LASERSCANNING DATA AS BASIS FOR DERIVING ORIENTEERING MAPS - A SURVEY OF THE POTENTIAL AND FURTHER RESEARCH

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Abstract

The technology of Airborne Laserscanning data is becoming increasingly interesting for the production of orienteering maps. This is based on the fact that Laserscanning data are available more easily and to lower costs and also that the quality of these data is permanently increasing. They are used to derive very precise contour lines and path networks. But Laserscanning data have an advanced potential for derving other elements of orienteering maps as well that should be the objective for further research, which will be discussed in this article, adding to former research on this topic (cp. Gartner et al, 2007; Ditz et al, 2005).

Introduction

Contour lines and path networks derived from Laserscanning data are a necessary fundament for a fast and accurate fieldwork. So far, mainly linear features of orienteering maps are derived from Laserscanning data. Gartner et al (2007) and Rufer et al (2007) have proven that also relevant point features can be derived from Laserscanning data, at least manually. The objective of current and ongoing work is to develop strategies and methods to derive automatically point, linear and areal features for the production of topographic maps in general and orienteering maps in special.

Based on existing data various concepts of deriving orienteering map elements are discussed and demonstrated. The usual applied procedure includes the geometrical modelling, the semantic classification and finally the cartographic modelling, consisting of generalization and symbolisation aspects. So far, all of these steps are independently processed and no direct work-flow has been achieved yet.

Results of various derivations are compared and analyzed due to already exisiting maps. This provides a significant benefit for further developments in this context and can also be seen as a framework for possible application to general reference maps.

2 State of the Art of Laser Scanning techniques as data acquisition method for topographic features

Airborne Laser Scanning has developed into a common data acquisition method for topographic features, especially for deriving digital elevation models (cp. Briese et al, 2007) but also for deriving topographic features such as buildings (cp. Rottensteiner et al 2004; Dorninger et al, 2008). The overall idea consists of the creation of point clouds of the earth ground for further processing. A laser pulse, which is emitted by a laser transmitter, receives also the backscattered return. By this the distance to the object based on the time of the flight and a positioning system including Differential Global Positioning System (DGPS) and Inertial Measurement Unit (IMU) can be determined.

Usually airborne laser scanning campaigns try to cover a particular area with laser pulses and thus result in related point clouds. An important measure in that context is the point density on ground, which varies according to the used device and the flying height. In the meantime point densities of up to 16 points per sqm can be reached, which enable the method of airborne laser scanning as a suitable method for detecting and modelling even small topographic features. This is true also in forested areas, as at least some of the pulses are typically able to penetrate trough the canopy and provide information about the ground altitude.

Based on the point clouds spohisticated algorithms apply to model the topography and/or specific features. This is usually based on reflections from the ground and has to be often cross-checked by manual editing and filtering of the data.

3 The project “Mannersdorf”

The test area Mannersdorf is located southeast of Vienna in the Leitha mountains (“Leithagebirge”) near the Hungarian border. A RIEGL Airborne Laser Scanner LMS-Q560 (Riegl, 2009), operated by the company Milan Flug GmbH (Milan, 2009) was used to collect the full-waveform Airborne Laser Scanning (ALS) data. The scan was performed between 26th March and 12th April 2007, where the trees were still leafless. The flight altitude was about 600 m above ground, which resulted in a laser footprint size of 30 cm on ground. A preliminary georeferencing was done by the data provider, the final georeferencing was performed by the Institute of Photogrammetry and Remote Sensing at the Vienna University of Technology applying the method of simultaneous fitting of aerial Laser Scanner strips, described in Kager (2004). These ALS data were originally used for archaeological prospection of forested areas (cp. Doneus et al 2008).

The processing of the full-waveform ALS data was executed with the program SCOP++ (Kraus et al, 2005; Inpho, 2009). Additional information of the received echoes allows the determination of first, last and further intermediate echoes. This is necessary for deriving a Digital Terrain Model (DTM) and a Digital Situation Model (DSM). To derive an enhanced DTM, the last echoes have to be classified in ground points and off-terrain points. In addition, the off-terrain points can be distinguished in houses and low-, medium- and high vegetation which can be used for further analysis as shown later.

