LPVE23 - WORKSHOP ON LAND PRODUCT VALIDATION AND EVOLUTION

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INVESTIGATION INTO 3D VEGETATION MODEL VALIDATION

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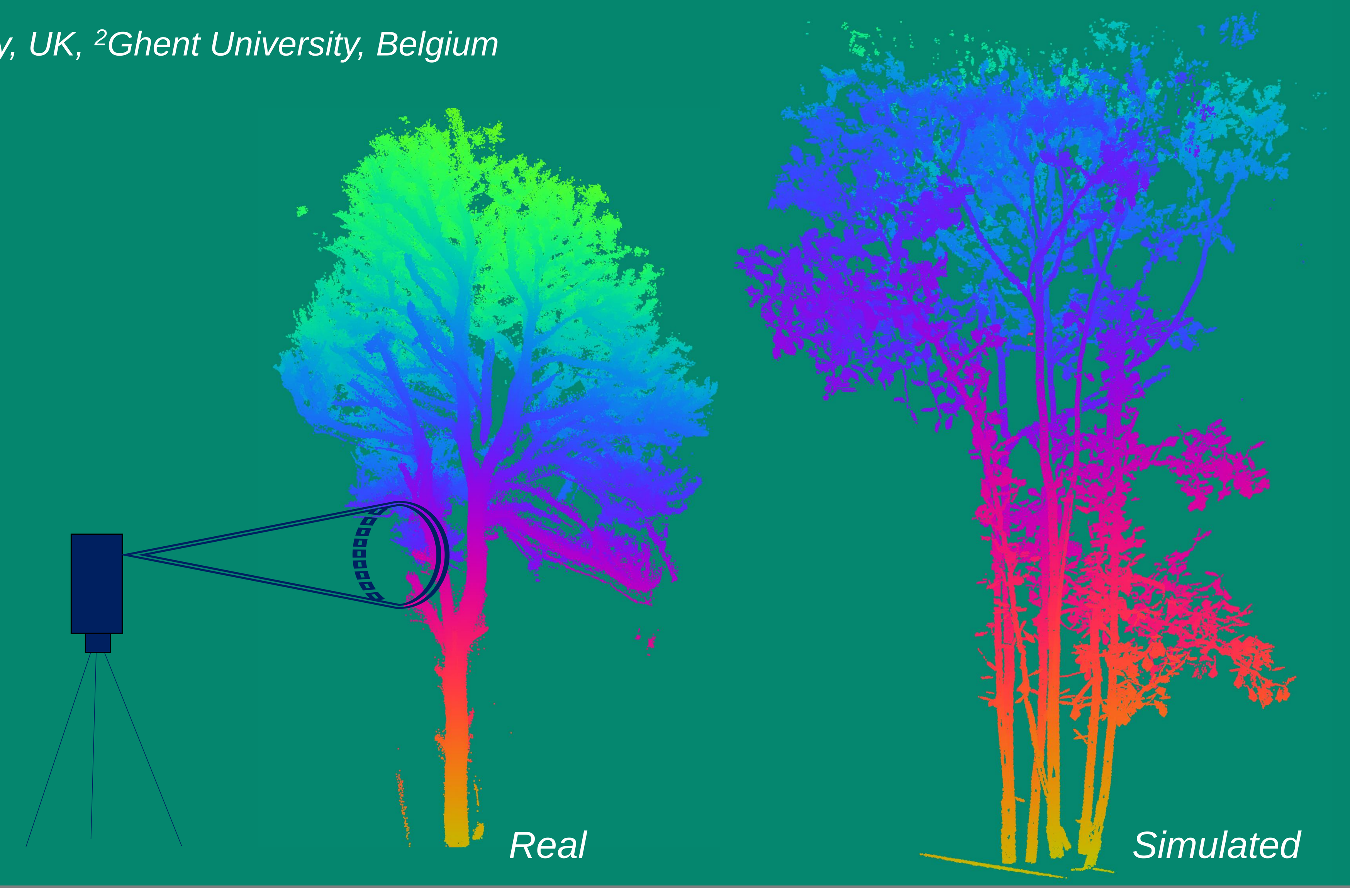
INTRODUCTION

