Generation of urban land cover maps and their enhancement

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The goal of this investigation is the automatic generation of an urban land cover map (LCM) of high cartographic quality. The applied operations are illustrated by means of an example. The focus is on the enhancement of the classification result. Previous publications deal with details of the used data, the applied tools, and the achieved accuracy (Höhle, 2021), (blogs 8,9,10).

Source data

The DSM-based orthoimage is the source data. It may be acquired from the national mapping organization. The DSM and the orthoimage are automatically produced from overlapping aerial images.

Figure 1. DSM-based orthoimage

The buildings, roads, parking lots, lawns, and trees are well imaged due to a high resolution of the used aerial images (ground sampling distance=0.2m).

Attributes which characterize the five selected classes (buildings, impervious surfaces, low vegetation, tree, clutter/background) are derived. These are elevations above ground (dh), normalized density vegetation index (NDVI) and an attribute profile (maxTree). All pixels and cells have a size of 0.2x0.2 m^2. Three samples per class are manually collected by digitizing the orthoimage. The classifier "Decision Tree" (DT) is calculated by means of the samples and the attributes. The DT is used to classify all pixels of the orthoimage. The automatically derived land cover map (LCM) is depicted in Figure 2.

Figure 2. Derived land cover map of classes 'buildings' (red), 'impervious surface' (grey), low vegetation ('green'), 'tree' (dark green) and 'clutter/background' (brown).

The five classes are well recognizable. The shape of the buildings is very irregular. Their outline should be comprised of straight, parallel, and orthogonal lines as they are in nature. The other classes are even more irregular. They contain also small spots. A generalization and enhancement will improve the representation of the LCM. These steps are descripted in the publication (Höhle, 20021) and in three previous blogs. The source material and the applied program package for the enhancement of buildings are described in (blog 10). A test of the geometric accuracy of the same test material revealed an average standard deviation of $\sigma_{x,y}$=0.9 m (blog 10).

Enhancement of the classification result

A simple method uses the three RGB bands. A better approach is the representation by colours for each class.

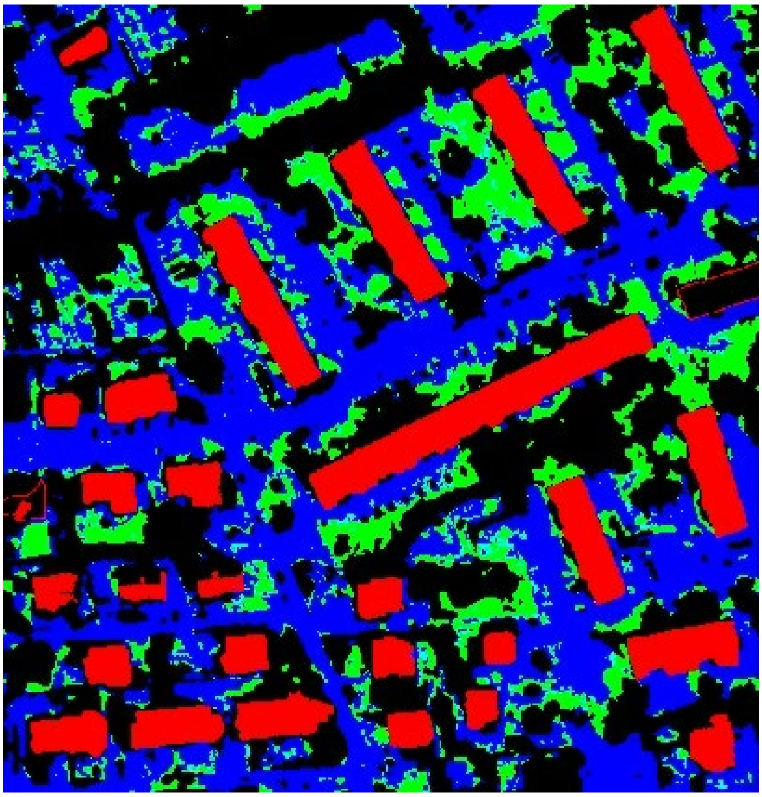

Figure 3. RGB-plot for the three classes, buildings (red), low vegetation (green), impervious surfaces (blue)

The enhancement is carried out in three steps. The first step smoothes the object's boundary lines and closes small gaps within the area. It is carried out by morphological operations (dilation, erosion). A structuring element is selected, in the example with size of 1x1 m^2. The second step generalizes the content. This is achieved by segmentation. Connected sets of pixels get a label and are filled with pixels. A threshold for area removes all objects of smaller size. In the example, this threshold is selected with 300 pixels (class 'buildings') or 500 pixels (=5 m diameter) for the other classes. The stack of five images containing the five classes is depicted in Figure 4.

