Individual Tree Segmentation from Terrestrial Laser Scanning Dataset

Dan Xie (1)
[1] Leica Geosystems (Shanghai) Co., Ltd, 2 Boyun Road, Pudong New District, Shanghai,201203, China
Email: xpan07@126.com

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ABSTRACT: Forests are a fundamental component of terrestrial ecosystems. They constitute diverse and irreplaceable habitats for a large part of living organisms. Forests also provide invaluable ecosystem services including oxygen production, carbon sequestration, water filtering, climate regulation, protection against avalanches, erosion and desertification. Understanding forest information is the first step in forest protection. So, it is particularly important to know how to measure tree information immediately and accurately. Recent advances in high resolution terrestrial laser scanning (TLS) systems have enabled us to quantify the forest structure in an unprecedented detail. Limiting the adoption of these new lidar-derived methods is the difficulty associated with accessing the information content of point clouds. To retrieve tree-scale metrics from these data, individual tree-level point clouds must be extracted from the larger-area point cloud. It generally involves laborious and time-consuming manual segmentation, especially for large amounts of trees or plots. The more complex the scene is, the more difficult and time-consuming this becomes. Thus, a point cloud segmentation algorithm for individual trees from an amount of point cloud data is proposed in this paper. Initially, generate a digital elevation model (DEM) from ground point cloud. And then normalize point cloud based on DEM. In the following step, create a slice to identify stems, and extract the tree point cloud though RANSAC and region growing. Finally, retrieve the tree-level structural parameters. This method provides reference for tree-level forest inventory based on TLS.

1 INTRODUCE

Forests are important component of natural resource. It has abundant species and complicated structure to generate complex ecosystems, which make invaluable contributions for oxygen production, carbon sequestration, water filtering, climate regulation, protection against avalanches, erosion and desertification(Kankare et al.,2013). Therefore, forest protection is meaningful topic and has already got increasing attentions. To meet the requirements of protecting forest, it’s essential to acquire and understand forest information by means of immediately and accurately measuring tree information. With a rise of high-precision laser-scanning technologies, many applications in forest scenes utilize them to obtain forest features, for example, traditional parameters of forest structure including stem diameter and tree height(Maas et al.,2008). Data from terrestrial laser scanning (TLS) in forest inventories is dramatically beneficial to achieve the digitization of the forest plots accurately at millimeter-level(Liang et al.,2016). In addition, other attributes which are useful to evaluate wood productivity and quality such as the stem curve or taper curve can be derived from TLS in high accuracy and efficiency(Liang et al.,2014). Nevertheless, the solution of tree extraction from TLS data should be taken into account. A method of reconstructing structure model of every tree in a forest plot is presented, based on tree information which is extracted refer to distance clustering characteristics and connectivity (Raumonen et al.,2015). Liang et al. evaluated the TLS algorithms based on processing results of identical forest datasets according to standardized attribute criteria and reliable evaluating indicators (Liang et al.,2018). Andrew Burt et al developed a software – treeseg to extract individual trees from lidar point clouds, it's open source including the basic data processing procedures covering Euclidean clustering, principal component analysis, region-based segmentation, shape fitting and connectivity testing(Burt et al.,2019).

2 METHODOLOGY

Inspired by treeseg, we proposed an algorithm to extract trees from TLS. It involved ground point segmentation from point cloud through Cloth Simulation Filter (CSF)(Zhang et al.,2016), point cloud normalization based on ground point, the tree point cloud extraction though RANSAC and region growing. Consequently, the tree-level structural parameters can be successfully derived.

2.1 CSF

CSF is filtering method to deal with airborne LiDAR data, which is based on cloth simulation. It can build up the relationship between the cloth nodes and the corresponding LiDAR points. Then a simulated surface matched with the real ground one can be generated in accordance with the locations of the cloth nodes. Accordingly, the ground points can be acquired from the LiDAR point cloud above this approximate surface.

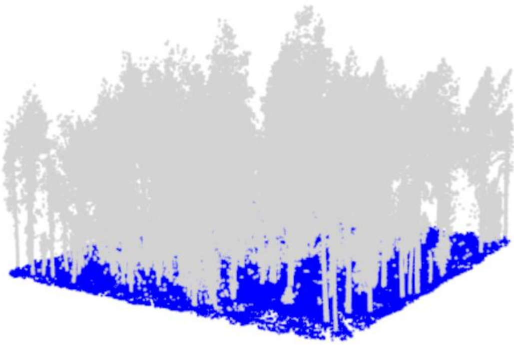


Figure 1 CSF (**blue**: ground **gray**: vegetation)

2.2 Height normalization

Point cloud normalization eliminates the effect of terrain for ground measurements. It makes possible give rise to compare vegetation heights above the ground, while also simplifies data analysis in the experimental areas. Fig.2 shows the normalization results of an area.

