Automated mapping using artificial intelligence

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Mapping of topographic objects requires today economic and simple methods. The applied method and tools should, however, result in accurate positions, complete coverage, and quality for all objects of topographic databases. This blog has the goal to apply the open-source tools recently published by EuroSDR (Höhle & Damodaran, 2023). The blog starts with a short description of the applied methodology and continues with an example.

1. The methodology of mapping

Source data are overlapping aerial images of four bands. By means of correlation a digital surface model (DSM) of very high density is derived. The DSM- based orthoimage is used to detect topographic objects by classification. Attributes, which characterize the selected topographic objects must be generated beforehand. The derived land cover map (LCM) must then be enhanced to vectors. In several steps of the production process artificial intelligence (AI) is applied which enables automation to a large extend.

2. Description of the used data

The data of the practical example comprise open-source data of a German mapping organization (LVA Halle). The following test data were downloaded from their portal:

-aerial images of 4 channels (R, G, B, NIR) and pixel size of 0.2m,

-DSM with cell size 0.2m x 0.2m,

-DSM based orthoimages with pixel size of 0.2m

-Digital terrain model (DTM) with cell size of 2m x 2m.

3. Derivation of supporting data

The land cover map to be produced as example should contain five classes (‘building’, ‘impervious surface’, ‘low vegetation’, ‘tree’, and ‘clutter background’. Some attributes characterizing these objects had to be generated. In the applied method, the attributes are the normalized difference vegetation index (NDVI), the normalized DSM (ndsm), the intensity values of the four channels of the orthoimages, and attribute profiles (AP) based on area-thresholding. Thereby, each pixel has 18 features and a resolution of 0.2m. The generation of the ndsm required a densification of the DTM using linear interpolation. The generation of the land cover map used the classifier "Decision Tree" (DT). To train this classifier, three samples per class were taken consisting of 11x11 pixels each. To estimate the quality of the classification, some check pixels were collected. For this purpose, the true value of 11 pixels per class, were determined by manual observation.

4. Generation of the land cover map

The selected test area of 240m x 250m has several detached houses, roads, grass and bush areas, high trees, and some other objects (swimming pools, cars, etc.). Only completely imaged houses shall be mapped in the example. The orthoimage is depicted in Figure 1 together with the selected samples.

Figure 1. DSM-based orthoimage and samples of the selected classes (green: 'building', red: 'impervious surface': white: 'low vegetation', yellow: 'tree', black: 'clutter background').

The derived DT is depicted in Figure 2. The values of the features in the DT are normalized. Of influence are especially the feature 1 (NDVI) and the feature 18 (ndsm). The classes of each pixel (1-5) are derived by pruning the DT.