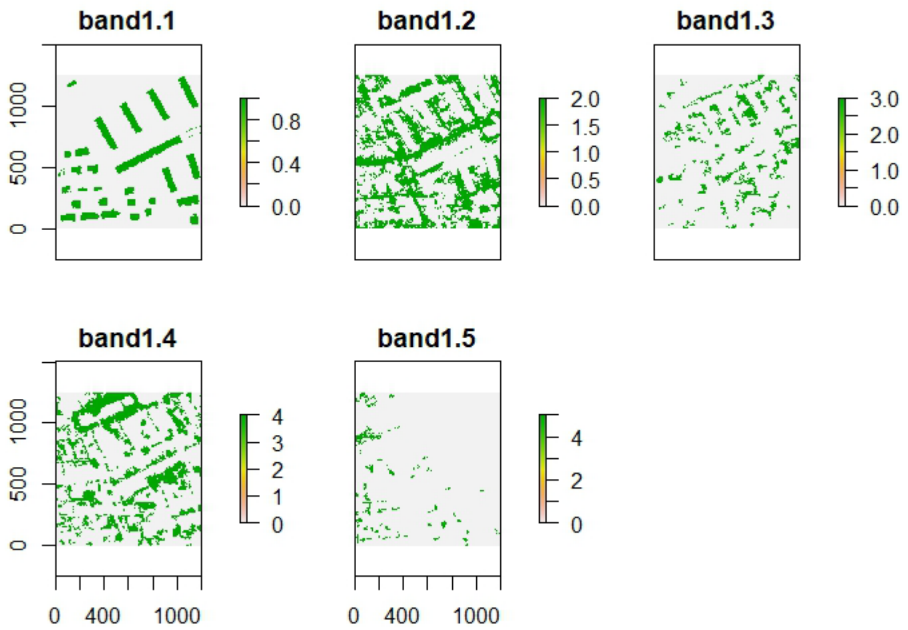

Figure 4. Stack of enhanced classes: ‘buildings’ (band1.1), ‘impervious surface’ (band1.2), low vegetation’ (band1.3), ‘tree’(band1.4), ‘clutter/background’ (band1.5).

The third step of enhancement generates straight, orthogonal, and parallel lines by least-squares adjustment. In the example, this is applied for class ‘buildings’ only. Detailed description of this step including the applied software tools are explained in (Höhle, 2021) and by blogs 8, 9,10, which all may be downloaded from the Internet.

Generation of the final LCM

After carrying out the enhancement one image vector containing the labels of each pixel is generated. The enhanced LCM can then be plotted with a palette of colours. In the last operation, the enhanced outline of buildings is added. Figure 5 shows the final LCM with all enhanced classes.

Figure 5. Enhanced land cover map: ‘buildings’ (red), ‘impervious surface’ (grey), ‘low vegetation’ (green), ‘tree’ (dark green) and ‘clutter/background’ (brown).

Discussion

The source data of the used example have a very high density (pixel size: 0.2m) which enables the detection of small objects. The processed LCM has 1200x1250 =1500000 pixels. The applied methodology of the generation is a combination of raster and vector operations. The result is a compromise between accuracy, readability, and speed of operation. Improvements are still possible.

References

Höhle, 2021. Automated mapping of buildings through classification of DSM-based ortho-images and cartographic enhancement. International Journal of Applied Earth Observations and Geoinformation 95 (2021) 102237. (https://doi.org/10.1016/j.jag.2020.102237)
Blog 8: The program package ‘buildenh_v1.3’.
Blog 9: Automated mapping using artificial intelligence.
Blog 10: Geometric accuracy of the automated generation of vectors.
These blogs are available at Joachim Höhle (academia.edu)

Data source: LVA Sachsen-Anhalt/Germany.