Major Woody Parts Segmentation in Forest Point Clouds with Normalized Intensity

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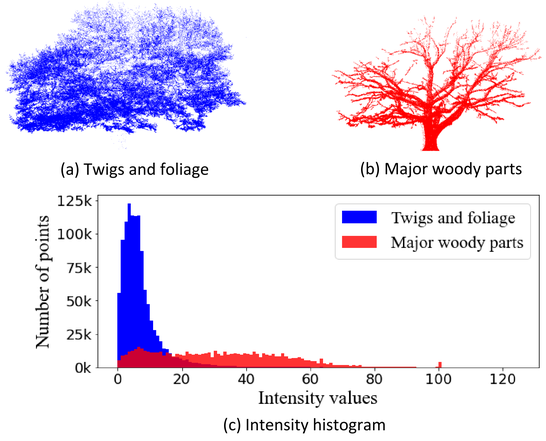
Abstract

We present a fast and fully unsupervised method for segmenting major woody parts using LiDAR data from a backpack Mobile Mapping System (MMS). Our method combines automatic thresholding of normalized radiometric and geometric features to extract major woody parts in point clouds. Compared to existing methods, our approach achieves higher performance on 14 trees with different sizes and species in both leaf-on and leaf-off seasons. Unlike static Terrestrial Laser Scanning, our MMS LiDAR data is more efficient and accurate due to its non-destructive and dynamic scanning capabilities. Our results demonstrate the potential of our method for deriving structural and biophysical attributes of trees.

INTRODUCTION

- Major woody parts dominate the majority of biomass and timber and so play an important role in a tree.
- Terrestrial Laser Scanning (TLS) has been used for major woody parts segmentation in recent years.
- However, TLS is slow and not scalable to capture large areas in a reasonable time.
- LiDAR intensity hasn't been fully exploited; it shows significant differences between major woody parts, twigs, and foliage (shown in Fig. 1.)
- With a backpack LiDAR system (shown in Fig. 2), we propose a fully unsupervised method that combines normalized radiometric and geometric information.



(a) Twigs and foliage (b) Major woody parts

(c) Intensity histogram

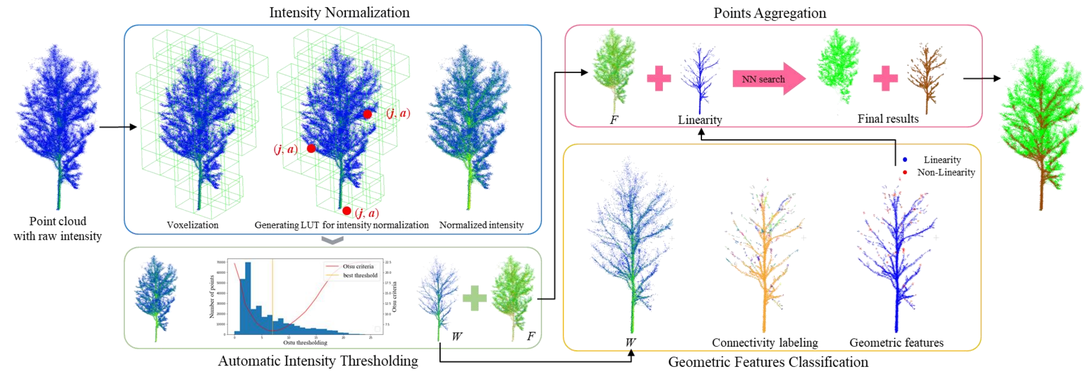
Fig. 1. A red maple's major woody parts, twigs, and foliage points with the corresponding distribution of raw intensity values.

Integration of the backpack LiDAR system:

1. Antenna
2. LiDAR scanner (Velodyne VLP-16 HiRes)
3. Micro computer (Raspberry Pi)
4. GNSS/INS system (NovAtel SPAN-CPT)
5. Camera (Sony α7RII + 32mm lens)

Fig. 2. The backpack system with its individual components.

