we selected areas in different types, like flat karst terrain, mountain karst terrain, flat areas, steep slopes, etc.

The resolution of sample data available and the type of LiDAR data was different as well. So we used DTM with 0.5 m resolution, DSM in 0.5 and 1 m resolution and point clouds in las format with density prom 5 to 15 point on square meters. We initially compared the different ASL data with existing orienteering maps to find out, how specific features, objects and phenomenon that should be presented on orienteering maps appear in ALS data sets. Using the experiences of such procedure we defined which objects that have to be mapped on orienteering maps are visible and recognisable from LiDAR data.

ANALYSES IN TEST AREAS

Initially set of small areas in Slovenia were selected to analyse possibility of deriving topographical data. Slovenian landscape is very diverse and there was not problem to find three areas representing different types of terrain (figure 4).

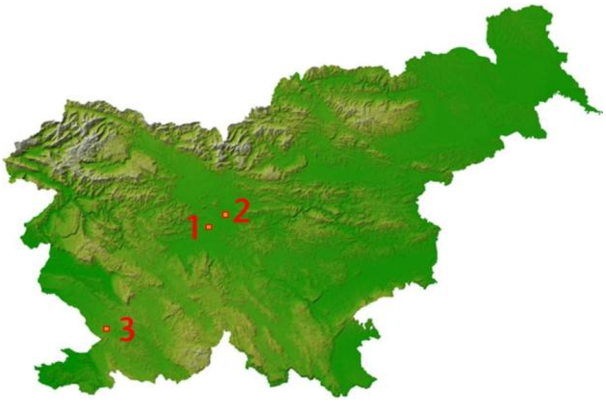
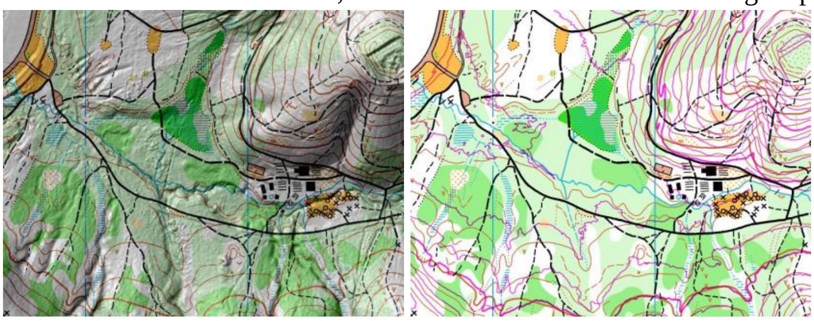


Figure 4: Test areas for feature type recognition

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 includes three different small areas near Dom�ale, one part is again steep continental relief, while two others are steep and karsty – surface rocks, depressions, pits, and no water objects appear in the area. The third area is typical moderate karst terrain near Lipica in Karst plateau.

As a reference data existing orienteering maps, made without using LiDAR data were used. However due to their obsolete content in some areas there could be some discrepancy with LiDAR data. 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, azimuth 315° (north-west), declination of the light source 45° and exaggeration factor 2. Additionally, contour lines with the same contour interval 5 m, the same as it is used in orienteering maps, were calculated.



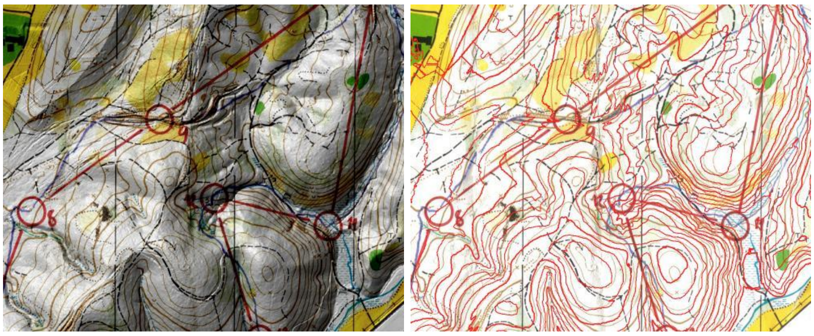


Figure 5: Test areas Ronik and Kolovec

Figures 5 show the areas with a steep continental relief. LiDAR hillshading and contours are combined with on orienteering map. On both cases we can clearly see, that contour lines almost perfectly fit the LiDAR contour lines, sometimes they are parallel displaced, but general shape is the same. Gullies, earth banks, paths are also clearly visible in the hillshading. Even some track displacements in original map can be clearly seen.