4 Analysis and Interpretation of results

The actual orienteering map “Mannersdorf” (2007) at the scale of 1: 10 000 was created by applying GPS as primary data acquisition method. The editorial work was done by a member of the Viennese Orienteering Club “Naturfreunde Wien”. In the research described in this paper the orienteering map “Mannersdorf” was used to analyse the potential of Laser Scanning data by visually comparing the data with the orienteering map. For a higher geometric accuracy, the orienteering map was geo-referenced in a GIS by referencing the road and the path network onto an orthophoto. The geo-referenced map is than compared with the filtered and classified ALS data. The results shown in the figures are enlarged to a scale of 1 : 4 000. The remaining inaccuracy of features (especially contour lines) could be explained with the method used for data acquisition of the map campaign.

In the following chapters the results of the qualitative comparison will be discussed. A special focus will be given to the geometrical quality of the results and the reliability of the classification of linear, point and areal features.

4.1 Linear features

As already demonstrated in Gartner et al (2007), linear features like paths and erosion gullies can easily be detected. Figure 1 shows at the upper part a DTM derived form ALS data with a grid width of 0,5 m and contour lines derived from the DTM. At the bottom, this DTM is combined with the orienteering map and the contour lines. Figure 1 illustrates, supporting the findings of Gartner et al (2007), the high geometrical quality of the contour lines derived from DTM in the context of orienteering maps.

Figure 2 shows that further linear features like rock faces and earth walls and not only erosion gullies or paths can be detected from the DTM. The upper part of figure 2 represents the DTM, while at the lower part of figure 2 the DTM is again combined with the orienteering map. The green markings display earth walls that are too small to be visualized with contour lines. This feature can be depicted with a high geometric accuracy and probability, as the comparison with the orienteering map shows.

