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Terrestrial photogrammetry for forest 3D modelling at the plot level

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Detailed information at the plot level on tree count, tree heights, crown base heights and diameters at breast height (DBH) are essential for monitoring forest regeneration, quantitative analyses of forest structure and dynamics, and for evaluating forest damage.
In the last decade, terrestrial laser scanning (TLS) has evolved as an alternative to traditional in-situ forest inventory methods, providing point clouds of high accuracies and resolutions. However, the high costs and weights of TLS devices and the required expertise for the acquisition and processing of TLS data hamper the extensive use of TLS for forest inventories at the plot level.
Thanks to recent advances in photogrammetry, terrestrial structure-from-motion (SfM) has become a low-cost, high quality alternative for deriving detailed 3D point clouds of forest plots.
This study evaluates the applicability of terrestrial photogrammetry to model forests at the plot level in 3D by means of consumer grade cameras. This investigation was conducted at six circular plots with different radius to cover at least 50 trees of the target tree species. Altogether six plots were established in Austria, Czech Republic and Slovakia, two in each country, in order to cover different conditions in terms of slope, forest density, undergrowth, tree species. For each plot, the following survey configuration is maintained. Targets within the plots are acquired by the total station, and they are either used as check points to estimate the accuracy of the photogrammetric reconstruction, or as ground control points for georeferencing the 3D model. Parallel to the photogrammetric acquisition, TLS data were collected in order to compare the two techniques concerning the derivation of forest information. Additionally, we measured the DBH with an electronic calliper, the tree positions with the total station, and the tree heights with a Vertex.
Parameters like DBH, taper function, and tree count were automatically detected from both TLS and SfM for each plot using a software developed at TU Wien (FAIT, Forest Analysis and Inventory Tool).
For each plot, the images were oriented with errors of only a few centimetres, according to the check points. The results show that terrestrial photogrammetry and TLS provide comparable results for the detection of the tree count and the DBH. However, the photogrammetric survey needs to be properly planned, and the reconstruction of the trees is limited to the area captured by the pictures. Using TLS data as reference, the accuracy of SfM ground points is on average better than 10 cm, even for very steep plots.
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