Extracting information from building roofs

-from airborne LiDAR and RGB data-

Mapping cities is deemed to be one of the most challenging tasks in the automated analysis of image data, as urban areas are composed of highly complex spatial and spectral structures. The extraction of up-to-date land cover and land use information for large urban areas requires high spatial resolution imagery and enables a detailed and cost-efficient mapping basis for an optimized management of cities. Pixel-based, graph-based, and object-based methods for the processing of radar data, multispectral to hyperspectral optical imagery, as well as LiDAR point clouds and thermal information are commonly applied. In this context, the eCognition software provides an excellent basis for the comprehensive analysis of different data, making use of a variety of implemented methods. Hereinafter, benefits of the synergistic analysis of optical imagery and LiDAR data for the detailed extraction of building roofs are outlined.

RGB (red, green, and blue) images are composed of three bands in different spectral domains of the visible light, with wavelengths approximately ranging from 450 nm – 750 nm. The information acquired by passive sensors, utilizing the sun's reflected energy, facilitates statements about surface materials of objects. Aerial point clouds recorded by active LiDAR (Light Detection And Ranging) sensors exhibit other details about the earth's surface. The emitted laser pulse is utilized to measure the distance between a target and the sensor platform and is able to describe the height of scanned objects. Furthermore, details about intensity and the number of returns are stored in the data sets. Figure 1 shows a comparative example of RGB and LiDAR images (in this case the number of returns) covering the same area. Obviously, different surface features are revealed by the individual data sets.

Fig. 1: Example of an RGB image (left) and LiDAR information (right) displaying the number of returns (the brighter the more returns)

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Frequently, LiDAR data are analyzed in combination with optical imagery in order to perform precise mapping of building roofs. The synthesis of both data types presents increased accuracies of extracted objects, given that the images are highly congruent regarding their position. Several benefits result from the synergistic use of both data types: In addition to elevation, intensity, and returns of point clouds, RGB data enable the inclusion of spectral signatures for segmentation and classification, thus providing a gain of information. The calculation of spectral (vegetation) indices based on the three channels of the visible light is also possible. Furthermore, RGBs tend to feature higher spatial resolutions than LiDAR data, which implies the precise mapping of small objects by the combination of both data sets. While point clouds suffer from regions without LiDAR signal information (e.g. next to building walls turned away from the sensor), true orthophotos or orthomosaics are capable of bridging these gaps.

In this example, the analysis concentrates on extracting features of a single building: roof type, roof aspects, roof material, and solar panels. In a first step, the available point clouds covering the same area are merged in order to minimize regions without LiDAR signal information. Subsequently, useful point cloud characteristics, such as the maximum elevation of all returns, the number of all returns, slope, and aspect for each pixel are calculated (Fig. 2). The elevation information is used to generate a normalized digital surface model (nDSM).