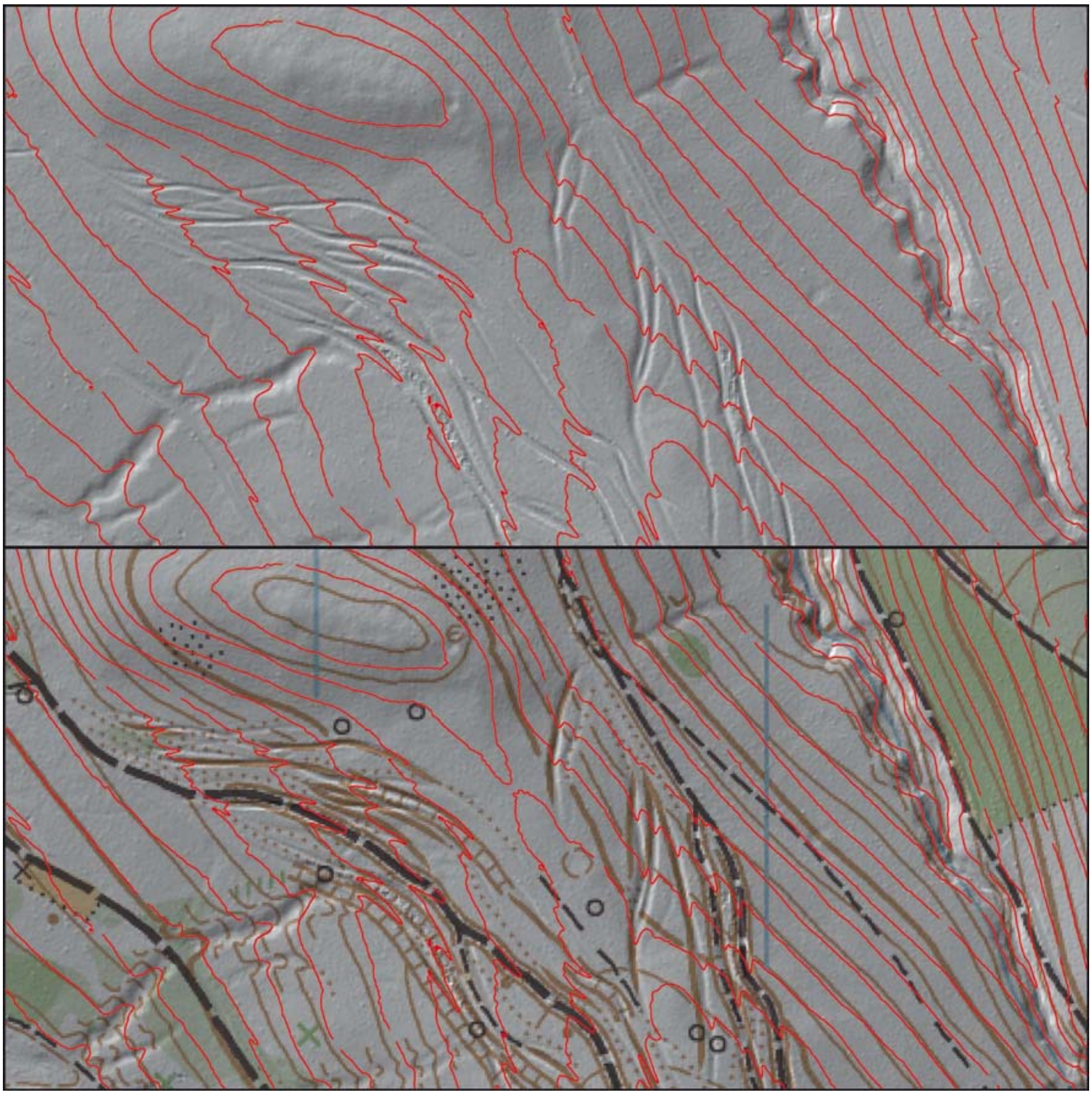

Figure 1: Linear features like erosion gullies, paths and contour lines

Rock faces can be detected easily as well in terms of the geometrical definition, as highlighted with blue markings. A semantic classification as rock face remains insecure and therefore uncertain.

In summary the geometry of linear features can be detected with sufficient reliability while a semantic classification of the feature type is hard to define. An additional validation is necessary, either by using additional data such as orthophoto or by executing a topographic field work campaign.

