Tree architecture descriptive models and applications

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Abstract

The spatial configuration of tree's elements is closely related to a number of forest ecosystem functions and services, such as biomass production and carbon sequestration. Through the development of architecture, trees optimize their access to the necessary resources. High sensitivity to the dynamic changes in the environment makes the architectural traits an important predictor of stand features, both quantitative and qualitative. However, detailed crown variables are rarely available and the measurement process is complex.

The aim of this thesis was to increase the potential applicability of tree architecture descriptive modelling in forestry. The objectives included: (i) to compare the active methods of forest trees' architectural description, according to their applicability in forest research and practice; and (ii) to develop a new method, which minimizes the existing limitations.

The horizontal representations of tree architecture are the simplest, and applicable to studying some effects of inter-tree competition and the light conditions within the forest canopy. The three-dimensional models retain the widest range of possible applications, while being the most complex. The vertical representations may be useful for examining the effects of local topography, wind conditions, and the relations between tree architecture and tree stability; however, the way of deriving such models from the three-dimensional ones seems impractical.

A simple photogrammetric method (Single Image Photogrammetry, SIP) was implemented to develop a vertical, quantitative tree architecture model; with only one digital image per tree. The method was tested in an upland, natural beech forest and lowland, managed pure sessile oak and oak mixed with Scots pine forest stands. All preselected, 85 mature trees were successfully measured with SIP, including 31 European beech trees and 54 sessile oaks. The architectural traits obtained from the geometric models included whole tree-, crown-, and branch-level variables. SIP-derived oak traits were compared with their counterparts from terrestrial laser scanning (TLS). High correlations were found for tree height, diameter at breast height, crown diameter and crown asymmetry; while branching angles (not compared directly) were useful for explaining the differences in TLS-based crown projection area, under varying forest stand conditions. The results provide evidence that SIP can be applied in forest research and practice. The method bridges a gap between the traditional forest mensuration praxis and the advanced remote sensing techniques.

Keywords: tree architecture; forest modelling; forest ecosystems; photogrammetry; geometry