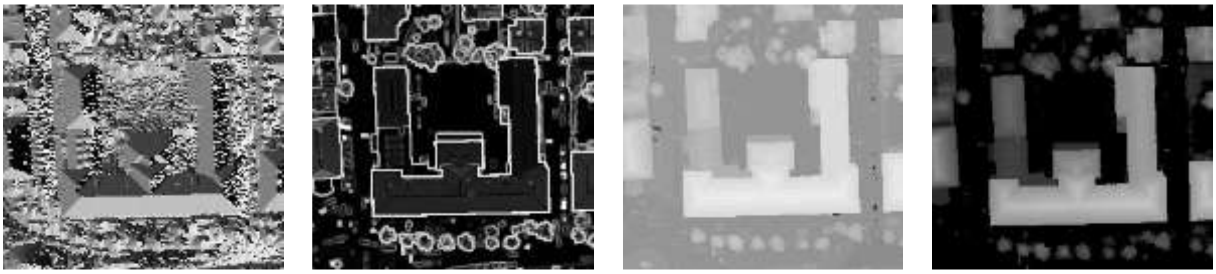


Fig. 2: Aspect, slope, DSM, and nDSM (left to right) extracted from point cloud

The area is divided into elevated and non-elevated objects based on the nDSM. Afterwards, meaningful objects are created by segmenting the elevated areas utilizing RGB and nDSM values. The initial building classification likewise benefits from a combination of greenness and number of returns, thus distinguishing between vegetation and buildings. Once the building is outlined (Fig. 3), further details can be extracted using spectral values, point cloud information, or both data sets in combination: distinction between flat roofs, pitched roofs, and flat roofs with red tiles (Fig. 4), extraction of aspects of different parts of the roof (Fig. 5), and classification of smaller roof details like solar panels (Fig. 6). The imaginary shift between the background RGB image and the superimposed classification results from the building tilt in the RGB image.

Fig. 3: Extracted building outlines

Fig. 4: Classification of roof types

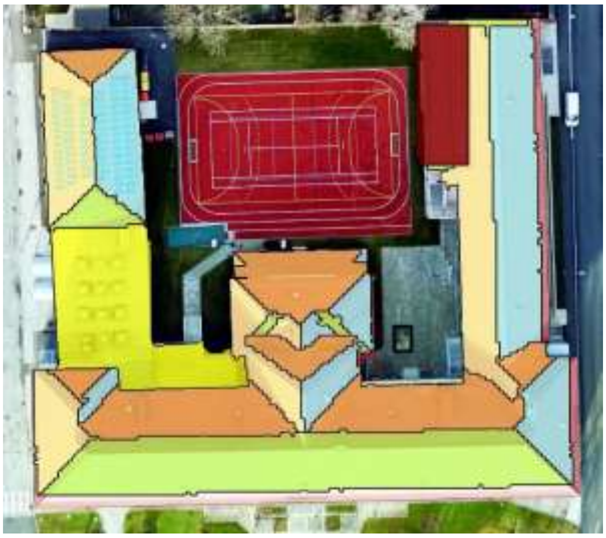


Fig. 5: Different aspects of the building's roof

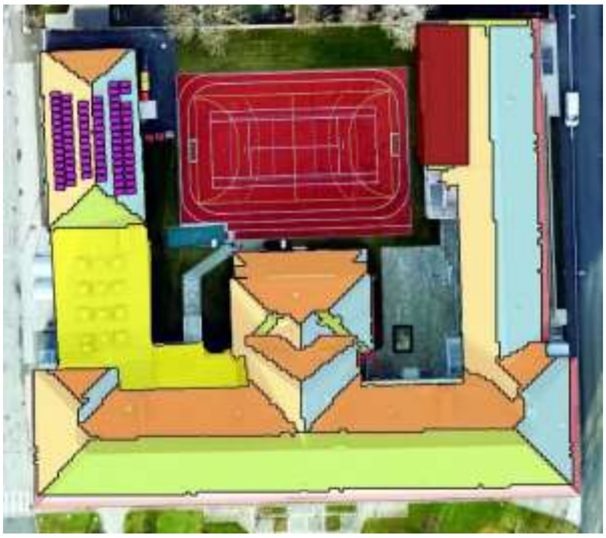


Fig. 6: Extraction of solar panels

When it comes to the export of classification results, frequently more generalized building outlines are desired for the inclusion of vector objects into existing databases. Depending on the demanded degree of abstraction a variety of eCognition parameters can be utilized to adapt the classification results. Figure 7 illustrates some examples related to the generalization of building outlines.