4.2 Point features

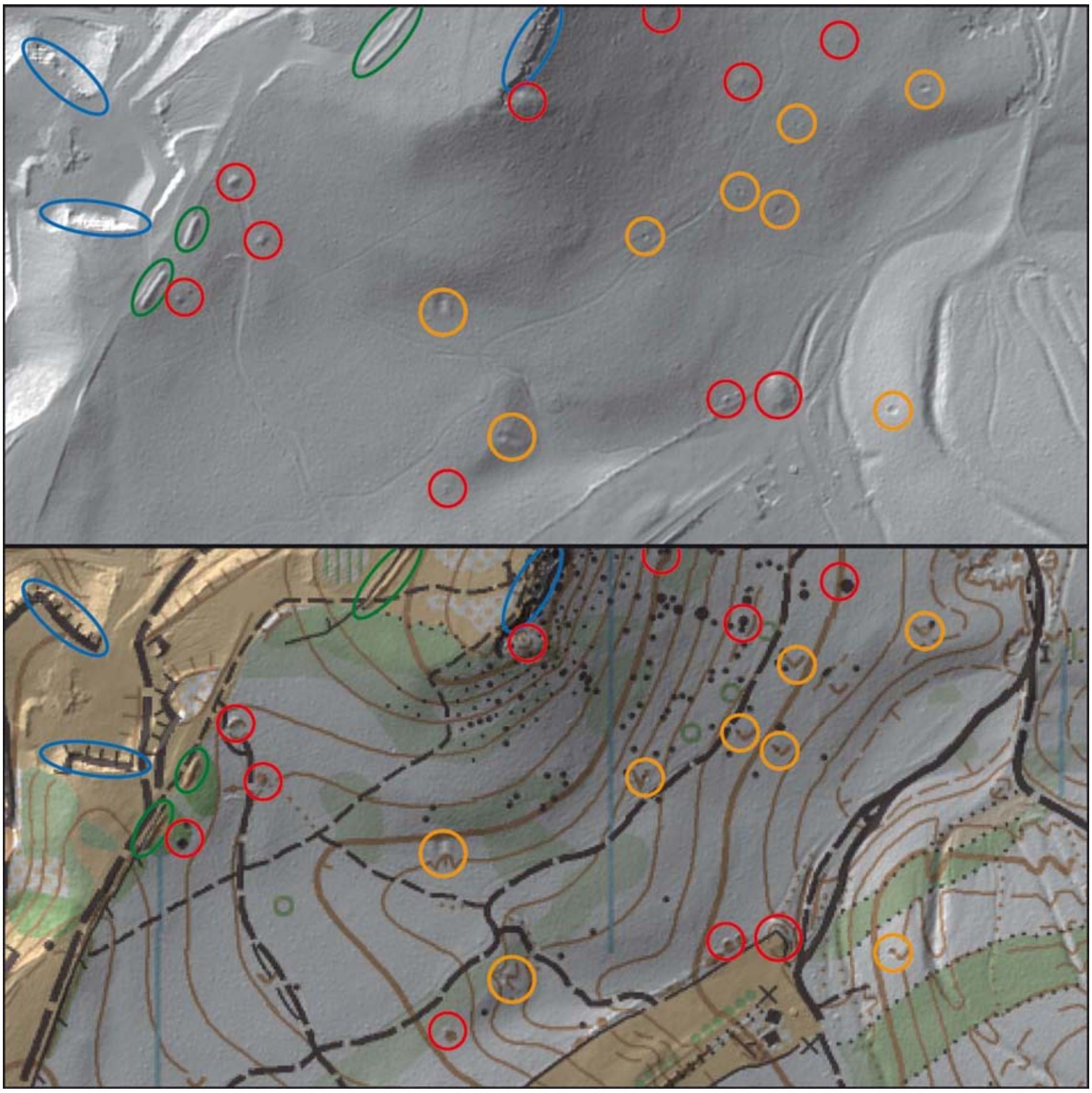

Figure 2: Point features like knolls, depressions, pits and boulders and further linear features like rock faces and earth walls

Point features can be detected with different grades of quality, using a high resolution DTM. Land forms like pits, holes or depressions can be depicted with a high geometric accuracy and probability, as shown in figure 2, marked with orange circles. The size of the feature is an important attribute to be used for the identification of the feature type. Features like small knolls and boulders, marked with red circles, can be depicted with a sufficient geometric accuracy but remain uncertain in their semantic plausibility, except those knolls that are large enough in size to be visualized with contour lines. The classification has to be done again at the field work.

There are not many experiences reported on detecting point features in the context of orienteering maps. The results shown above are promising, but currently not operational. The numbers of possible point features that can be depicted is still negligible in terms of what would be needed for deriving all relevant point features of common orienteering maps. The achieved geometric accuracy is definitively sufficient for the purpose of an orienteering map, but the semantic plausibility of some features has to be improved to guarantee a significant fundament for the necessary field work and to minimize time and effort of classification of not identified features.

4.3 Areal features

For the detection of areal features, especially vegetation, a DSM has to be used. At the lower part of figures 3 and 4, the DSM is shown in combination with the orienteering map. The filtered point cloud of the first pulse data could be applied to depict open land, as illustrated in figure 3 at the upper part with the green lines. The orange lines of figure 3 shows areas of rough open land that could not depicted from the DSM, but that are slightly represented with a different surface structure compared to the ground structure of the surrounding forest. These areas can also be recognized in classified model of high vegetation, due to different structures. The model of high vegetation is shown at the lower parts of figures 3 and 4.

For the detection of areas of constricted runnability, the classified model of high vegetation, created during the process of generating the DTM, has to be used. Figure 4 illustrates an example of this model, were relatively sharp edges of these areas of constricted runnability could be discovered. One possible explanation for this phenomenon could be a different height of the vegetation in the areas with constricted runnability compared to the height of trees in open forest.

