VirtSilv A.I. 3D platform for sustainable forest management

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1. Introduction

Climate-Smart Forestry is a sustainable forest management approach for increasing these positive climate impacts on society (Verkerk et al. 2020). In response to climate change, the approach intends to reduce greenhouse gas emissions, adapt forest management to create resilient forests, and focus on active forest management with the goal of sustainability by increasing productivity while simultaneously offering all forest benefits (Nabuurs et al. 2017; Bowditch et al. 2020).

Nowadays, the availability and affordability of equipment and techniques are continuously increasing. LIDAR devices have become more portable, at ever-increasingly affordable prices, along with techniques for generating 3D scenes from measurements (Tang et al. 2015). This has enabled the building of virtual worlds that reflect the natural landscapes using precision measurements. Particularly, terrestrial lidar systems collect large amounts of data varying from tens of thousands to billions of 3D points to determine the 3D space surrounding a given point in 3D (Paris et al. 2017)

Virtual tree measurements are achieved today by using software applications and allometric approaches (Yu et al. 2013; Kankare et al. 2015; Liang et al. 2014; Astrup et al. 2014; Newnham et al. 2015; Tomșa, Curtu, and Niță 2021). However, the quality of results and maturity of these algorithms are still low (Tansey et al. 2009; Li et al. 2012). Furthermore, there is no technological group on the market that would be able to provide a complete set of solutions to the problem, from the measurements in the forest to creating digital twins of each tree (Raumonen et al. 2013). As a platform that responds to the realities of the forest, VirtSilv provides industry-specific services in all segments (Forest Design 2020). VirtSilv is an online platform that uses AI customizable algorithms to produce unique shapes of trees as digital support for a fully automated traceability IT circuit between forest management, transport, and the wood industry.

The article aimed to validate the automatic workflow of processing 3D pointclouds to produce digital twins for every tree in a specific forest using GeoSLAM mobile LiDAR scanner and VirtSilv AI platform.

2. Materials and Methods

2.1 Study area and data

Several measurement campaigns were carried out, using mobile LIDAR device and traditional forest inventory tools (tape for DBH and vertex logger IV for height), focusing on 3 plots of 1 ha size in Carpathian Mountains, Ciucas Massif.

The plots were scanned using ZEB Horizon, a scanner based on LiDAR technology, and included in the category of Terrestrial Laser Scanners (TLS). This is a 3D scanner of high-speed used for measurements that require recording of details. ZEB Horizon Scanner uses laser technology, weighing 1.3 kg it is designed for outdoor applications that require scanning up to 100 m and at an accuracy of 1-3 cm. The scanner uses a rotating mirror to beam around the area that is scanned. The measurement characteristics consist of up to 300,000 repetitions per second. Data acquired using GEOSLAM Horizon technology is a point cloud in the form of three-dimensional data compiled using SLAM (simultaneous localization and mapping). The scanning time suitable to produce dense pointclouds was on an average of approximately 20 minutes/hectare for each plot.

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2.2 VirtSilv software

The raw data generated during the scanning process enables the visual identification of individual tree structures, but they are not yet quantitatively differentiated. To create individual raw material for digital twin, VirtSilv first separates the ground from the trees, and then it reconstructs each tree separately. For segmentation the algorithm takes 3 steps to estimate each tree's footprint simultaneously. The algorithm begins at a large nucleus of points with high density and then grows by accretion until it meets neighbouring trees. The novelty of VirtSilv is that parallelize the computation so the average processing time of segmentation for 1 hectare of scanned forest is 30 minutes.

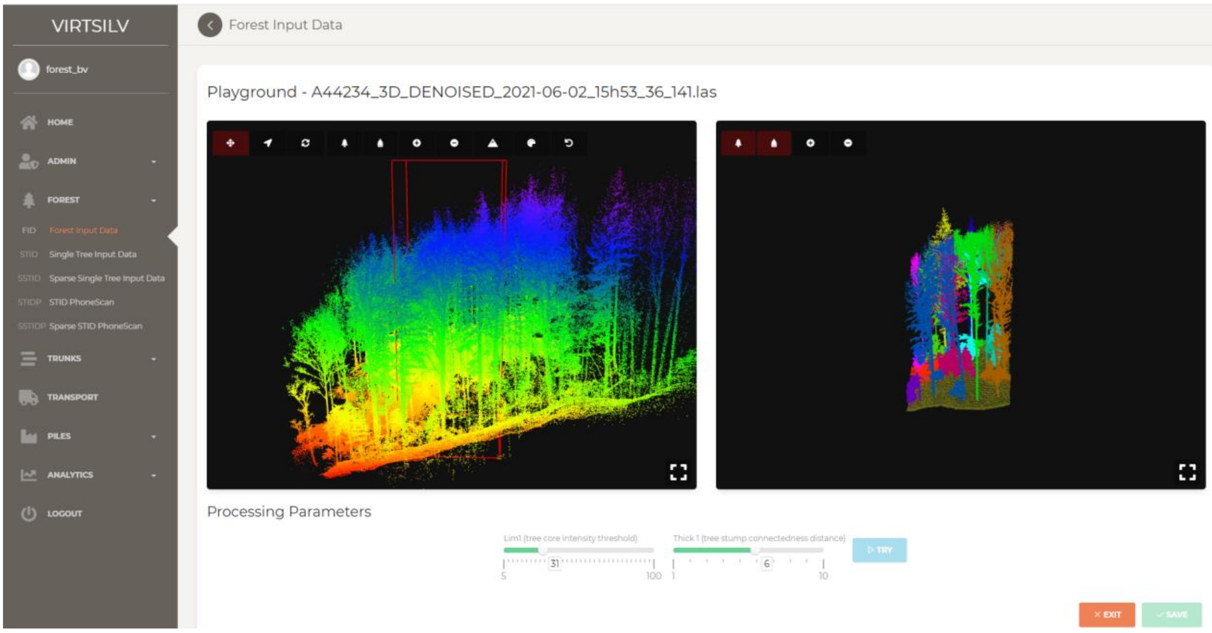
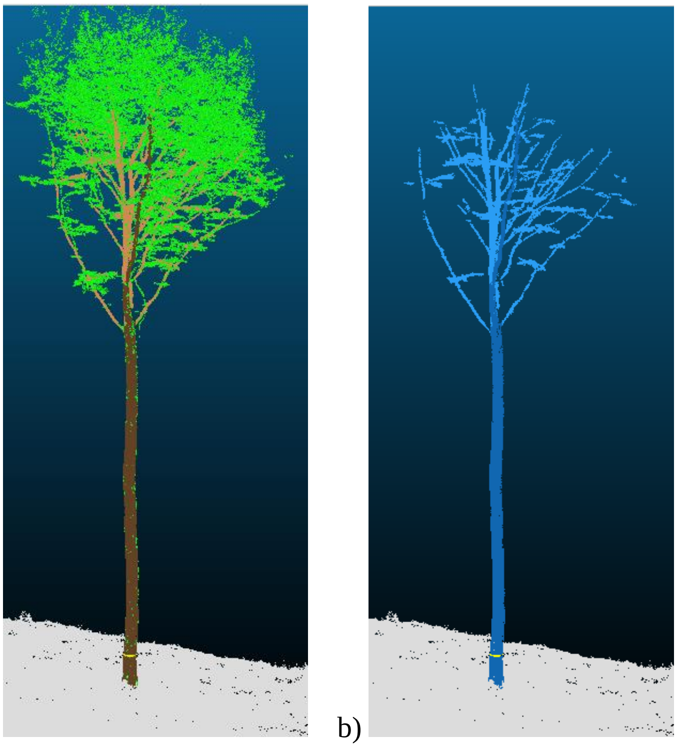


