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Refinement of ALS point cloud through the assessment of bare-earth classification algorithms: the AYPONA Project case study

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INTRODUCTION

Aerial laser scanning (ALS) data are frequently used for archaeological survey, especially over forested areas where other methods are limited by visibility (aerial or satellite imagery) or accessibility in the field (geophysics). The emergence of these new datasets promotes the development of new tools for data visualisation through a multitude of spatial filters focused on archaeological detection (Lastools, RVT, LiVT). These specific software packages, despite some limitations regarding the size allocated to the processed files are increasingly helpful for the exploration of the data. Processed images can be used for automated detection and for exploring large areas where traditional data interpretation is time consuming. All of these developments are based on an efficient classified dataset, often delivered by the contractor. In the case of the AYPONA Project, this classification was rough and some inconsistencies were quickly detected. In order

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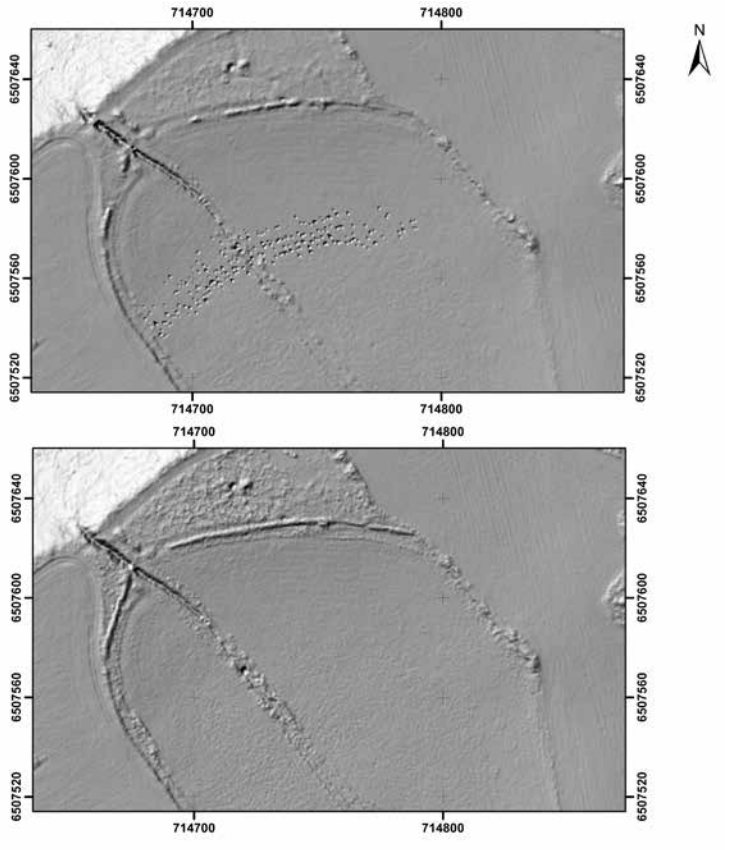

Fig. 1. Hillshade filtering applied to the presented procedure (b) and to previously processed data (a). The new filter keeps walls under low dense vegetation and removes outliers

to improve the full exploitation of our dataset, different algorithms were assessed through free scripts/software available on the Web in order to find the best way to classify the return points in the specific case of slope and flat areas with low and dense vegetation.

THE AYPONA PROJECT

Corent is a major site for understanding patterns of proto-urbanisation in Gaul, revealing the complexity of the Arverni territory and the close connection it had with the Mediterranean world from the Bronze Age to the Gallic Wars. The settlement covers an area of 50 ha and is located 15 km south of Clermont-Ferrand (France), on a volcanic plateau. According to the results of excavations undertaken since 2001, Corent reached its prominence during the Gallic period, but proved also to be a major settlement during the Bronze Age and Antiquity. Religious and assembly buildings, areas

for handcraft activity and a commercial complex have been unearthed. The tremendous archaeological potential of the site is the main driving force of the AYPONA Project "Landscapes and faces of an Arverni agglomeration: an integrated and diachronic approach of the settlement of the oppidum of Corent." Its goal is to merge different approaches such as environmental archaeology, GIS, geoarchaeology and remote sensing to model the spatio-temporal trajectories over the long-time, and to understand the human impact and the appropriation of this settlement until the development of an urban agglomeration. The project is based on high spatial and temporal resolution analysis, in order to understand the landscape changes and define the challenges faced by the local population in the context of the environmental evolution of the site. In addition to current excavations, our work is based on coring, trenching, environmental analysis and a geomatic approach that utilizes LiDAR.

ALS DATASET

The ALS dataset was collected over an area of 22 km^2 with a Lit Mapper 6800 by IMAO aerial survey. It delivered a high point density (18 pt/m^2) and a full dataset cut into 140 slabs. The data were initially processed for bare-earth classification and a DEM was generated by the contractor. Erratic outliers and effects induced by the reattachment of the slabs affected the quality of the processed data. Moreover, the first visual analysis showed some inconstancies from a strong filtering process that removed ground points which could be potential archeological remains. This problem was obvious under low and dense vegetation, where walls could not be distinguished because of the plant coverage. The vegetation was a challenge in any case, because of the proximity of the trees to the remains/ground and on the slopes. After classification, open areas revealed a strong decrease of point density as well. In order to improve this classification, different algorithms were tried.

ASSESSMENT OF ALGORITHMS

In an initial step outliers were removed. These outliers were characterized by a lower intensity than other returns. This simple filtering produced an initial processed dataset which was especially useful regarding the effects generated by these points during the classification. At a second stage, three different algorithms partly tested in other studies were tried (Lugmayer-Klimczyk *et al.* 2014). They were selected because they have been developed specifically for the classification of bare-earth and vegetation. The first is an algorithm implemented in SAGA software developed through a slope-based filtering (Vosselman 2000). The second one is the BCAL algorithm developed by the Boise Center Aerospace Laboratory of Idaho for shrub-steppe ecosystems (Tinkham *et al.* 2011). The last one, Multiscale Curvature Classification, was developed by the Moscow Forestry Sciences Laboratory of the USFS Rocky Mountain research Station (Evans and Hudak 2007) for high biomass forest ecosystems.

CONCLUSION

In our case study, the Multiscale Curvature Classification algorithm proved superior for the classification of points (Fig. 1), while BCAL and Vosselman algorithms failed under the low dense

vegetation, especially on the slopes. Nevertheless, this solution was not perfect, because of the persistence of some artifacts. The filter removed the remains of a medieval tower in the vicinity of the settlement as well as small bridges, although other contemporary buildings were not interpreted as vegetation points. In the future, other algorithms should be assessed, like the Opitz algorithms that produce a classification between trees and bare-earth, but also archaeological remains. Work will now be continued, checking different hypotheses about rampart and door systems of this settlement, using geophysical methodologies (ERT, etc.).

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