Abstract "A century of national forest inventories – informing past, present and future decisions"

Abstract title:		Applicability of terrestrial photogrammetry based on Structure from Motion for deriving plot-level forest parameters.
Take-home message:		*Terrestrial photogrammetry provides a cost-effective and high quality method to support forest management and monitoring at the plot level with accuracies comparable with those from TLS.*
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General topic, see website: (please double click on the check box and activate the relevant one)	☐	Improving future NFIs by learning from the past
	☐	NFIs today and in the future
	☒	Cutting edge and futuristic inventory techniques and technologies
Preferred presentation form:	☒	Oral presentation
	☐	Poster
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Applicability of terrestrial photogrammetry based on Structure from Motion for deriving plot-level forest parameters

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Comprehensive and detailed information at the plot level about the state and dynamics of forests is essential for forest monitoring and management planning. Traditional plot-scale forest measurements are derived by a rather time-consuming field sampling. The main interest forest related parameters in forest inventory are the diameter-at-breast height (DBH), tree position and the tree height, which are conventionally measured using clinometers, callipers, and tapes. Over the last few decades the integration between the field sampling and remote sensing technologies is widely acknowledged and in most of the case, field sampling measures are used as validation data of remote sensing derived forest parameters. For forest planning and monitoring at the plot-level, terrestrial laser scanning (TLS) has evolved as an alternative to traditional in-situ forest inventory methods for providing detailed and accurate estimates of forest metrics from point clouds. The main drawbacks of this technologies are the high costs per area for acquisition and data processing and the need of high expertise for acquiring the scanner data and their processing since multiple scanning positions are required in order to avoid occlusion by stems and branches. Due to these drawbacks, terrestrial photogrammetric point clouds are rapidly gaining popularity in forestry as a low-cost, high quality alternative to TLS at the plot level. The overall goal of the study is to evaluate the applicability of terrestrial photogrammetry based on Structure from Motion (SfM) for deriving plot-level forest parameters such as tree position, DBH, stem curve by means of a consumer grade camera. In particular, we want to assess the quality (i.e. accuracy and completeness) of the photogrammetric results and the repeatability of the photogrammetric survey and the comparison with TLS in terms of costs and applicability. The investigation was conducted at six circular plots located in Austria, the Czech Republic and Slovakia, two in each country, in order to cover different conditions in terms of slope, forest density and age, undergrowth, and tree species. Photogrammetric targets were used as check points to estimate the accuracy of the photogrammetric reconstruction, or as ground control points for georeferencing the 3D model. For each plot, the reference data of the forest parameters were obtained by conducting field surveys and TLS measurements simultaneously to the photogrammetric acquisitions. The TLS was also used to estimate the accuracy of the photogrammetric ground height, which is a necessary product to derive the normalized height of the trees. We automatically derived tree positions, tree counts, DBHs and stem curve from both TLS and SfM for each plot using a software developed at TU Wien (FAIT, Forest Analysis and Inventory Tool), and the results were compared. For each plot, the images were oriented with errors of a few millimetres only, according to check point residuals. For all six plots, more than 90% of the trees were

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reconstructed from SfM data. All missing trees have diameters of less than 5 cm. Overall plots, the median difference of SfM and TLS DBH is 0.4 cm. The resulting stem curves show that the median difference of SfM and TLS stem diameters is 0.7 cm up to 3 m above ground and increases to 4 cm for higher elevations. This work shows that with the adopted camera geometry, terrestrial photogrammetry is an accurate and cost-effective alternative to TLS for DBH, tree detection, and stem curve up to a few meters above ground.

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