Testing ALS Visualisation Methods for Detecting Kiln Remains in a Densely Vegetated Area in Japan

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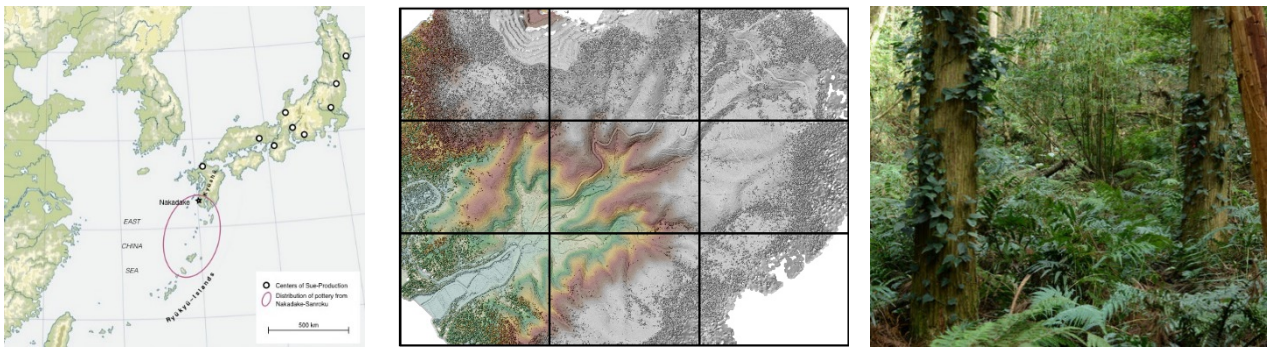
Introduction

Since 2012, field walking surveys and geophysical prospection as well as an excavation have documented remains of several Sue pottery kilns dating in the 9th century at Nakadake Sanroku, Kagoshima prefecture, southern Japan (Fig. 1a; Nakamura and Yoshimoto, 2015; Matsusaki, 2018). They were constructed by digging tunnels into the slope of hills, typically with a width of about 2 m and a length of more than 5 m. Most of the tunnels collapsed in the course of time forming elongated depressions with a depth of about 20 cm. These remains are hard to detect in the densely forested, mountainous area (Fig. 1c). Therefore, airborne Lidar was considered the method of choice for effectively identifying additional kiln sites. Only a few Lidar projects have been carried out in Japan up to now, and these focused on more prominent features such as castle remains. But this new project had not only to deal with the dense vegetation and large differences in altitude, but also with mostly inconspicuous sites in an area that experienced considerable relief change by agricultural use during medieval and early modern times.



a *b* *c*

Fig. 1. a) Location of the study area; b) ALS tiles; c) typical vegetation (© Maria Shinoto, Michael Doneus).

In May 2018, Lidar data was acquired using a scanner of type RIEGL VUX-1UAV on an octocopter (Glyphon Dynamics GD-X8-SP) in a test region covering 0.5 km². At least 100 points/m² were recorded with a conservatively estimated horizontal precision of 10 cm on densely covered forest surface.

Experience from the Rhineland area showed that sunken roads could be reliably identified in forest areas based on 1 m grid data (Herzog, 2017). Therefore, it seemed more than likely that the laser scanning elevation data of the Japanese study area suffices for detecting kiln sites. However, postprocessing the data turned out to be a challenge. This presentation will discuss the outcomes including some of the difficulties met when applying the low-cost or free software available for the visualisation of Lidar data.

Comparison of Visualisation Software

Nakanihon Air Service recorded the Lidar data and provided the outcome in several file formats, subdivided into nine tiles, each covering 400 m x 300 m (Fig. 1b): las, xyz and interpolated grids with a cell size of 5 cm.

