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Detecting and connecting agricultural ditches using LiDAR data

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High-resolution hydrological data are essential for spatially-targeted water resource management decisions and future modelling efforts. For Flanders, small water courses like agricultural ditches and their connection to the river network are incomplete in the official digital atlas. High-resolution LiDAR data offer the prospect for automated detection of ditches, but there is no established method or software to do so nor to predict how these are connected to each other and the wider hydrographic network.

An aerial LiDAR database encompassing at least 16 points per square meter linked with simultaneously collected digital RGB aerial images, is available for Flanders. The potential of detecting agricultural ditches and their connectivity based on point LiDAR data was investigated in a 1.9 km^2 study area located in the alluvial valley of the river Demer. The area consists of agricultural parcels and woodland with a ditch network of approximately 17 km. The entire network of open ditches, and the location of culverts were mapped during a field survey to test the effectiveness of the proposed method.

In the first step of the proposed method, the LiDAR point data were transformed into a raster DEM with a 1-m resolution to reduce the amount of data to be analyzed. This was done by interpolating the bare earth points using the nearest neighborhood method. In a next step, a morphological approach was used for detecting a preliminary network as traditional flow algorithms are not suitable for detecting small water courses in low-lying areas. This resulted in a preliminary classified raster image with ditch and non-ditch cells.

After eliminating small details that are the result of background noise, the resulting classified raster image was vectorized to match the format of the digital watercourse network. As the vectorisation does not always adequately represent the shape of linear features, the results did not meet the high-quality cartographic needs. The spatial accuracy of the derived ditches was improved by referring to the original LiDAR point cloud data. In each 1-m buffer of the preliminary detected network vertices, the lowest LiDAR point was taken as the vertex of an improved network, shifting the preliminary network into the lowest 'depressions' of the study area.

A drawback of a morphological approach is that the connectivity of the network is usually poor since the pixels are processed separately. Therefore, the field observations on connectivity (including culverts) were used to develop an empirical model to estimate the probability of connectivity between LiDAR-derived ditch segments from auxiliary datasets and hydrological and morphological properties of the preliminary network. This allowed deriving a connectivity probability map. The underlying model was tested by cross-validating the field observations on connectivity.