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How Tree Movement Influences Tree Metrics Derived from Laser Scanning Point Clouds

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By simulating laser scanning of dynamic tree scenes, we investigate how tree movement during point cloud acquisition affects the accuracy of a range of tree metrics.

Terrestrial laser scanning (TLS) has proven to be an effective surveying method for forestry and ecology, producing highly detailed 3D point clouds of trees. From these point clouds, a variety of metrics can be derived, such as tree and crown dimensions, stem diameter and taper, foliage parameters, and woody volume. In this way, TLS supports traditional forest inventory and monitoring, and provides valuable in-situ data for the calibration of remote sensing approaches.

Typically, TLS point clouds are acquired from multiple scan positions to increase coverage and minimise occlusion. Scans from these positions are then co-registered and merged into a single point cloud. If wind is blowing during data acquisition and branches and leaves are moving, the merged point clouds may show multiple or blurred representations of branches and leaves. This is likely to affect the quality of the tree information derived from the point clouds. Although this problem is well known, few studies have systematically investigated the effect of vegetation movement during the scanning process on the derived tree metrics.

The aim of this work is to quantify the errors induced by vegetation movement during TLS acquisition on a variety of metrics. We also investigate the extent to which point cloud filtering methods and the omission of 'problematic' scan positions can improve metric accuracies.

To enable a systematic and controlled investigation, we use virtual laser scanning (VLS) with the open-source laser scanning simulator HELIOS++ [1, 2]. We first generate synthetic 3D tree models using procedural modelling [3, 4]. These tree models are then animated in different scenarios by simulating different wind conditions. For each wind scenario, the trees are virtually scanned from multiple positions, each scan being performed at a randomly sampled frame of the animation. From the simulated multi-scan TLS point clouds, we estimate several point cloud metrics, both with and without prior point cloud filtering. We compare the metrics with metrics derived from the reference meshes or point clouds.

Performing such an analysis in a simulation environment has several major strengths: a) we can isolate the wind effects from other errors such as co-registration errors, b) we can define arbitrary

custom wind scenarios and do not need to carry out real wind measurements, and c) reference data is available in the form of the input 3D tree models and base simulations without wind.

We demonstrate how VLS can be used to investigate wind effects, which are a common source of error and uncertainty in TLS of vegetation. This not only allows us to develop strategies to account for these effects, but also informs us of the importance of modelling these effects when using VLS in other contexts, such as algorithm development or machine learning.

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