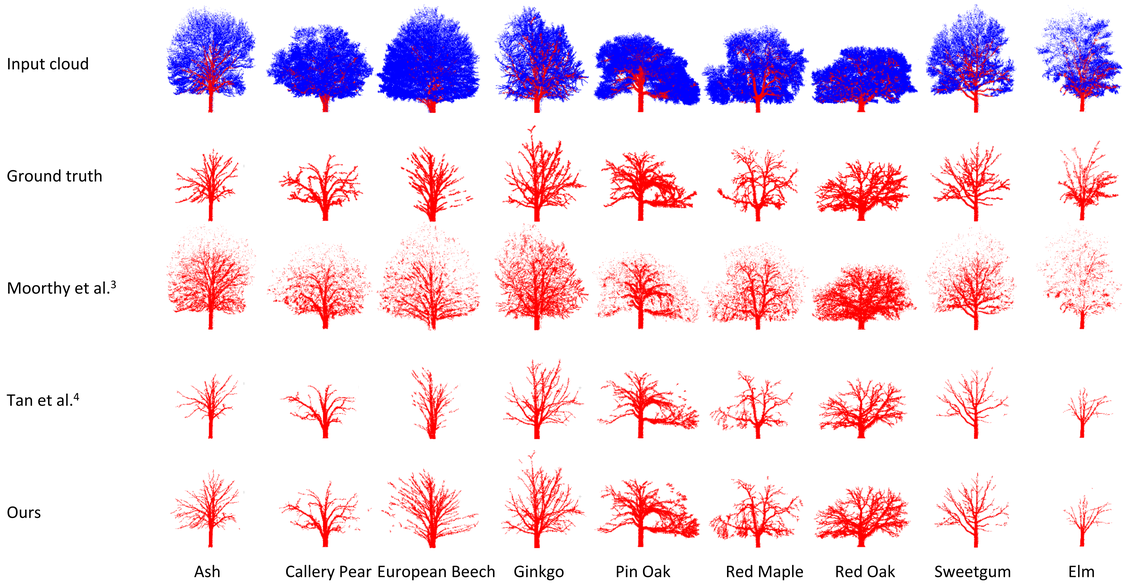
METHODS



Processing workflow:

1. Unsupervised intensity normalization (laser beam-based intensity normalization)[1]
2. Automatic intensity thresholding (Otsu's method, minimize intra-class variance)[2]
3. Geometric features classification (eigenvalue decomposition)
4. Major wood points aggregation (nearest neighbor search)

RESULTS



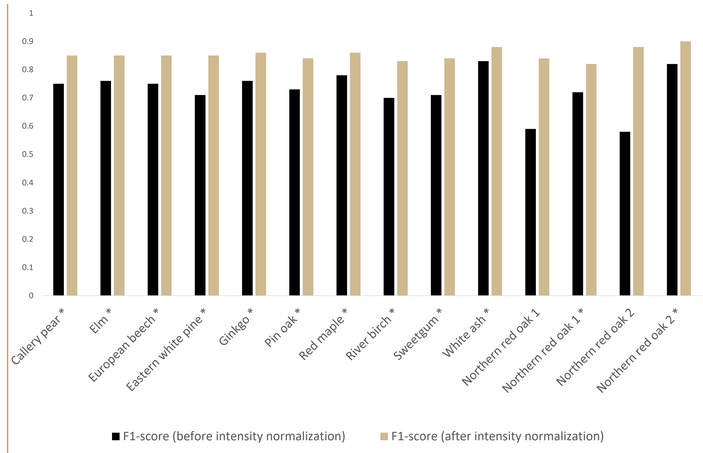


Fig 3. Comparison between before- and after-intensity normalization in different tree species (* represents leaf-off season)

Table 2. Comparison between the proposed method and others in prior works

Methods	Running time	Precision	Recall	F1-score
Moorthy et al.	3.5 hours	0.46	0.55	0.50
Tan et al.	15 seconds	0.68	0.72	0.70
Ours	**8 seconds**	**0.87**	**0.86**	**0.86**

DISCUSSION

1. Our approach is able to improve the accuracy of major woody parts segmentation across different tree species in different seasons.
2. This research provides new potential for quick data acquisition and segmentation.
3. We plan to expand this approach to major woody parts segmentation at the plot- and stand-level.

REFERENCES

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