Figure 1: Raw data processing dashboard.

When all the individual tree segments are identified, the remaining task is to recognize tree trunks and model their numerical dimensions on a simple and flexible basis, thereby giving the potential for the digital twinning process. To overcome the limitations of current techniques, VirtSilv algorithms are designed around the following principles (figure 2):

- The trunk shape of segments of sufficiently small height can be approximated very well by inclined cone trunks.
- The vertical projection of the data obtained from segments of sufficiently small height can be approximated by a ring of points with relatively high density.
- Generally, the successive segments in the vertical array are very well aligned, in the sense that the angle and bending of each segment, concerning that vertical changes are low.

Thus, the VirtSilv algorithm is focused on extracting chains of cone trunks as a numerical model for trunks. The average time of producing the 3D model of a tree digital twin is less than one minute.



a) b)

Figure 2: Single tree point classification in a) trunk, branches and leaves+ small branches and b) model generated for woody part

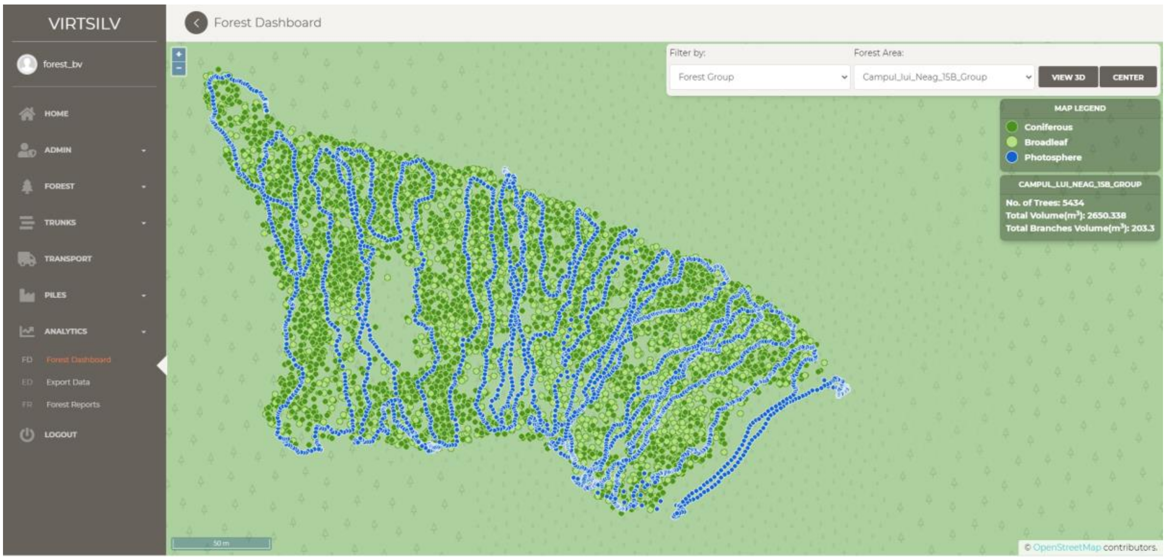


Figure 3: The final product dashboard.

3. Conclusion

A number of 1399 trees were scanned with LiDAR to create digital twins and for validation were measured with traditional tools such as tape and vertex. The segmentation algorithm developed in the platform to extract individual 3D trees an accuracy varying between 95-98% was recorded. This result was higher in accuracy than reported by other solutions. When compared to traditional measurements the bias for diameter at breast height (DBH) and height was not significant. Digital twinning offers a blockchain solution for digitalization and AI platforms are able to provide technological advantage in preserving and restoring biodiversity with sustainable forest management.

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