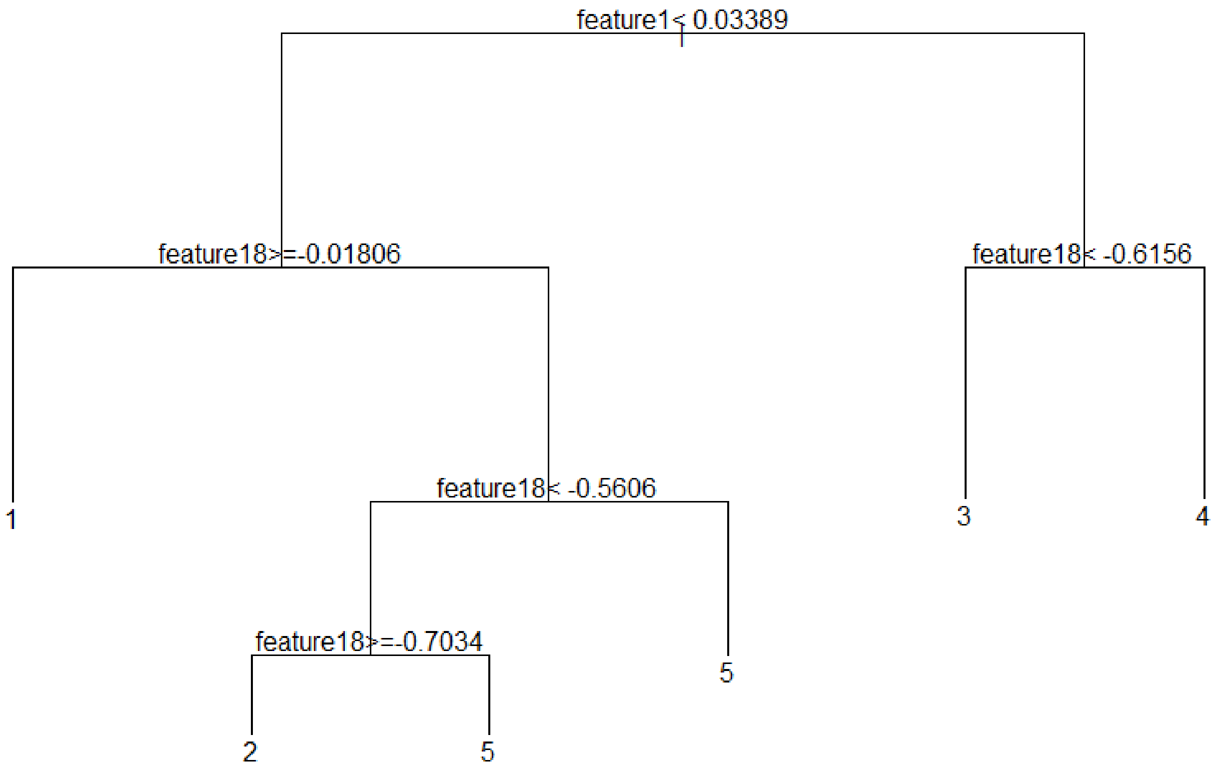

Figure 2. Derived Decision Tree (class 1: ‘building’, 2: ‘impervious surface’, 3: ‘low vegetation’, 4: ‘tree’, 5: ‘clutter background’).

The generated land cover map is depicted in Figure 3. The derived classes are well separated. Even small parts of the buildings, e.g., balconies are mapped thanks to the very high density of the DSM. Some misinterpretations are also visible, e.g., tiny red areas cannot be buildings.

Figure 3. Generated land cover map (red: ‘building’, gray: ‘impervious surface’, green: ‘low vegetation’, dark green: ‘tree’, brown: ‘clutter background’).

The thematic accuracy of the LCM is estimated by means of 55 checkpoints. Its overall accuracy is calculated from an error-matrix with 97%. The F1-value for class ‘building’ is 92%.

In the following, only buildings will be enhanced. This occurs in two steps. First, all buildings are extracted and enhanced in raster form. The image processing package

“EBImage” is used to remove objects smaller than 25 m^2. Other improvements regard the smoothing of the edges. Figure 4 depicts the resulting raster plot.

Figure 4. Enhanced class ‘building’.

Thereafter, all buildings are converted into vectors. This vectorizing is carried out by means of the “Hough transform”. The derived approximate lines are then adjusted by least squares and intersected after the sequence of lines has been determined using one of three different methods. Parallelism and orthogonality of the lines are again achieved by least-squares adjustment. Lines with other orientation are mapped with some interaction. This enhancement is carried out by the software tool “buildenh_v1.3.R”.

Figure 5 depicts the resulting vectors on top of the DSM-based orthoimage.

All buildings are mapped with orthogonal and parallel sides as they are very likely in nature.

Figure 5. Enhanced buildings generated by the software tool “buildenh_v1.3.R”

The automated generation of the vector plot could be improved when more manual work is used. For example, the misalignment of some buildings can be avoided when the roof ridge of the building is digitized and used as the main orientation of the building. Interactivity is required for the selection of a few parameters. Artificial intelligence is applied to make suggestions for some parameters, e.g., the method for the determination of the line-sequence. The other topographic objects of the generated land cover map ('impervious surface', 'low vegetation', 'tree') can be mapped as well with high cartographic and geometric quality.

This example demonstrates that the automated mapping can achieve good results. Manual editing can still improve the quality of the enhancement, but the processing time will increase. The applied method is a kind of monoplotting. The high geometric accuracy of manual compilation with stereo-systems cannot be achieved. However, this approach does not require either expensive systems or experienced operators.

References

EuroSDR, 2023. Automated Extraction of Topographic Map Data from Remotely Sensed Imagery by Classification and Cartographic Enhancement - An Introduction to New Mapping Tools. Official publication No.75.
Eurosdr_publication_ndeg_75.pdf

buildenh - a collection of R-scripts for the cartographic enhancement of buildings generated by classification of remote sensing imagery."
https://github.com/JoaHoe/buildenh_v1.3