Some using of airborne laser scanning in archaeology

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Abstract. Since autumn 2009 the entire area of the Czech Republic has been mapped by the technology known as ALS. Investors of this project are the Czech Office for Surveying, Mapping and Cadastre (CUZK), the Ministry of Defense and the Ministry of Agriculture of the Czech Republic. The aim of the mapping is to get an authentic and detailed digital terrain model (DTM) of the Czech Republic. About 80% (autumn 2012) of the Czech territory is currently covered by the DTM based on ALS, and by spring 2013 the mapping should be completed. The standard deviation of model points in altitude is better than 20cm. The technology of aerial laser scanning from the last ten years has been well used for DTM generation; A DTM displayed in an appropriate form can be used as a data source for searching and describing of archaeological sites – mainly in forested areas. In 2012 we started the project focused on the search for old and possible new archaeological areas by use of ALS. For the identification of small digs or historical objects, custom made data with high density and precision is needed. The goal of our project is to identify interesting known and unknown formations on the entire territory of the Czech Republic and make their ground verification. Not only archaeological and historical sites are discovered; also identified were interesting and unknown mining structures from the past such as the rests from a historical military fortification. This contribution will refer about results of our project.

Keywords. ALS, DTM, terrain classification, archaeology, shaded relief, mining

1. Introduction

The mapping of the Czech Republic territory using ALS method will be finished by July 2013. It began in 2009 with the main reason of creating a better digital terrain model (DTM) for better orthophoto production. Density of this DTM is 1-2 points/m2 [1], [4]. Accuracy is given by standard deviation and reaches 19cm in the high; this is enough for searching and mapping of objects with a size of tens of meters and larger. The full-waveform scanner RIEGL LMS 680 on board Czech aircraft L410 is currently being used. The average flying height is approximately 1200-1500 m above ground level. The aerial laser scanning (ALS) data seems to be appropriate tool for documentation or detection archaeological sites on a larger scale; unfortunately the ALS data is generally too expensive to be commonly used for archaeological purposes only. In our research we try to use ALS data acquired by public service (Czech Office for Surveying, Mapping and Cadastre) for mapping purposes. This data has in general lower density than expensive custom-made data, but they can be borrowed for research purpose. We used the DTM in shaded surface form. Our work is based on visual interpretation of the ALS data around known archaeological sites and searching of new areas. The orthophotos from different years and vegetation period helps in many cases in this project. It is also possible to use different outputs from the original DTM to better display terrain discontinuities, which could be caused by human activity. It can serve for searching for unknown historic sites - remains of forts, barrows, etc. Using a shaded surface with resolution 1m, we are able to descry objects with size from about 10m. It is hard to find small objects (e.g. barrows) from data noise. The chance to find such an object strongly depends on the season in which the data was acquired, and the vegetation cover [2], [3]. It is almost impossible to perfectly classify the lidar signal-returns from dense deciduous forests in the summer [10].
2. Methods

We use visual image interpretation based on gray scale shaded relief, which is distributed as a tiff file. The files are segmented as well as the Czech map Series scale 1:5000. Software SCOP++ was used for data preparation to the form of shaded relief with following parameters: illumination azimuth 315° (north-west), height above terrain 45°, pixel size is 1x1m. [4], [5]. Terrain break lines, partial primitives and structures are highlighted using shaded relief. [6], [7], [8], [9]. Using visual interpretation not only known or unknown archaeological and historical sites are discovered; there were identified interesting yet unknown mining structures from the past such as rests of historical military fortification from the Thirty years war, the Prussia-Austria war, the 2nd World War and from the Cold war [2], [3] (Fig. 1-12). Visual interpretation of shaded relief isn’t the only source of good results; other information is necessary, such as on-line maps (tourist, historical), free orthophotos on web (there are layers from 2002 with 1m pixel, from 2006 with 50cm pixel and from 2012 with 25cm pixel size), history web sites, literature and field survey. Majority of found objects were verified using web –tourist map and by using of literature (thematical atlas of historical objects and lexicons, Fig.10). Only of about 5% of found objects seems to be unknown (Fig.2, 3); it is necessary verify these objects using terrestrial prospection or by searching in archives. At the moment, we have data from approximately 70% of the Czech Republic area and 50% is visually interpreted. Interesting results were obtained.

3. Results

In terms of found objects we created characteristic classes:

- Forts
- Castles
- Historical military objects (fortification)
- Historical mining activity
- Fortified settlement
- Burial mounds
- Abandoned villages

Forts

Figure 1. Mrdice near Pardubice - remnants of fort from 14th century; shown here is a better mapping of the known sites. You can see differences between past and present-day methods (old sketch based on stepping, situation displayed in shaded relief and orthophoto).
Figure 2. Examples of new found objects, Liteň – unknown object - perhaps searched for yet not found; shaded relief and orthophoto (Geodis,a.s.).

Castles

Figure 3. Undefined object near Lichnice castle on opposite hill; shaded relief and orthophoto (Geodis,a.s.).

Military objects

Figure 4. Provodin – rampart from the Prussia - Austria war in the mid of 18th century, 1.5km long (ALS data and photo from field survey)
Figure 5. Dobřenice, Osičky – near Hradec Králové - found on orthophoto (no ALS data are at disposal yet). Here was battle between Prussia and Austria, 1866. It is may be field fortification remnants. Orthophoto (Geodis,a.s.).

Figure 6. Right, historical image of a redoubt; left: redoubt near Volary in forested area on shaded relief

Figure 7. Artillery redoubt from Prussia – Austria war near Třeboutice on ALS data (left) and on orthophoto (right, Geodis, a.s.).
Figure 8. Černošín near Třebel (castle) – unknown object - may be a field fortification from Thirty Years War; near Třebel was battle between Sweden and Austrian Empire (1647); shaded relief and orthophoto (Geodis,a.s.).

Mining activity

Figure 9. Mining pits Jachymov; Medieval silver mines and uranium mines from last century; shaded relief and orthophoto (Geodis,a.s.).

Fortified settlement

Figure 10. Object identification with new fortification details– Celtic oppidum Vladař; shaded relief and tourist map (www.mapy.cz).
Burial Mounds

Figure 11. Examples of found objects, other barrows near Radetice; shaded relief and orthophoto (Geodis,a.s.).

Abandoned villages

In the Czech Republic, there are many abandoned villages or settlements. They were abandoned for various reasons:

- After the Thirty Years War
- After the 2nd World War (after the expulsion of the Sudeten Germans)
- Due to construction or mining activity

Figure 12. Hřebečná - orthophoto (Geodis,a.s.) from 2011 and orthophoto from the fifties (based on historical aerial photos) and northern part of Hřebečná today on ALS data

4. Conclusions

We found many problems in the use of ALS data in archaeology, which lead to a small number of newly found objects:

- Errors from automatic filtration
- Low data density (but the main purpose of data collection was not an archaeology)
- Only one type of shaded surface (there are a lot of possibilities how it is possible to visualize DTM)
- „Interesting“ object found on shaded relief are not archaeological sites
- Many objects are not known „normally“ – only for historical specialists
- Errors caused by low dense vegetation; manual control needed

Generally we can say that ALS data and orthophotos provide interesting information for archaeology and historical object documentation.

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References
