The use of terrestrial LiDAR for enhance forest inventory.

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ABSTRACT

Terrestrial LiDAR (TLidar) is an emerging technology that has high potential for forestry applications. It provides a detailed three-dimensional (3D) point cloud representation of forest structure at tree- and plot-level from which a wide range of forest attributes could be extracted with appropriate methods. Consequently, TLidar potentially offers the opportunity to expand on the estimation of new attributes beyond what is currently measured with conventional forest inventory. The presentation will describe how the use of TLiDAR data can enhance forest inventory. More specifically it will describe three novel sets of algorithms involving the use of TLiDAR data.

The first set of algorithms provides information on forest plots that can routinely be extracted from TLiDAR using existing algorithms currently available as open source. The set of attributes includes stem diameter at breast height, tree height, map of tree position, digital terrain model and canopy height model.

The second set includes four new algorithms developed in our group to estimate structural attributes from the point cloud collected in field plots, namely (1) the automatic estimation of stem taper of all trees in a plot, (2) the automatic segmentation of all the tree crowns, (3) tools to allow spatial analysis of tree growth/competition and (4) tools to quantify tree branchiness for wood quality assessment. Algorithms 1 and 2 are innovative adaptations of specific mathematical principles to take advantage of the spatially-explicit information provided by the TLiDAR data. Our validation tests provided an average error on stem taper generally within 1.2 cm for the lower part of the stem (up to 5 to 10 m depending on the stand/tree configuration) and increasing rapidly in the upper part of the stem where signal occlusion becomes important. The crown segmentation method was capable to extract with success 90% of the tree crowns in a coniferous stand and 85% in a deciduous stand. Algorithms 3 and 4 were designed as interactive tools to manipulate the TLiDAR point cloud data for specialized analysis such as branchiness as well as crown mensuration in the context of tree growth and competition.

The third set of new algorithms relates to the explicit 3D representation of tree components and dealing with LiDAR data limitations. More specifically, the main limitations that are intrinsic to TLiDAR acquisition systems include signal occlusion, over- and under-sampling and noise. The proposed procedure, called L-Vox, uses a voxel representation of the TLiDAR point cloud. Spatial distribution of canopy components is described through a new structural index called the Relative Density Index (RDI). Calculating the RDI from a point cloud by using the acquisition configuration allows dealing with the LiDAR data limitation while allowing a true 3D representation of the spatial distribution of canopy components. We demonstrate the capabilities brought by the L-Vox algorithms through a test case where RDI values are used to assess the spruce budworm damage on white spruce stands using a three-years monitoring TLiDAR scanning. All the new algorithms developed by our group are currently being further validated in preparation for their final implementation on an Open Source platform called CompuTree, specifically designed for the analysis of LiDAR data.

Earth Observation Summit 2017, Montréal, 20 to 22 June 2017. https://crss-sct.ca/conferences/csrs2017/