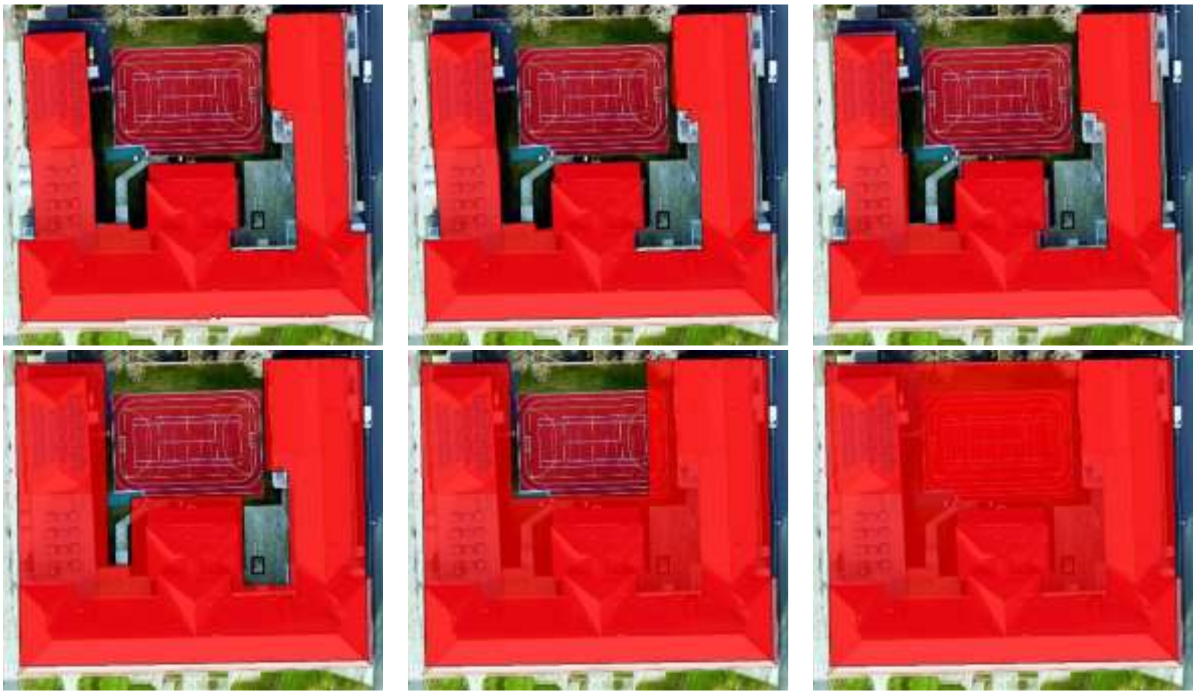


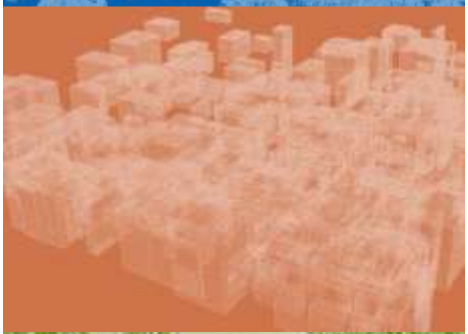
Fig. 7: Generalization of building outlines for different degrees of abstraction

Overview of the application of LiDAR & RGB data for mapping roof details

Input data	Airborne LiDAR point cloud Airborne RGB image
Preprocessing	Merging the available point clouds and filling small gaps in order to minimize no-data values; extracting information from point cloud to raster layer
Software	eCognition Developer eCognition Server (recommended for large data sets)
Ruleware	Tama Group multi-stage approach: • Extraction of nDSM • Classification of elevated and non-elevated objects • Classification of buildings • Classification of roof types and roof details • Generalization of building outlines
Results	Output format: • Image data (JPEG/TIF/PNG) • Maps (SHP) • Classified point cloud (LAS) • Statistics

City Mapping Applications
Information Extraction from LiDAR & RGB Data

Tama Group specializes in automated information extraction, especially in object-based image analysis with eCognition.



We analyze images from various sensors and continue to refine our methods of automating information extraction. In doing so we combine machine learning, deep learning and expert knowledge.

With our **forest portal**, we are able to offer an image-based digital twin of his forest to practically every forestry company. This allows us to provide important information about the managed forest area in a clear manner.

Our **information factories** offer solutions for specific questions in various industrial areas such as agriculture, construction, energy, transport, environmental protection and materials science.

Distribution of Trimble eCognition: We offer an extensive sales, support and training portfolio, including our 4D maintenance package.

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