This example demonstrates as well the constraints that have to be estimated at present state of research. The edges of those areas of high vegetation in the classified model are not significant certain to achieve a sufficient geometric accuracy and it could not be guaranteed that all areas with constricted runnability could be recognized.

Figure 3 illustrates in the classified model of high vegetation on the left side, that open land, marked with red lines, has also a significant different structure compared to the rest of the vegetation. The disadvantage of this model as a basis for the depiction of open land is again the poor geometric accuracy of the boundary.

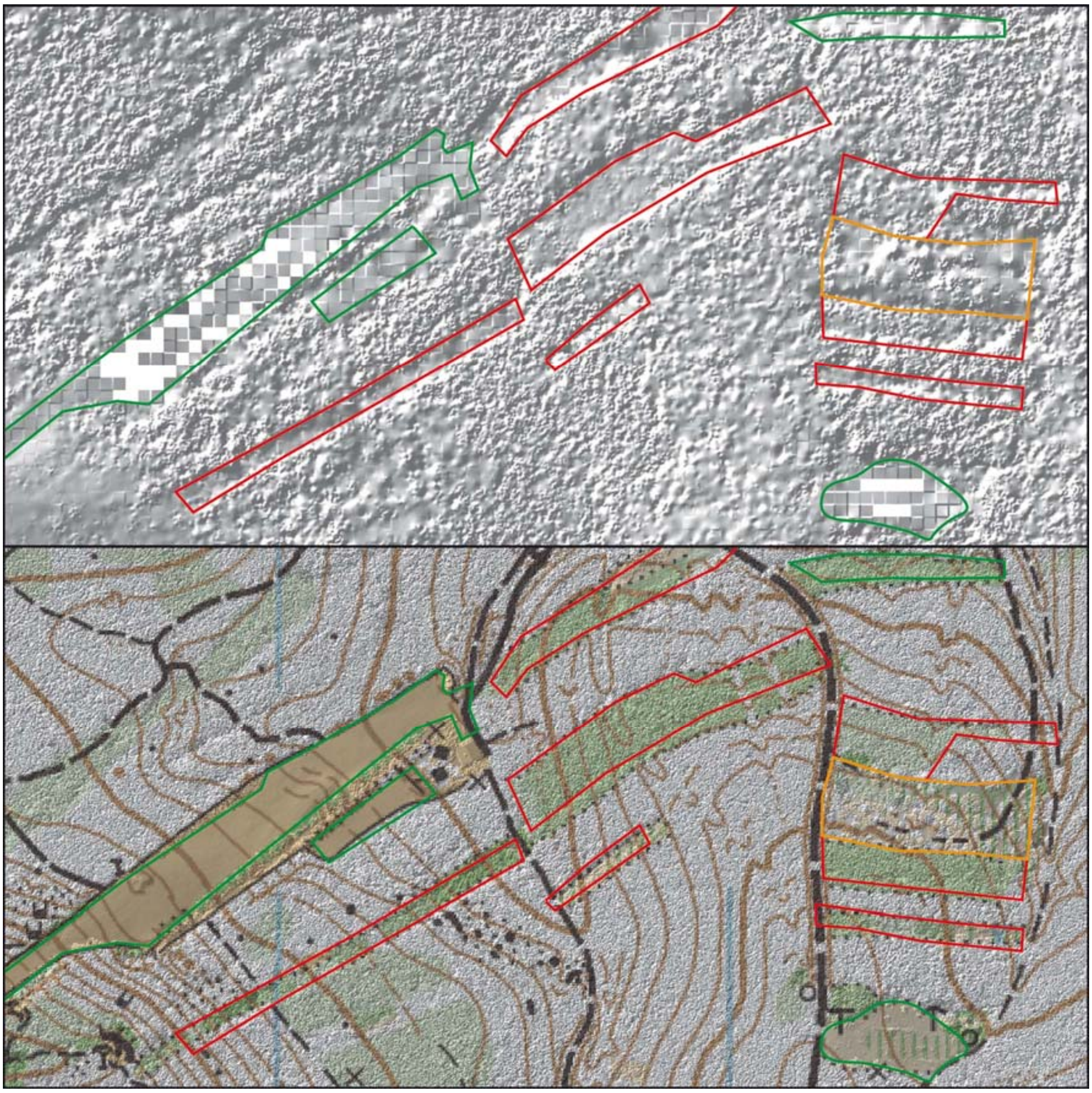

Figure 3: Detection of areas with different vegetation

To summarize, the potential of LaserScanning data as a fundament for deriving areal features of orienteering maps is still in an immature status. The problem of defining certain and sharp geometrical definitions has to be seen in a close context with the semantic definition of the features. However, it can be assumed, that as shown in the comparison above, particular characteristics of orienteering maps as e.g. the “runnabiliy of forests” might be derivable in the future.

