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Semi-automatic mapping of cultural heritage from airborne laser scanning using deep learning

Øivind Due Trier (1), Arnt-Børre Salberg (1), Lars Holger Pilø (2), Christer Tonning (3), Hans Marius Johansen (4), and Dagrun Aarsten (5)

(1) Norwegian Computing Center, Oslo, Norway, (2) Oppland County Administration, Lillehammer, Norway., (3) Vestfold County Administration, Tønsberg, Norway., (4) Sør-Trøndelag County Authority, Trondheim, Norway., (5) TerraTec AS, Oslo, Norway.

This paper proposes to use deep learning to improve semi-automatic mapping of cultural heritage from airborne laser scanning (ALS) data.

Automatic detection methods, based on traditional pattern recognition, have been applied in a number of cultural heritage mapping projects in Norway for the past five years. Automatic detection of pits and heaps have been combined with visual interpretation of the ALS data for the mapping of deer hunting systems, iron production sites, grave mounds and charcoal kilns.

However, the performance of the automatic detection methods varies substantially between ALS datasets. For the mapping of deer hunting systems on flat gravel and sand sediment deposits, the automatic detection results were almost perfect. However, some false detections appeared in the terrain outside of the sediment deposits. These could be explained by other pit-like landscape features, like parts of river courses, spaces between boulders, and modern terrain modifications. However, these were easy to spot during visual interpretation, and the number of missed individual pitfall traps was still low.

For the mapping of grave mounds, the automatic method produced a large number of false detections, reducing the usefulness of the semi-automatic approach. The mound structure is a very common natural terrain feature, and the grave mounds are less distinct in shape than the pitfall traps. Still, applying automatic mound detection on an entire municipality did lead to a new discovery of an Iron Age grave field with more than 15 individual mounds. Automatic mound detection also proved to be useful for a detailed re-mapping of Norway's largest Iron Age grave yard, which contains almost 1000 individual graves.

Combined pit and mound detection has been applied to the mapping of more than 1000 charcoal kilns that were used by an iron work 350-200 years ago. The majority of charcoal kilns were indirectly detected as either pits on the circumference, a central mound, or both. However, kilns with a flat interior and a shallow ditch along the circumference were often missed by the automatic detection method.

The successfulness of automatic detection seems to depend on two factors: (1) the density of ALS ground hits on the cultural heritage structures being sought, and (2) to what extent these structures stand out from natural terrain structures. The first factor may, to some extent, be improved by using a higher number of ALS pulses per square meter. The second factor is difficult to change, and also highlights another challenge: how to make a general automatic method that is applicable in all types of terrain within a country.

The mixed experience with traditional pattern recognition for semi-automatic mapping of cultural heritage led us to consider deep learning as an alternative approach. The main principle is that a general feature detector has been trained on a large image database. The feature detector is then tailored to a specific task by using a modest number of images of true and false examples of the features being sought. Results of using deep learning are compared with previous results using traditional pattern recognition.