Integrating LiDAR data into the workflow of cartographic representation

Thomas Gloor, OCAD Inc.

Abstract. In former days, the production of topographic maps required a lot of different data sources and the use of various (software-) applications. Since ten years, mapping, cadastral and land registration authorities are carrying out airborne laser scanning (LiDAR) to produce a Digital Elevation Model (DEM). It can replace different sources for cartographic representation. In order to optimize the whole workflow of cartographic representation and reduce its field work as much as possible, a DEM module has been integrated into the cartographic software OCAD. The experience shows, integrating LiDAR data into the workflow of cartographic representation improves the accuracy of the map, reduces the amount of work in the field highly and results in more efficient map production.

Keywords: cartographic representation, cartographic software, LiDAR, topographic maps

1. Introduction

In the past, the production of topographic maps required a lot of different data sources and the use of various (software-) applications. For instance, contour lines had to be derived by plotting them from aerial photos with a 3-D stereograph, water bodies, forest boundaries and man-made features were vectorized from rectified orthophotos, relief shading had to be created by hand in hundreds of hours. Missing map objects had to be identified and captured in the terrain. Finally, these various outcomes have to be incorporated into a whole map. These processes were very time consuming and expensive.

Since ten years, mapping, cadastral and land registration authorities e.g. in Switzerland, Sweden or Denmark are carrying out airborne laser scanning (LiDAR) covering the whole country to produce a Digital Elevation Model (DEM) for an affordable price or even free of charge. It can replace different sources for cartographic representation. For instance, contour lines and relief shading can be derived directly out of the DEM. Moreover, due to the high accuracy of the LiDAR data, its relief shading pictures allow identifying small ditches in the field, rock faces in slopes and even footpaths in forests, covered by trees.

2. Approach and Methods

In order to derive different interpretations of LiDAR data an analysis tool has been implemented into the cartographic software OCAD. It analyzes several different file types for LiDAR data or DEM data like:

- ESRI ASCII Grid (*.asc),
- Raw data ASCII XYZ file (*.xyz),
- ASCII Grid XYZ file (*.xyz),
- LAS file (*.las) and
- SRTM file (*.hgt) file.

At the end of the analysis procedure the imported LiDAR data or DEM will be saved in the OCAD DEM file format (*.ocdDem) and will be loaded to the OCAD map. The cell size range of the DEM can be set according its use between 0.01 and 650 m. The DEM can be split or merged with other DEM as well. Moreover, the difference of upper and lower DEM can be calculated and classified by heights.

The OCAD DEM file type allows deriving various interpretations and the OCAD DEM difference file allows classifying height of vegetation or buildings. The following outcomes support the cartographic workflow for topographic maps most.

3. Results

3.1. Create Contour Lines

Contour line interval can be chosen individually either for form lines, ordinary contour lines or index contour lines (for example 1m, 5m, 25m) at the same time. In addition they can be assigned to map symbols (e.g. brown dashed line, line, and thick line) as well.

However, calculating contour lines for a single sheet of a topographic map could run for hours or even days in order to have continuous contour lines. To reduce time, an option has been implemented calculating contour lines according small tiles of the DEM. Afterwards; the split contour lines will be merged to continuous contour lines. This procedure reduces the time for calculation intensely.

Depending on the quality of the input data, the derived contour lines must be smoothed to achieve cartographic representing standards (see Fig. 1a). Smoothing tool like with Douglas-Peucker algorithm or converting into Bézier curves will produce smooth bends of the contour lines (see Fig. 1b).

