ABSTRACT

Ural, Serkan. Ph.D., Purdue University, December 2017. Global Optimization Approach to the Labeling of Airborne LiDAR Point Clouds. Major Professor: Jie Shan.

Airborne lidar systems provide an unstructured 3D sampling of the objects on and above the ground. Building extraction has traditionally been among the most sought-after applications of airborne lidar topographic mapping along with digital elevation model generation. Extracting buildings from point clouds requires the labeling of the point cloud. Recent methods take advantage of the point properties calculated within a local neighborhood to achieve such labeling. Considering only the properties of individual points however, disregards spatial coherence. The relative change of point properties in the immediate surrounding of each point as well as spatial relationships between neighboring points need to be examined to account for spatial conformity. This dissertation, formulates point labeling problem under a global graph-cut optimization solution. The energy function, represented by a graph formulating a Markov Random Field (MRF), consists of a data term and a smoothness term. The solution to the labeling problem is obtained by finding the minimum-cut on the graph.

We have employed this framework for three different labeling tasks on airborne lidar point clouds. Ground filtering, building extraction, and roof-plane segmentation. We tested our ground filtering algorithm on 15 ISPRS test samples. The results show that an average accuracy of 91.3% can be achieved with an average Type I error of 17.4% and average Type II error of 7.2%. We tested our building extraction results on two airborne lidar datasets with different point densities containing 933,932 points in one dataset and 753,876 points in the other. Test results for building vs. non-building point labeling show that we could achieve 97.9% overall accuracy with a kappa value of 0.91 for the dataset with 1.18 pts/m^2 average point density and a 96.8% accuracy with a kappa value of 0.90 for the dataset with 8.83 pts/m^2 average point density. In addition, we have also evaluated the transferability of collected training from one dataset to another dataset that is acquired

at a different time and place with similar point density. We were able to successfully label points in one dataset with the training data collected for other.

In summary, our framework could successfully label points in point clouds with different characteristics for all three labeling problems we have introduced. It can handle airborne lidar datasets with similar acquisition characteristics using the same training samples. Observed mislabeling occur mainly for low points and discontinuities in ground filtering. In building extraction, trees too close to the rooftops cause mislabeling of building roofs as trees. Dense tree tops with no local vertical sampling are often mislabeled as buildings.