# Mapping City Signatures

-directly from airborne LiDAR data-

Aerial point clouds recorded by LiDAR (Light Detection And Ranging) sensors provide valuable information about the earth's surface, including the signature of cities. 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. The acquired information is capable of characterizing objects and cover of such objects over time and over large areas. Frequently, LiDAR data are analyzed in combination with optical imagery in order to perform precise city mapping. Since data availability may be limited for various reasons, the extraction of objects in a city, here referred to as the city signature, is introduced. Our method is based solely on laser scanning point clouds

The city of Horn, Austria, was captured by two LAS-files of a RIEGL laser scanner system LMS-Q1560 (Fig. 1). The data is utilized to extract LiDAR point classes as defined by ASPRS (American Society for Photogrammetry & Remote Sensing; version 1.4). More precisely, we concentrate on mapping (2) ground, (3) low vegetation, (4) medium vegetation, (5) high vegetation, (6) buildings, and (9) water. Furthermore, the class ground is subdivided into the (1.1) road network and (1.2) cars (moving and still). Recorded by two sensors from slightly different positions (Fig. 2), both data sets are combined and data gaps are filled in order to minimize LiDAR "shadow", which refers to regions without LiDAR signal information (e.g. next to building walls turned away from the sensor).

*Fig. 1: The available LiDAR point cloud [RIEGL Laser Measurement Systems GmbH]*

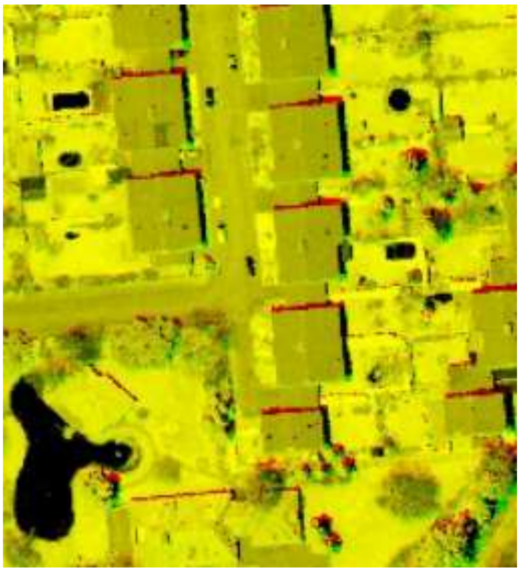


*Fig. 2: Overlay of the two intensity images with LiDAR "shadow" in red and green*

Initially, we create a normalized digital surface model. We extract this from point cloud elevation values. Now, the data set is automatically classified into elevated and non-elevated regions. Objects near the earth's surface, like cars, the road network, water bodies, and lower vegetation are then characterized by segmentation of the ground class. For that purpose, features like shape, texture, and neighborhood of objects are utilized to delineate the land cover classification in detail. Likewise, further ASPRS classes of elevated segments (buildings and vegetation) are extracted mainly based on LiDAR returns (Fig. 3) and the different object heights (Fig. 4). An experimental part of the data processing deals with the recognition of moving cars, exploiting that the two different point clouds showing a slight temporal offset.

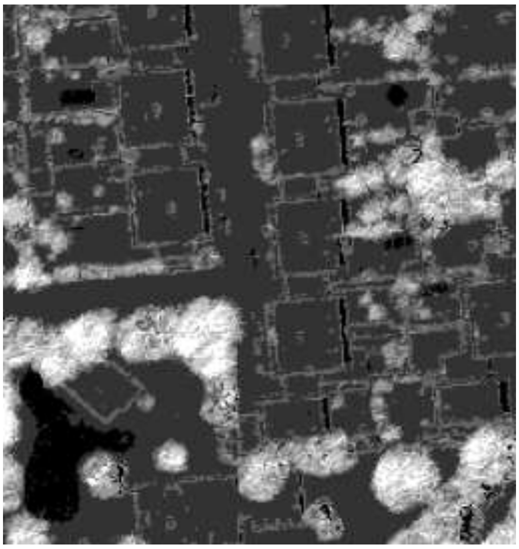


*Fig. 3: Number of returns (brighter = more returns)*

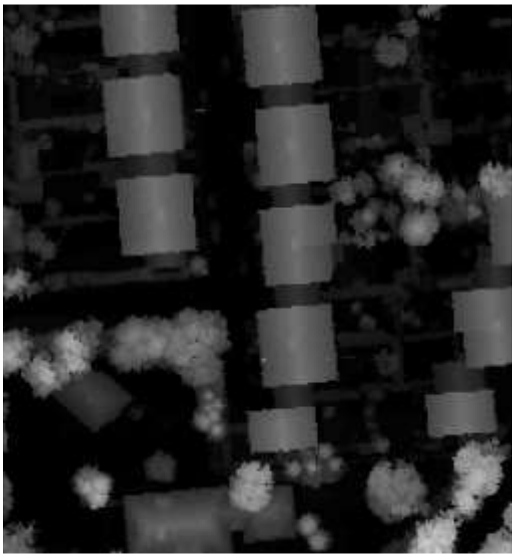


*Fig. 4: Extracted normalized digital surface model*

*Fig. 5: Subset of the classification result, showing the ASPRS classes and additional objects like cars*

