Branch detection based on TLS data

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1. Introduction

Terrestrial Laserscanning (TLS) has been established as the standard method for detailed 3D scanning and reconstruction of trees with millimetre accuracy. The data acquisition is commonly done with multi-scan acquisitions to minimize occlusions on the stems. Assuming that the co-registration of the individual TLS scans have a high accuracy i.e. less than few millimetres, the 3D stem can be reconstructed e.g. with quantitative structure models (QSM) or cylinder fittings. Until now, the branch detection was not of great importance because for economical purposes mainly the stem volume is of interest.

In this contribution, an operational approach for branch detection and assessment of the branch diameter classes based on multi san TLS data is presented. The investigations were carried out for a test area in Carinthia, southern Austria.

2. Study area and data

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The study area is located in the southern part of Austria, in the federal state of Carinthia. For the spruce dominated forest stand a TLS campaign with a Riegl VZ400i was carried out on 5th of November 2020. In total 18 scan positions were needed to cover approx. 1.700 m².

The forest stand is even-aged with tree heights >30m and about 120 years old. The stand obviously has grown up with large tree spacing and no pruning: in most cases the dead branches go down the whole stem, the living branches start already in 7-10m height. The density in comparison to yield-table expectations (“Fichte Hochgebirge”) is about 80%.

The scan positions were chosen unplanned intuitively between the trees. The distance between consecutive scan positions was about 10 steps (5-8 meters). With a scan resolution of 20 x 20 milli-degrees one single record takes only 3 minutes, so accurate planning of scan-positions was considered to be not necessary. The Riegl software RiSCAN PRO is able to co-reference scan-positions without artificial tie-points. The whole scanning fieldwork took less than 2 hours.

3. Methods

TLS pre-processing

The acquired TLS scans were co-registered with RiSCAN MultiStationAdjustment (MSA2), which works without artificial tie-points. The co-registered point cloud was exported as las-file.

Stem modelling

Based on the co-registered point cloud a digital terrain model (DTM) was derived using a hierarchic robust method implemented in the OPALS software (Pfeifer et al., 2014). In addition to the DTM a digital surface model (DSM) was calculated using the landcover-dependent approach described in Hollaus et al. (2010). Finally, the normalized digital surface model (nDSM) was computed by

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subtracting the DTM from the DSM. All of these topographic models have a raster resolution of 0.2 x 0.2 m². The DTM was further used to normalize the heights of the point cloud, and the nDSM was used to assess the tree height.

To model the stems with cylinders approximate position of the individual stems are needed. Based on a voxel approach the stem positions are detected by analysing the point densities in successive layers. Finally, the stem is modelled by robust least-square fittings of cylinders to neighbouring points of the detected stem positions.

Branch detection

The branch detection and branch diameter estimation is done on equirectangular projections (Eysn et al., 2013) of branch points. Based on the modelled stem cylinders the branch points are selected within a cylindrical shell around the stem (internal radius is cylinder radius plus 5 cm, external radius is cylinder radius plus 10 cm). The equirectangular projection is done for each tree separately and uses the cylinder angle as x-axis and the height as y-axis. The point density and the distribution of the distances are used for detecting the branch positions. The branch diameters are estimated by quantiles based on the 3D branch point extends. For this branch diameter estimation only the horizontal range of the classified branch points is considered because no points on the upper side of the branches are available due to the scanning geometry.

The branch processing of the TLS data was done with the OPALS software (Pfeifer et al., 2014) and Python.

4. Results and discussion

The automatic detection of individual tree positions has a high degree of completeness. For trees with a diameter at breast height (DBH) >0.15 m the completeness is >95%. Also the stem modelling with a series of cylinders lead to high completeness and correctness. In average stems could be modelled up to two third of the tree height (Figure 1). For the upper parts of the scanned spruce trees occlusions of the stems increase dramatically due to the increase of branches, which is why, a reliable direct modelling of the stem is no longer possible.

The applied branch detection approach leads to high degree of completeness and works fully automatic. As can be seen in Figure 1e also the diameter classes can be estimated based on the TLS data.

5. Conclusion and Outlook

The presented workflow shows a robust way of extracting stem and branch information from TLS data. The derived 3D stem model can be used for e.g. estimating stem biomass, deriving taber functions, or for timber assortment. The branch information can also be used for timber assortment but also as a kind of “finger printing” of the individual trees. In future work the potential of using such “branch finger printing” in addition to the stem properties (i.e. taber function, deviation from the circular cross section, etc.) for certification of stem origin will be investigated.