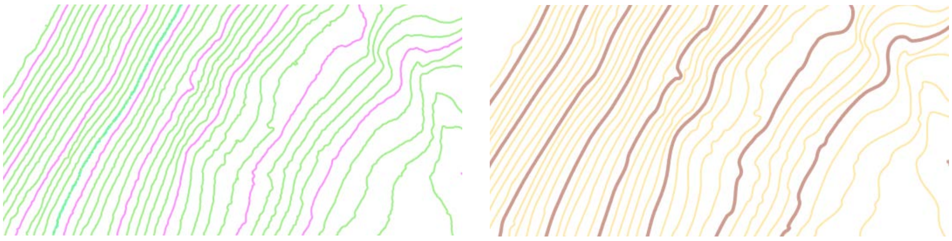

Figure 1a. Derived contour lines (green) and index contour lines (purple) from LiDAR Data. **1b** Contour lines smoothed with Douglas-Peucker algorithm and converted into Bézier curves.

3.2. Create Hill Shading

Topographic maps are often enriched with a (analytical) hill shading to replace a dense contour line image or to combine it with contour lines to improve its pseudo 3-D effect. Nowadays, the high accuracy of the LiDAR data and its (analytical) relief shading pictures allows identifying small ditches in the field, rock faces in slopes and even footpaths in forests, covered by trees.

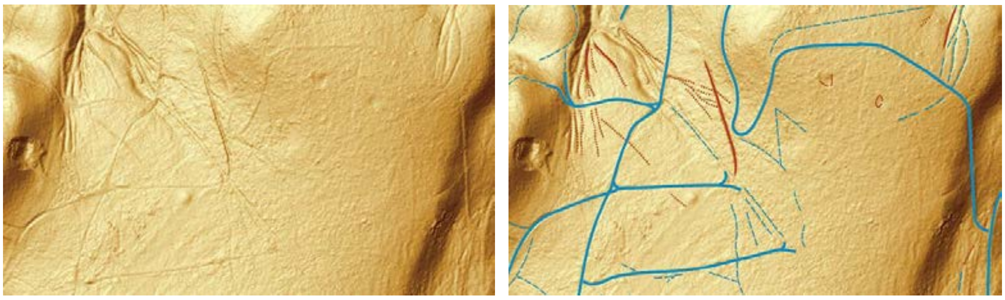

Figure 2a. Analytical hill shading of high accuracy LiDAR data. **2b** Vectorization and interpretation of man-made and land form features in the relief shading like tracks, footpath or even ditches.

Therefore, two calculation methods of the OCAD DEM analysis tool are available. The first option is optimized to see outlines of man-made and land form features (see Fig. 2a and b). The second option has an oblique light shading and is therefore recommended method if the hill shading should be used as a background relief of a map (see Fig. 3b).

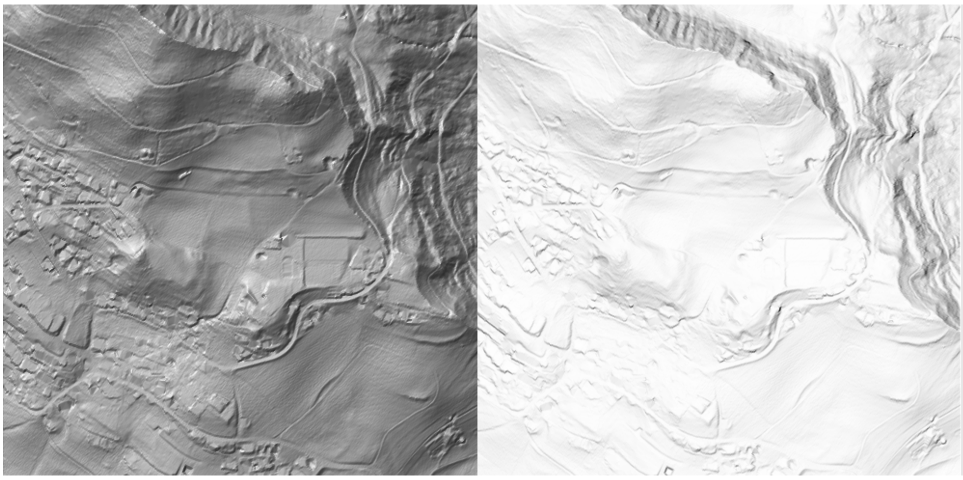

Figure 3a. Derived relief shading optimized to see outlines of features. **3b** Derived relief shading with oblique light shading recommended as a background relief of a map.

