A Min-cut Approach to Building Detection from Airborne Lidar Point Clouds
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Airborne lidar systems provide an unstructured 3-D sampling of the features on and above the ground. Direct utilization of these usually massive collections of point locations for practical purposes is very limited. Identifying the location, extent, and geometry of various feature types (e.g. ground, vegetation, buildings, etc.) with a simpler, better structured and more manageable representation is usually of more interest for many applications. Especially, building detection, extraction and reconstruction have traditionally been among the most sought after applications of airborne lidar topographic mapping along with ground filtering and DEM generation. Existing building extraction methods employ various mechanisms. Utilizing individual points over or in combination with grid sampling is common practice to avoid loss of information due to simplification. More recent methods also take advantage of the point features calculated within a local neighborhood for determining planar roof surfaces. Considering only the properties of individual points however, disregards spatial coherence. The relative change of point features in the immediate surrounding of each point needs to be examined in order to account for spatial coherence.

In this study, we establish point labeling as an energy minimization problem which accounts for both local and global effects on point labels. The energy function, formulated on a graph, consists of a data term and a smoothness term. The data term provides the quantification of how likely each point is to be labeled as a surface or a non-surface point. The smoothness term on the other hand, ensures spatial coherence by evaluating point pairs. We construct the graph by considering the points as its nodes connected to each other via natural neighborhood. Each node is also connected to two auxiliary nodes representing point labels for surface and non-surface points. The edges connecting the nodes to the label nodes are formulated to hold the data cost term of the energy function. Histograms of structure tensor point features generated for each point govern the calculation of data costs. The edges connecting the nodes with their neighbors are the smoothness costs regulated by a smoothness function. The solution to the labeling problem is obtained by finding the minimum-cut on the graph which equals to minimum energy. We test our algorithm on an airborne lidar dataset containing 933,932 points that are manually labeled as building and not-building. First, we filter ground points using a separate min-cut based ground filtering algorithm. Then, off-ground points are labeled as surface and non-surface. After labeling, we remove the points which do not constitute a building by their connectivity, size, and height to obtain building points. Test results show that our algorithm is able to label building points with 97.4% accuracy and a kappa value of 0.891.