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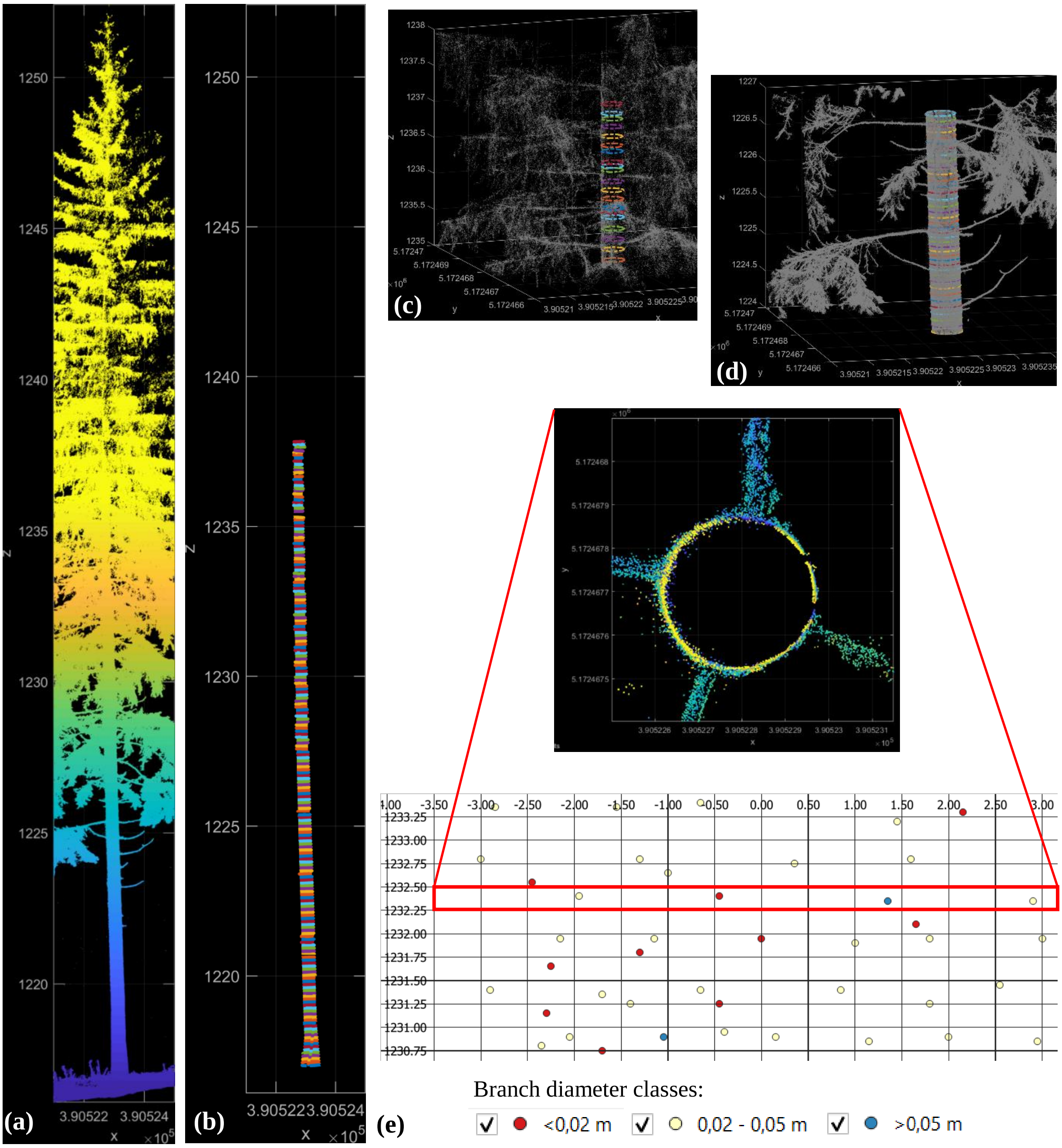

Figure 1: (a) TLS point cloud of an extracted tree, (b) modelled tree stem, (c ,d) point clouds for different height slices overlaid with the fitted stem models, (e) subset of the equirectangular map with the detected branch positions. The x-axis correspond to the cylinder angle and the y-axis to the height. The colors represent the different diameter classes.

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