RESEARCH STATEMENT: 4D Modeling of Smart Forest

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Overview

«It is not the strongest of the species that survives, nor the most intelligent that survives.
It is the one that is most adaptable to change»
(Charles Darwin)

Populations are growing around the world while the planet faces major global challenges such as climate change and environmental degradation. As a researcher, I feel a responsibility to combat these issues through my work. Sustainable forest management creates outcomes that are socially just, ecologically sound and economically viable [1]; intended to protect the environment, expand the Earth's natural resource base, and maintain and improve soil fertility. Environmental innovations based on sustainable management will potentially overcome the above challenges, helping us to improve the world for all. Let's be adaptable.

My research aims to set new frontiers to advance the cross-disciplinary generation of plant and computer scientists together with engineers. My experience until now has inspired me to make a career on the computing side of Environmental Data Science. Moreover, my deeply interdisciplinary and collaborative approach definitely reflects this interest. Overall, my **scientific mission** is to develop AI-based digital approaches within the experimental plant sciences framework, as well as implementing software tools and services that may potentially increase the usability of breakthrough imaging technologies.

Research Theme: AI-based digital innovations applied to Climate Smart Forestry

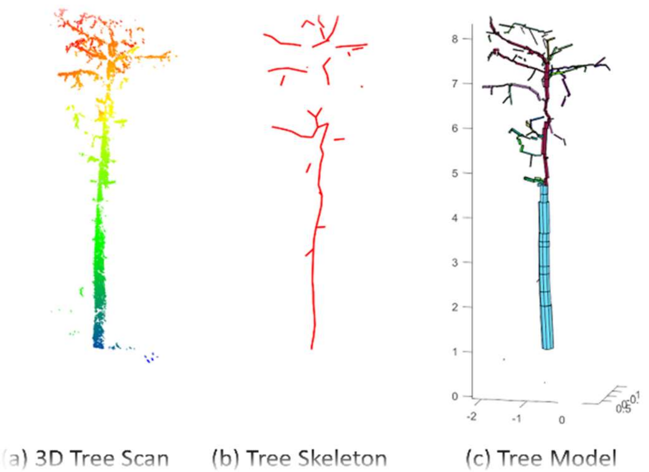

Figure 1. Tree PCD processing from TLIDAR

Technological advances in photogrammetry including SfM (Structure from Motion), NeRF (Neural Radiance Fields) and LiDAR, offer the possibility to use terrestrial, aerial and satellite platforms to accurately measure structural metrics [2]. Preliminary results highlight a notable capture of the structural and vegetation data detectable on the ground with the use of UAS technology and alternative platforms [3].

Figures 1 and 2 show the processing of the point cloud acquired by TLIDAR (Terrestrial LIDAR) and by drones or UAS (Uncrewed Aerial Systems) in forest. Concretely, Figure 1 highlights the potential of point clouds from **terrestrial LiDAR** in trees for geometric analysis; by first, a skeleton extraction based on a constrained Laplacian smoothing algorithm driving the registration in temporal series; and secondly, by a quantitative structure model that describes its basic topological (branching structure), geometric and volumetric properties [4].

About Figure 2, this link illustrates a video of the **point cloud data processing by drone**-based photogrammetry carried out [5] [Video: 3D Forest].

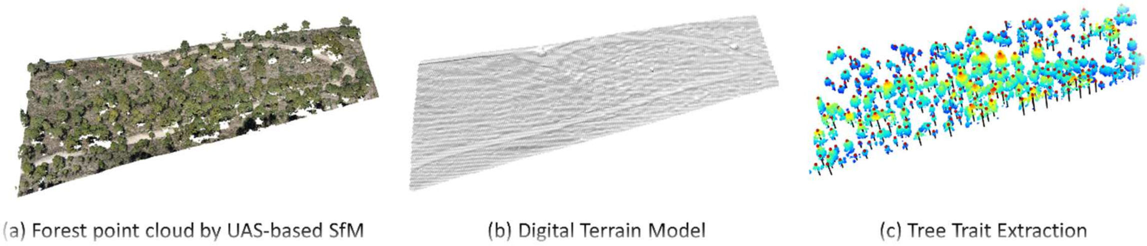

Figure 2. Tree point cloud data processing from drone

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Regarding **satellite data**, I already developed a temporal- spatial data fusion algorithm (Figure 3) [6].

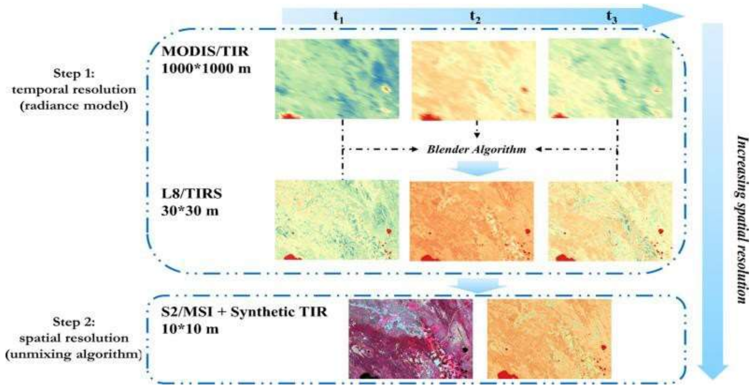

Figure 3. Conceptual workflow of the data fusion algorithm already developed.

Going forward, I am excited to apply all of my knowledge and experience to **real-time forest inventory** and **forest climate resilience**, studying more complex traits; concretely to investigate **biodiversity** and **forest dynamics due to climate-driven disturbances by AI-based digital innovations.** These approaches will advance 4D detail mapping of **structurally complex forests**, enabling **ecosystem functioning** to be monitored; adopting multi-modal representation learning algorithms to further improve the generalization performance and afford data-efficient and understandable climate-smart forest dynamics [7,8]. Furthermore, I will consider applying and combining spatial-temporal and spectral data fusion algorithms from satellites with point cloud data.
In addition, I am interested on developing a **holistic decision support tool** based on digital twin by close-range end remote sensing data for valuation assessments of **NBS'** (Natural-based solutions) implementation, conservation and restoration, with a focus on forestry and its regulating ES (Ecosystem Services).

References

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