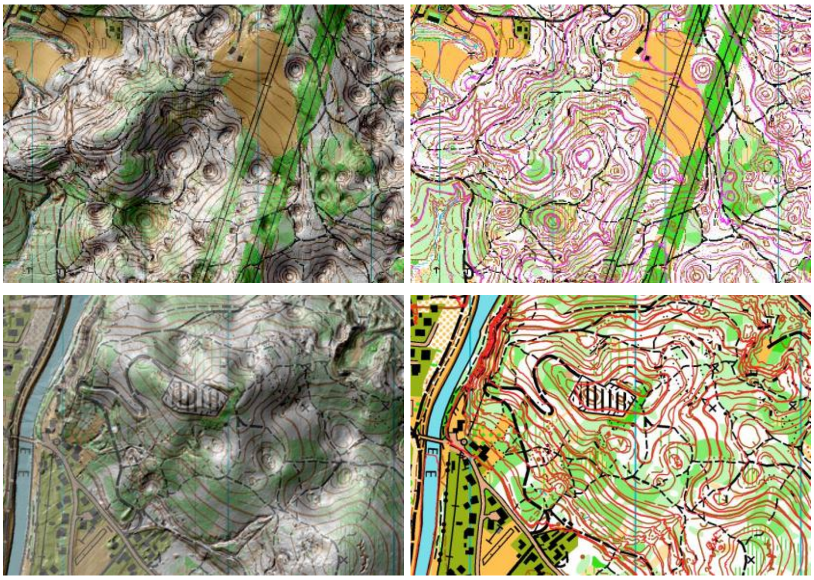


Figure 6: Test areas Krumperk and Šumberk

Figures 6 show two addition areas near Dom&#0;ale. The conclusions can be similar as at first two test areas, but in this case in karst type of relief some typical karst phenomena, especially depressions, are clearly visible. Even cliffs along the river and steep walls of abandoned quarry can be easily recognised.

The third typical area was selected in basic karstic 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 (figures 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.

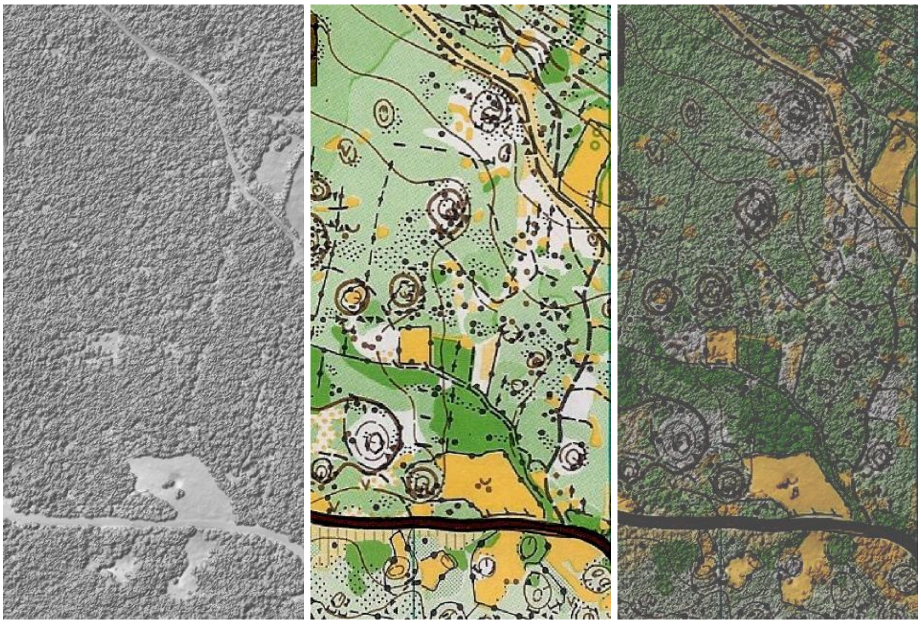


Figure 7: Test area Lipica - ALS hillshading, Orienteering map, combination

MAPS MADE USING LIDAR DATA

Upon experiences in the previous tests we tried to create a new map mainly using LiDAR data as a source. The test was done in the neighbouring area to the test area 1, near Ljubljana. From original LiDAR data we first extracted DTM with 0.5 m resolution and created hillshading image of the relief (figure 8 left). From this image we captured all recognised point or linear type shapes, that indicates some changes in the terrain. Some shapes were so specific that we managed to define the feature type, for the most of them field check was necessarily. The contour lines were created directly from LiDAR data with only some smoothing. Vegetation was extracted manually from refection data image (figure 8 middle). The result of the test was small orienteering map, presented in figure 8 right. 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.