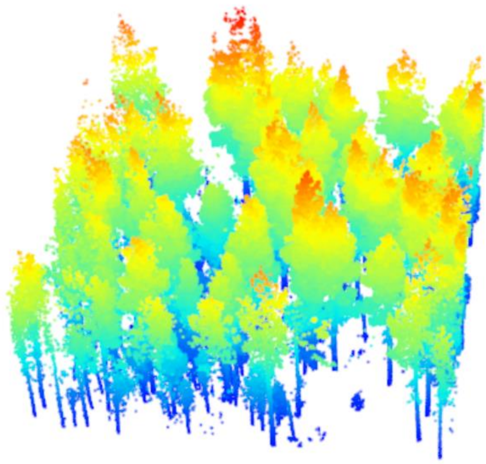


Figure 2 Point cloud after height normalization

2.3 Create a slice to identify stems

To segment a single tree from the point cloud, a method of creating a slice can be applied. For slicing data, it’s critical to distinguish target object from non-target points. We define a threshold and use Euclidean clustering to cluster tree stems, then segment cylinders through RANSAC cylinder fitting. Once cylinders are figured out, the locations of trees are apparent. As shown in Fig.3, the point with z-axis between 2m-3m was extracted. Correspondingly, the extraction result of tree stems is displayed in Fig.4. Meanwhile, the locations of the trees can be obtained as Fig.5.

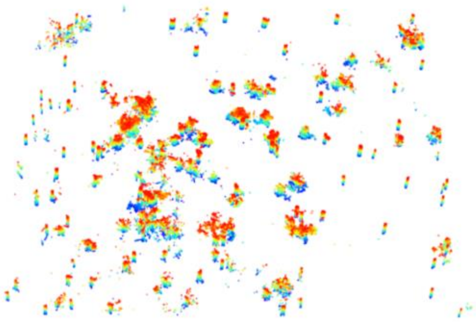


Figure 3 Slice(2m-3m)

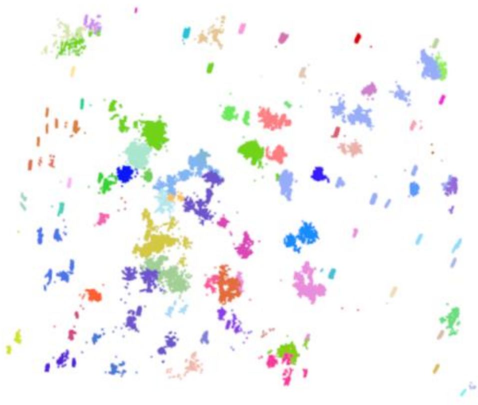


Figure 4 Tree stems from slice

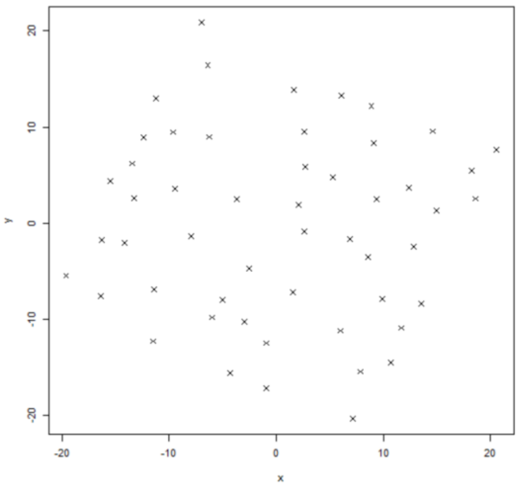
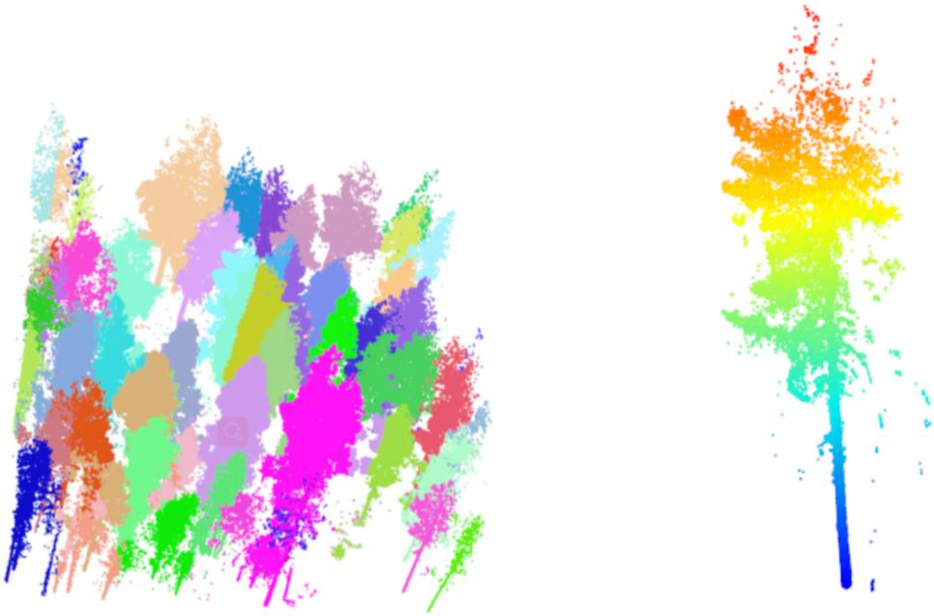


Figure 5 location of the trees

2.4 Region growing

Based on calculating the cylindrical parameters of the trunk, an effective algorithm Region growing can be used to separate the whole tree from the point cloud. Fig.6 and Fig.7 respectively present segment result and an individual tree point cloud.



Segmentation Individual Tree

Figure 6 Individual tree Segmentation

3 CONCLUSION

In this work, we present a method of tree extraction from point clouds which can effectively obtain individual tree point clouds. We validate the method through the application of a TLS benchmark dataset. It can provides a reference for extracting tree information from TLS point clouds.

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