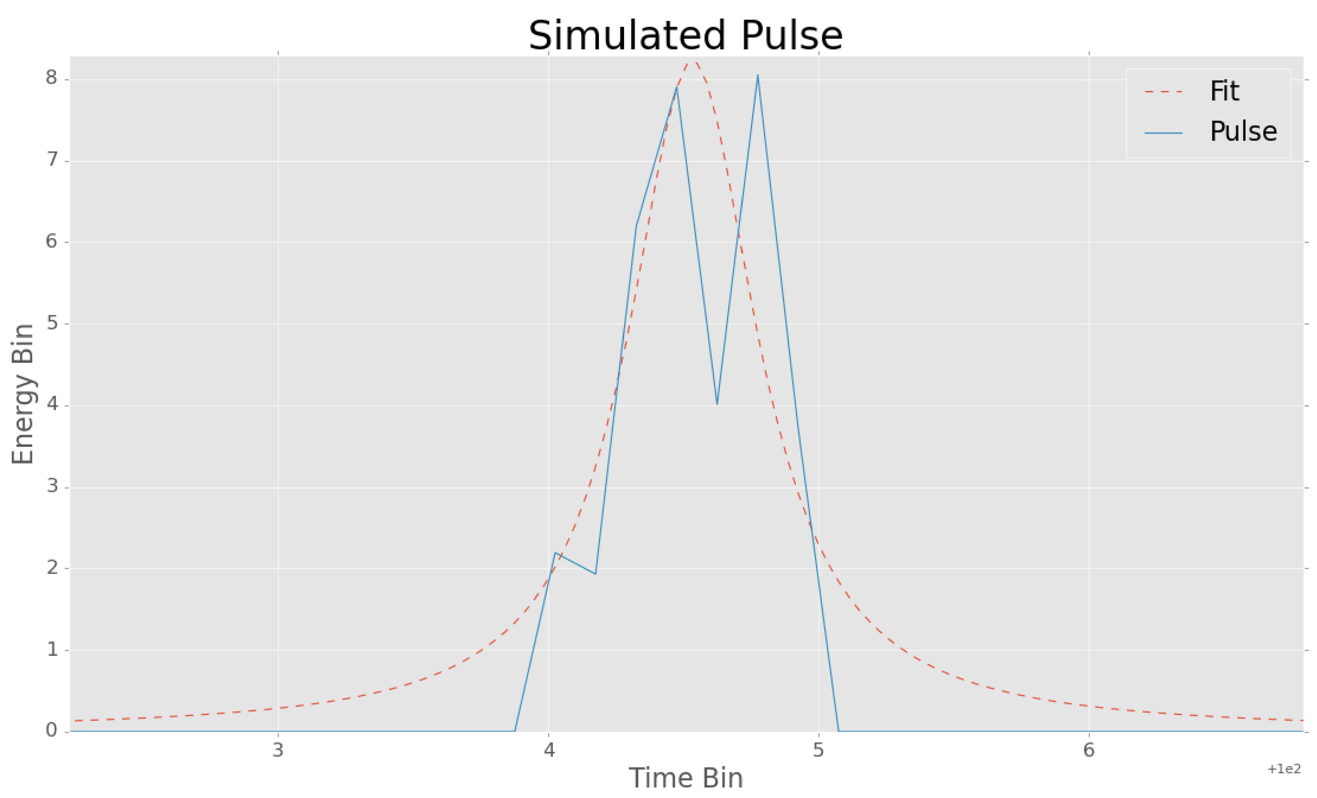
3D models of vegetation structure, combined with radiometric characterisation, are a vital tool in determining the radiative regime of a plant canopy. When combined with radiative transfer (RT) modelling they can be used to infer uncertainties and biases within measurements. For instance, satellite product algorithms employ a multitude of assumptions about the state of a plant canopy/illumination conditions/etc. in the determination of products such as Leaf Area Index (LAI) and the fraction of absorbed photosynthetically active radiation (fAPAR). The effect of these assumptions can be tested with a representative 3D model and an RT model. However, for useable and comparable results, the 3D model's similarity to reality should be quantified. Ideally, this would consist of a standardised method using a reliable metric. This research investigates a possible route to determining the "closeness-to-reality" of a hyper-realistic 3D model of Wytham Woods 3D model [Calders, et al (2018)] via the comparison of LiDAR simulations and measurements.



WYTHAM WOODS MODEL

The Wytham Woods model [Calders, et al (2018)] consists of 559 trees of various species (Sycamore dominated). The model was created using LiDAR measurements of a 6-hectare site at 20 m spacing, while the central central 1-hectare was reconstructed. A processing pipeline including data cleaning, filtering, tree segmentation and leaf addition was applied to return the 3D descriptions of the individual trees. Radiometric measurements with an ASD spectrometer were also collected, sampling the leaves, bark, and understory to determine the reflectance of these canopy components.

SIMULATIONS AND PROCESSING



Terrestrial LiDAR scanner (TLS)

TLS systems create detailed point clouds of their surroundings by emitting light pulses and recording the returning time and energy of those pulses. We replicated this process using a simulation model of a Riegl VZ-400i in *Librat* [Lewis (1999)] since this was the instrument used. VZ-400i specific parameters were determined, including the wavelength, pulse shape, pulse length, and measurement resolution. Following the simulations, pulse processing, including waveform decomposition, needed to be performed. An adaptive algorithm was created which took the returned pulse properties and fit a Lorentz curve according to the number of peaks present as well as the pulse width. For clear multiple returns, multiple peaks would be detected, but for a complex partial return of a single waveform, one Lorentz curve would be fitted. The graph to the left shows an example of a complex pulse, with a fitted Lorentz function used to determine the 'true' return centre

COMPARISON

Comparison Issues

The simulated and real point clouds need to be compared to assess similarity. However, there are lots of issues with doing this such as:

- Complex structure of point cloud containing 559 trees plus understory
- Millions of data points
- Intricate processing pipeline recreated without verification from manufacturers

Comparison Techniques

There is a lot of literature focusing on point cloud comparison and highlighting the difficulties. Here, we tested the absolute value of the Hausdorff distances (AVOHD) using a method described in [Yaxin et al, 2020]. The AVOHD is useful since it minimises the effects of differing numbers of points in the datasets being compared. However, angular misalignment can cause large AVOHD values. Ultimately, relating the AVOHD to similarity and then applying this to uncertainty evaluation of real measurements needs to be completed. AVOHD has been found to be a reasonable way to identify structural differences – although not radiometric differences – but more needs to be done in order to link model and simulation comparability to uncertainties and biases.

NEXT STEPS

1. Use AVOHD to compare real and simulated measurements
2. Identify improvements in model from AVOHD value
3. Complete comparison on improved model
4. Use AVOHD to infer uncertainties and biases in real measurements

Calders, K., Origo, N., et al (2018a). Realistic forest stand reconstruction from terrestrial lidar for radiative transfer modelling. Remote Sensing, 10:1–15

Lewis, Philip. "Three-dimensional plant modelling for remote sensing simulation studies using the Botanical Plant Modelling System." *Agronomie* 19.3-4 (1999): 185-210.

Li, Yaxin, et al. "Simulation of tree point cloud based on the ray-tracing algorithm and three-dimensional tree model." *biosystems engineering* 200 (2020): 259-271.