Building detection based on ALS data

brief description

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The proposed building detection algorithm is a part of a comprehensive method for automated 3D building reconstruction. Objects are extracted based solely on 3D point cloud, acquired by airborne LIDAR sensors. In the preprocessing step raster height image is interpolated from the original data. The presented detection approach is solved in three successive steps:

- initial identification of building mask,
- removal of vegetation and small elements,
- clustering pixels into individual objects and identification of the corresponding 3D points.

In order to identify the initial building mask that contains also other small elements and parts of high vegetation, four-directional filter was developed which allows the analysis of terrain profiles. The surface slope S_i assigned to the i-th pixel is calculated as following:

$$S_i = arctg(\frac{H_i - H_{i-1}}{d}), \quad S_i \in \left[-\frac{\pi}{2}, \frac{\pi}{2} \right] \quad ,$$

where d is the size of the pixel side.

Depends on the analysis direction, the slope at the edge of a building is positive (terrain-building) or negative (building-terrain). If the value of the slope S_i is positive and exceeds the predefined minimum value S_{up} = 70 °, the i-th pixel is marked as potentially belonging to the building. The same label is assigned to the following pixels until a negative slope is detected, which value is greater than S_{down} = 30 °. The second threshold for the transition terrain-building is designed to avoid incorrect labeling due to possible variations in the slope value resulting from surface roughness or random errors. In order to achieve correct identification results in case of complex buildings with numerous height changes within building contour, analysis are performed twice in the opposite directions (fig.1). This enables to benefit from the complementary character of the results, without the need of introducing additional height parameters. The whole process is repeated taking into account both the image rows and columns, which allows to verify the results and increase the detection accuracy. As a consequence, the resulting building mask (BM) is the common product of two filters performed in two directions: vertical (Up-Down, Down-Up) and horizontal (Left-Righ, Right-Left):

$$BM = (UD \cup DU) \cap (LR \cup RL) \ .$$

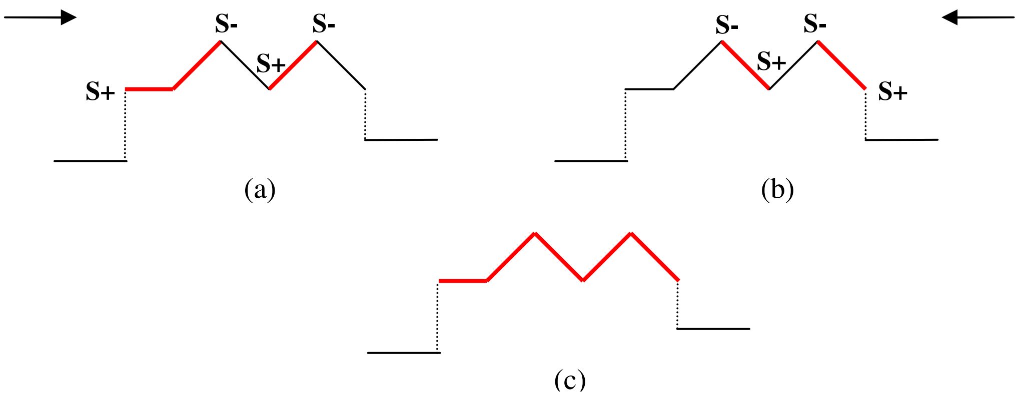
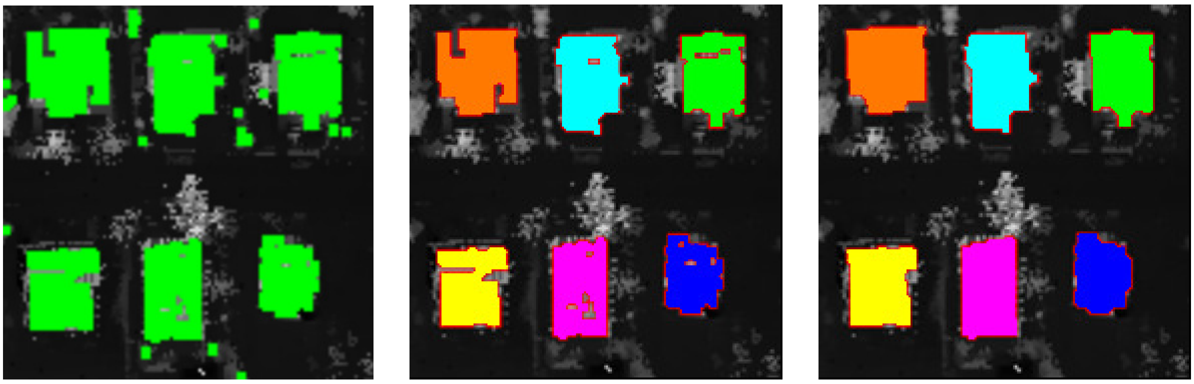


Fig.1: Initial identification of building mask. Proceeding scheme of one filter (vertical/ horizontal) carried out in opposite directions; S + positive slope exceeding the threshold value, S- negative slope exceeding the threshold value.

The initial building mask received as a result of the four-directional filter execution may contain certain amount of data that belong to other objects. Most of them represent vegetation - separated group of trees as well as crowns adjacent to building roofs. A characteristic feature of such areas that distinguish them from buildings is the lack of a compact structure and composition of numerous small elements. This property was used to develop an algorithm which is based on morphological erosion. It requires selecting several structural elements with different shape and size that enables to delete elongated and scattered objects.

The ultimate goal of identification process is to extract separated group of 3D points representing individual buildings. Based on the connected components analysis neighboring pixels are grouped together to form distinct objects. Thus extracted building areas may contain gaps resulting from random LiDAR errors or occurrence of the objects located above the roof (e.q. chimneys or antennas). Therefore, the iterative process is performed in order to fill the gaps and return coherent individual objects. Finally, building pixels are mapped onto the point cloud, enabling to identify sets of 3D points that are the input for further 3D building reconstruction.



(a) (b) (c)

Fig.2: Identification of separated objects. Building mask (a), connected components analysis (b), filling the gaps and formulating coherent areas (c), (figures depicts own dataset).