For visualising these data, four programs were used: Relief Visualisation Toolbox (RVT – Kokalj and Somrak, 2019), QGIS, MapInfo with plugin Vertical Mapper (MIP/VM), and planlauf/TERRAIN. RVT was successfully applied for nearly all Lidar grid tiles provided by the Ordnance Survey institution in the Rhineland (Herzog, 2017). Version 1.3 of this user-friendly toolbox offers ten methods for visualising

elevation grid data beyond simple hillshading; it is able to create all desired visualisations in one run. For the Rhineland data, hillshading from multiple directions, simple local relief model (SLRM) as well as positive and negative openness were considered the most useful RVT methods. All possible visualisation options of RVT 1.3 with default parameters were generated for five of the Lidar data grid tiles in the Japanese study area for unchanged elevation and exaggeration factor 5 (e.g. Fig. 2, SLRM / RVT). However, often RVT results based on the grid files supplied by Nakanihon Air Service or calculated by GIS software were disappointing at first sight. This could be addressed by selecting an appropriate contrast enhancement.

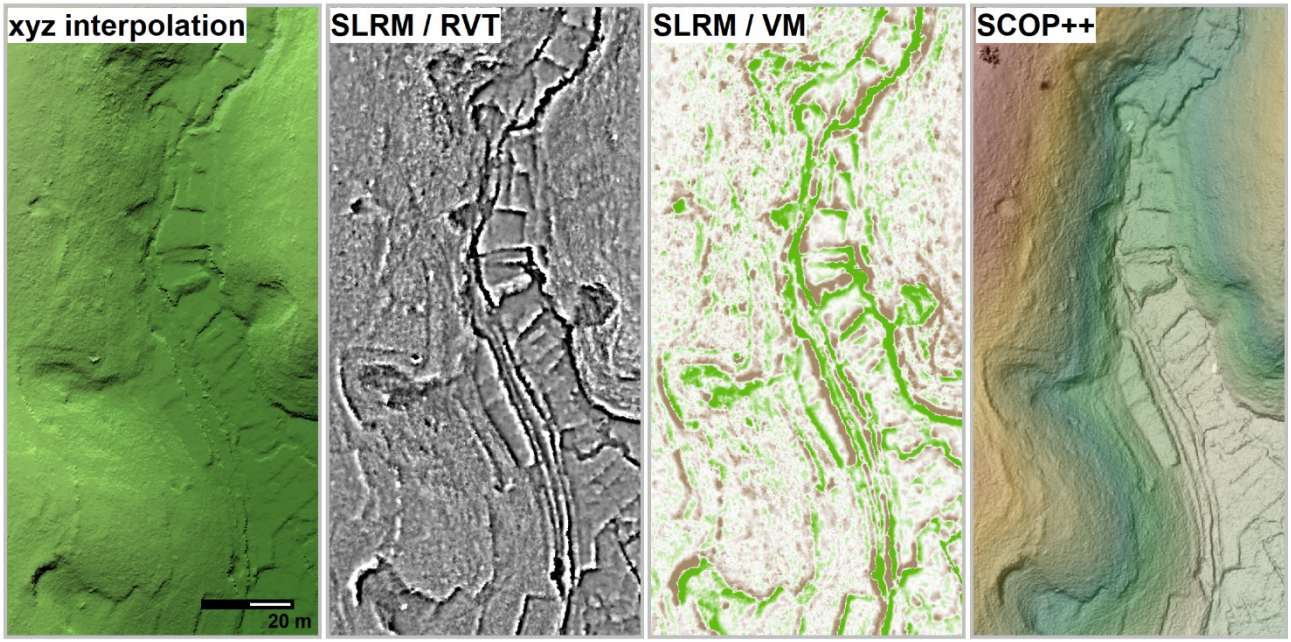


Fig. 2. Visualisations in a sample area with mostly high point density (© Irmela Herzog and Michael Doneus). Potential kiln sites were identified for each major indentation of the slope.

QGIS (3.4) and MIP/VM also include functions for visualising elevation grids (e.g. hillshade, slope, multiple hillshade, openness, sky-view factor, topographic prominence index) and for interpolation. MIP/VM was used to create an interpolation of the points in the xyz files (Fig. 2, left) and a SLRM visualisation (Fig. 2 SLRM / VM), green colour marking local depressions and brown local ridges or mounds; in most situations, this SLRM visualisation is more intuitive than that provided by RVT.