3.3. Calculate Slope Gradient

Slope gradient map also shows paths or relief features independent from light shading. However, slope gradient maps can be used to identify cliffs and rock faces as well. Continuous values of grey represent gradients of the slope (see Fig. 4a) starting from white (0° = white) and end with black (90° = black)

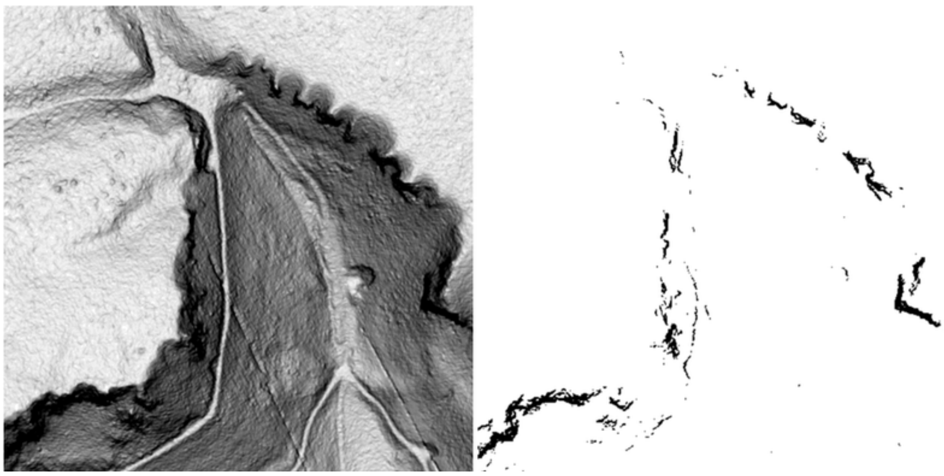

Figure 4a. Slope gradient map starting from 0° (= white) and ends at 90° (= black) **4b.** Cliff map, threshold at 45°.

In order to detect cliffs a threshold value has to be defined. All values below it will be represented as white (x° < white) and all values above it will be represented as black (x° ≥ black). The threshold for cliffs and rock faces between 42° and45° is suitable (see Fig. 4a).

3.4. Calculate DEM Difference

The differences from the upper DEM (Digital Surface Model, DSM) and lower DEM (Digital Terrain Model, DTM) calculated at the same location result in a height map. For better analysis the heights can be classified. For instance, the area with no difference of the DTM and the DSM are displayed in white, a height difference up to 15m appears in red (see Fig 5).

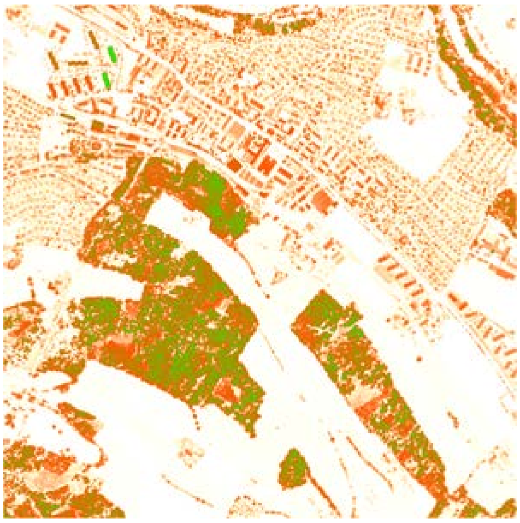

Figure 5. The area with no difference of the DTM and the DSM are displayed in white, a height difference up to 15m appears in red. (Test data Wabern from swisstopo).

4. Conclusion

Experience shows, integrating LiDAR data into the workflow of cartographic representation improves the accuracy of the map, reduces the amount of work in the field highly and results in a more efficient map production, especially for orienteering maps. However, the use of LiDAR to create topographic maps offers a lot of possibilities, to make the cartographic workflow even more efficient. Automatic deduction of man-made and land form features is only one example.