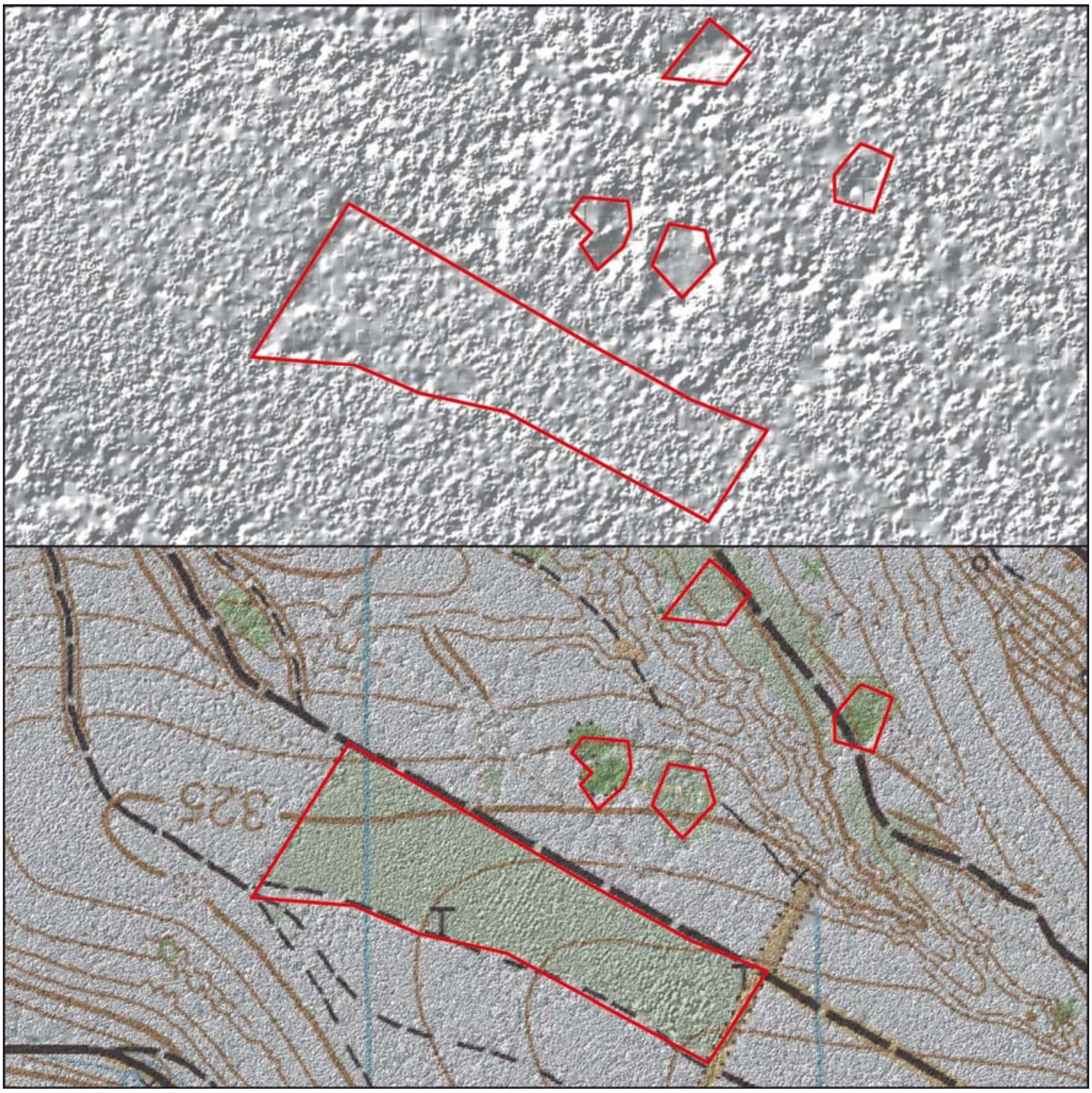

Figure 4: Detection of areas with constricted runnability

5 Conclusions

As a result of the qualitative comparison being described in this paper it can be stated, that by applying interpretation methods and geometric derivation algorithms, point, linear and areal map features can be derived from ALS data, which have comparable characteristic as features being derived from “classical” cartographic methods. Research in that area, especially in the context of orienteering maps, is still in an immature state but the results being available so far demonstrate promising potential.

Further work will have to done in means of establishing a direct work-flow. A special focus will have to be given on small man-made features and vegetation classification as demanded by the International Orienteering Federation (IOF) Map Specifications.

References

Briese, C., Doneus, M., Pfeifer, N., Melzer, T. (2007): Verbesserte DGM-Erstellung mittels Full-Waveform Airborne Laserscanning. In: "Dreiländertagung; Von der Medizintechnik bis zur Planetenforschung - Photogrammetrie und Fernerkundung für das 21. Jahrhundert", E. Seyfert (Ed.), Publikationen der Deutschen Gesellschaft für Photogrammetrie, Fernerkundung und Geoinformation E.V., Band 16 (2007), p. 215-222.

Ditz, R., Gartner, G. (2005): Applying Laser Scanning as a basis for deriving Orienteering Maps of Vienna. In: Proceedings of the 22nd International Cartographic Conference, A Coruna, 2005.

Doneus, M., Briese, C., Fera, M., Janner, M. (2008): Archaeological prospection of forested areas using full-waveform airborne laser scanning. In: Journal of Archaeological Science 35, 2008, p. 882-893.

