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A New Method of Equiangular Sectorial Voxelization of Single-scan Terrestrial Laser Scanning Data and Its Applications in Forest Defoliation Estimation

Langning Huo (1,2) and Xiaoli Zhang (1)

(1) Beijing Forestry University, Forestry College, China (langning_huo@bjfu.edu.cn, zhang-xl@263.net), (2) Swedish University of Agricultural Sciences, Sweden (langning.huo@slu.se)

Abstract
Voxelization is an efficient and frequently used data process for Terrestrial Laser Scanning (TLS) data to achieve data management and reduction. In this study, an innovative method of equiangular sectorial voxelization is presented based on the distinctive point distribution characteristic of single-scan TLS. It has the function of containing the same number of laser beams going through each voxel, resulting in metrics that can be applied to delineate forest conditions. To verify the effectiveness of the new voxelization method and illustrate its application, 48 plots and 1098 individual trees with different defoliation degree were scanned using single-scan TLS. Their defoliation could be linearly regressed using only point density derived from this new shape of voxels, resulting in 0.89 R2 value and 11.7 RMSE (% of defoliation) for individual-tree-scale estimation, and 0.83 R2 value and 12.1 RMSE (% of defoliation) for plot-scale estimation. We conclude that the new voxelization method was effective, and the point density calculated based on that was an efficient feature revealing forest defoliation.

Keywords
Single-scan TLS; Voxelization; Point density; Defoliation; Regression.

Highlights
1) Proposes a new method of voxelization specialized for single-scan TLS.
2) Uses angular coordinates when dividing voxels, generating sectorial voxels instead of cubic.
3) Investigates beams as sampling to measure the percentage of the space occupied by forest canopy
4) Verifies point density derived from such voxels as being robust for foliation delineation.
5) Explores a new application of TLS in tree defoliation estimation.