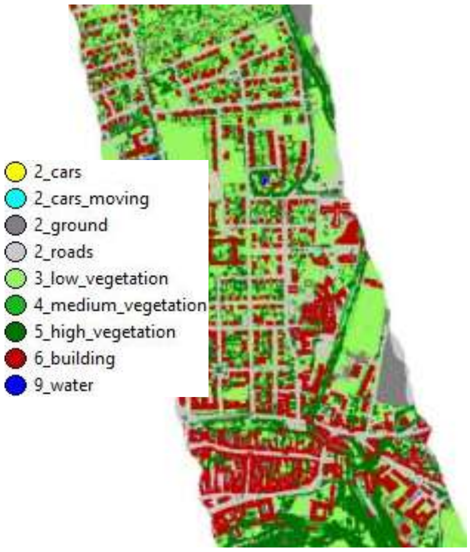



*Fig. 6: Classification result for the entire area of the input data*

Accuracy assessments of random samples for each class proof meaningful classification results, even though classification is exclusively computed by LiDAR data. For most of the samples the classification resulted in correct membership. Finally, a very important step is to export the extracted ASPRS classes into the existing or into a new LiDAR file to enable further analyses of the point cloud if desired (Fig. 7).

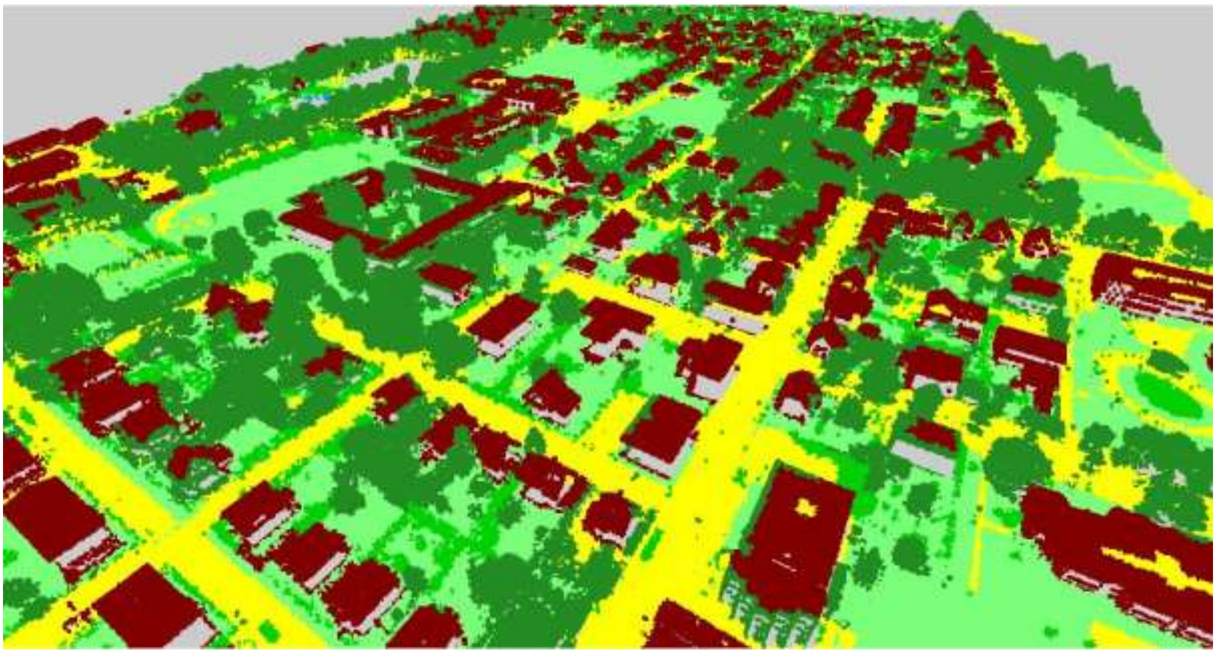


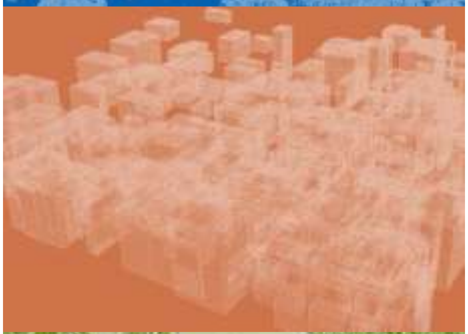
*Fig. 7: Export of the extracted ASPRS classes to a new point cloud*

Overview of the application of LiDAR data for city mapping

| | |
|---|---|
| Input data | Airborne LiDAR point cloud |
| Preprocessing | Merging the two available point clouds and filling small gaps in order to minimize no-data values |
| Software | eCognition Developer<br>eCognition Server (recommended for large data sets) |
| Ruleware | Tama Group multi-stage approach:<br>• Extraction of nDSM and additional layers from point cloud<br>• Classification of non-elevated objects<br>• Classification of elevated objects<br>• Detection of moving objects (cars)<br>• Export of ASPRS standard LiDAR classes to point cloud |
| Results | Output format:<br>• Image data (JPEG/TIF/PNG)<br>• Precise coordinates<br>• Point cloud (LAS) |

# CITY MAPPING APPLICATIONS
## INFORMATION EXTRACTION FROM LIDAR 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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