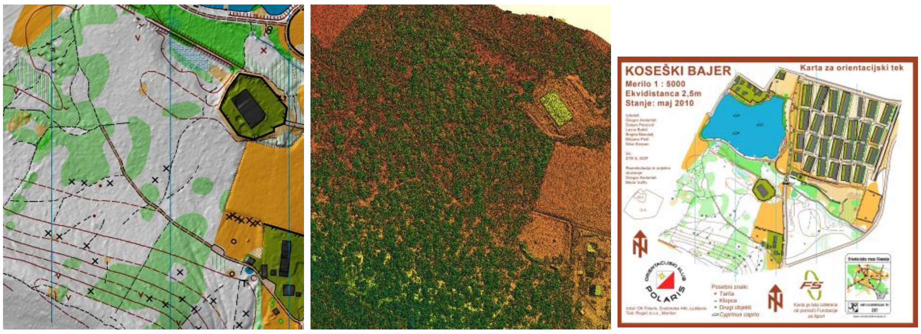


Figure 8: Orienteering map made mainly from LiDAR data

With the second case we went a step forward; our goal was to create an orienteering map with as less terrain work as possible. The truth is that for the foot orienteering map this would be quite impossible, but for the ski orienteering map such idea could be real. The area was quite large, the final map measures almost 8 sq. km. We started with national basic topographic database; we took buildings, roads, major power lines, streams and other water features. Most data were captured from LiDAR data, hillshading made from ground DTM was used for capturing ground terrain features (figure 9 upper right), while vegetation density and rides were identified from DSM hillshading (figure 9 upper left). Contour lines were created from DTM, too, while for object interpretation orthophoto images were used. Using only described bases the map was prepared without any hour spent on the terrain. The last part of map were ski tracks, we captured all of them the day before the competition using GPS devices, we just put one GPS logger on ratrac which prepared wide ski tracks. Minor track were made with scooter, again equipped with GPS logger. Finnaly, only 2 hours general field checking was done, more or less to check and to proof ourselves that map is correct.

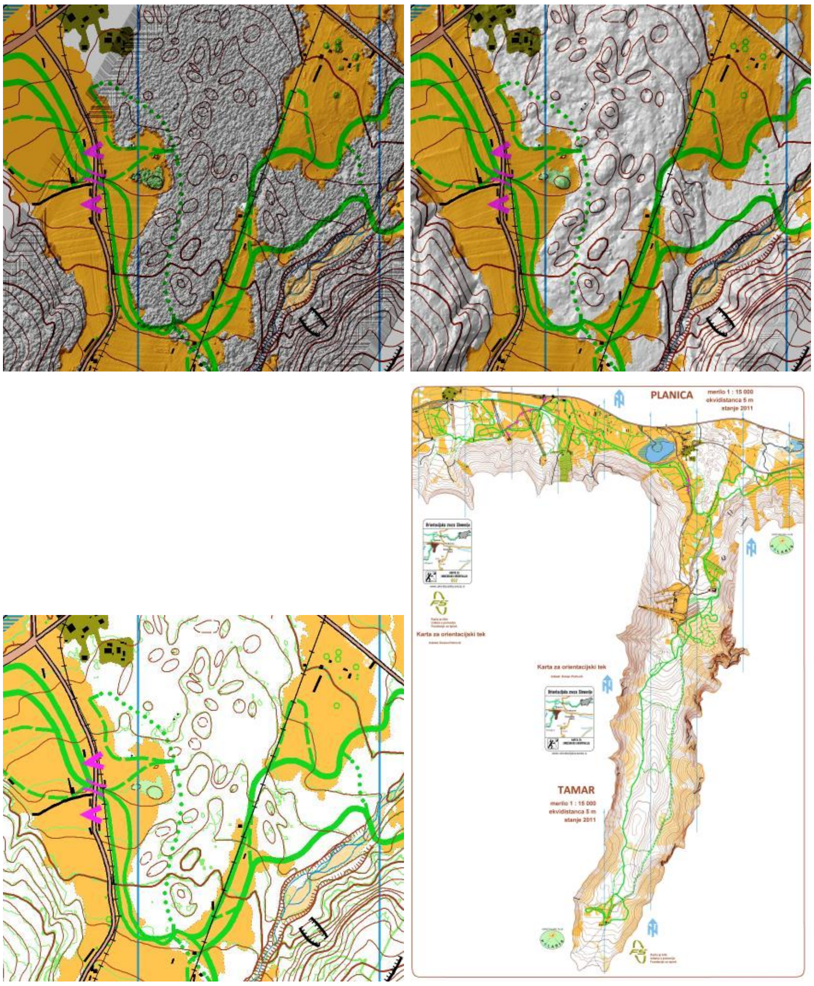


Figure 9: ski orienteering map made with no "traditional" field checking

CONCLUSION

The main goals of described tests were to get some experiences using LiDAR data for orienteering maps with general intention to reduce the amount of terrain work and to improve absolute accuracy of orienteering maps. With the final test we definitely showed that at least for ski orienteering maps the amount of terrain work can be reduced almost completely, but this could not be the case for foot orienteering maps. Our next project will be map for mountain bike orienteering, discipline, where again maps are not so dense and we expect that the terrain work could be again reduced only on GPS tracking of all paths and tracks, at the same time their categorization have to be done.

For the future efficient use of LiDAR data for orienteering maps some more tests and research have to be made. 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). Visual capturing from hillshading is also time consuming and may result in loss of data. Therefore, 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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