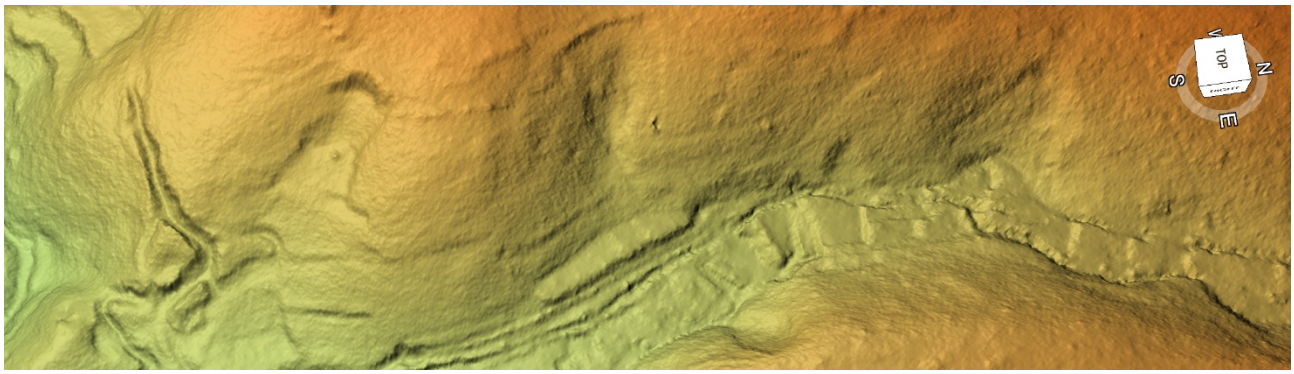


Fig. 3. 3D view generated by planlauf/TERRAIN based on the grid data (© Irmela Herzog).

But only after filtering the las files with specialized software (SCOP++) satisfying results for this complex data set were achieved (Fig. 2, right; details on SCOP++ are published by Doneus and Briese, 2006). The visualisation of the SCOP++ outcome in Fig. 2 uses the possibility of GIS programs to blend two or more layers, thus combining several visualisations into a single image (see also Kokalj and Somrak, 2019). In this case, slope, hillshade and colour-coded heights were combined.

An alternative low-cost program (non-commercial licence) is planlauf/TERRAIN (planlauf GmbH, 2019). This Windows application uses gaming approaches for mesh decimation and thus allows virtual flights through the 3D landscape in real time that can be saved as mpeg files. It is also possible to generate high-resolution screenshots (Fig. 3).

Discussion and Conclusions

Free or low-cost software supports the creation of a large number of (archaeologically) useful visualisations. In our case study, SLRM, both variants of openness, multiple hillshades and a combination of hillshade, slope and colour-coded heights seemed to be most useful. SLRM allows the identification of extremely shallow relief features. Multiple hillshades deliver a more intuitive picture, but directional bias results in horizontal displacement of features. This disadvantage is avoided by both openness variants, that allow a more accurate mapping of features in GIS. The combination of slope, hillshade and colour-coded heights conveys both the steepness of the terrain and the height differences in an intuitive way. Finally, virtual flights in a 3D environment enhance the perception of the 3D shapes of the archaeological features detected (see also Verhoeven 2017).

In this densely vegetated area in south Japan with substantial variation of altitudes, UAV-based Lidar proved to be a viable survey method. However, reliability of ALS data in such complex situations is still an issue. Simple approaches for assessing the reliability include density estimation of the recorded surface points and ground inspection. In early spring 2019, field work confirmed selected kiln sites identified in Lidar visualisations (Shinoto et al., 2019). SLRM maps and simple contour maps (interval: 20 cm) derived from the ALS data assisted orientation during ground inspection in case of GPS inaccuracies due to signal loss.

Still, analysing ALS data of a large area is time-consuming. Thus, developing algorithms for detecting relevant archaeological features will be another challenge for future research.

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