Dorninger, P., Pfeifer, N. (2008): A Comprehensive Automated 3D Approach for Building Extraction, Reconstruction, and Regularization from Airborne Laser Scanning Point Clouds. In: Sensors, 8 (2008), 11, p. 7323-7343.

Gartner, G., Ditz, R., Pfeifer, N., Briese, C., Mücke, W. (2007): Laser scanning Data for Cartographic Data Modelling of Orienteering Maps. In: Proceedings of the 23rd International Cartographic Conference, Moscow, 2007.

Inpho (2009): http://www.inpho.de/ (last visited 2009 07 29)

Kager, H. (2004): Discrepancies between Overlapping Laser Scanning Strips-Simultaneous Fitting of Aerial Laser Scanner Strips. In: Proceedings of the XXth Congress of the International Society for Photogrammetry and Remote Sensing, O. Altan (ed.), Istanbul, Vol XXXV, Part B/1 (2004), p. 555-560.

Kraus, K., Otepka, J. (2005): DTM Modelling and Visualization - The SCOP Approach. Photogrammetric Week. Wichmann Verlag, Heidelberg (2005), p. 241-252.

Milan (2009): http://www.milan-flug.de/ (last visited 2009 07 29)

Riegl (2009): http://www.riegl.com/ (last visited 2009 07 29)

Rottensteiner F., Briese C. (2004): Automatische Erfassung von Gebäudemodellen aus Laserscannerdaten und die Integration von Luftbildern. In: Photogrammetrie, Fernerkundung, Geoinformation (Pfg), Heft 4 (2004), p. 269-277.

Rufer, F., Steiner, U. (2007): Erfahrungen mit Laser Scanning Daten, Empfehlungen. SOLV Kärtelertagung 2007.
(http://www.swiss-orienteering.ch/files/kommission_karten/kt/kt2007_erfahrungen_empfehlungen-laser_scanning.pdf) (last visited 2009 07 29)