Artificial Intelligence for Retrieval of Forest Biomass & Structure

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Timely and accurate information on forest above-ground biomass (AGB) is required for understanding carbon balance, future climate, the sustainability of current politics and the emerging bioeconomy. Optical Earth Observation (EO) in the visible to short infrared spectral region can contribute to this challenge. However, despite optimistic case studies, no global applications using optical EO for biomass retrieval have emerged. The volume of EO data is increasing exponentially and new instruments will measure with better spatial and spectral resolutions, calling for new processing algorithms.

Artificial intelligence (AI) can overcome many of the shortcomings in existing empirical methods for retrieving forest characteristics such as its structure and biomass from EO data. Up to now, AI has been applied to simple canopies with little structure and no woody biomass. Recent developments in deep learning have made it feasible to utilize it for analyzing complex structured vegetation with significant AGB storage such as the boreal forest. We hypothesize that with a carefully selected approach, AI can retrieve the forest AGB which is indirectly, but physically, related to the structural parameters affecting forest reflectance, e.g., crown volume and shape, or tree density.

We present a new research project funded by Academy of Finland AIPSE program aimed at using advanced AI methods, a well-validated physically-based forest reflectance model, and EO data to map forests in the boreal zone. We will use the simulated spectra and the corresponding forest structural data to train AI algorithms; once trained, we will apply the algorithms to optical EO data from Sweden, Finland, Estonia and Russia, and hyperspectral data from Finland. The AI retrieval results will be compared against forestry data from test sites in each of these regions. The scientific goals of the project are to determine

1) the potential of modern AI algorithms in retrieving forest AGB from EO data;
2) the most suitable AI algorithm for performing such a retrieval; and
3) the required EO data characteristics (e.g. spectral and spatial resolutions) for a successful physically-based AI retrieval of forest structure and biomass.

At this early stage of the project which started on 1.1.2018, we focus on evaluating the forest reflectance model performance using newly available forestry database by Finnish Forest Centre. The plotwise forest structure data is used to parameterize the Forest Reflectance and Transmittance model FRT and the predictions compared with airborne imaging spectroscopy data from Hyytiälä area from 2015 and 2017.