MSIAM – 2nd year research internship

Unsupervised, probabilistic learning of leaf area density from UAV-lidar data

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Location of internship: Inria, Montbonnot plus 2 weeks circa in AMAP, Montpellier
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Allowance: about 550 euros per month
Duration: 5-6 months (starting in February)

Context

Leaf area density (LAD) is a fundamental variable in earth's global energy balance (principal medium of gas exchange between biosphere and atmosphere) and there is much interest in its measurement via remote sensing. Lidar, an active optical sensing technique, is poised to revolutionize our capacity to map leaf area over space and time and should provide much-improved estimates of this quantity in evergreen forests. LAD estimation from Lidar measurements usually relies on restrictive assumptions (such as homogeneity and independence) in leaf density and orientation distributions. More accurate LAD estimation is expected by accounting for variability across space and species (Pisek *et al.,* 2013).

In state-of-the art approaches, LAD is estimated by statistical approaches, maximizing with respect to LAD the likelihood function

$$L(\theta, \Phi, LAD) = \prod_{i=1}^{n} s_i k(\theta, \Phi) e^{-k(\theta,\Phi) l_i s_i}$$

where l_i is an observed sample of n distances between hits along the optical path, s_i is the area of the beam section intercepted by target, θ and Φ are the azimuth and elevation components of beam light beam incidence angle, and the attenuation coefficient $k(\theta,)$is related to LAD and ratio of projected to actual foliage area $G(\theta, \Phi)$by $k(\theta, \Phi) = G(\theta, \Phi)\mathrm{LAD}$.

Tasks

The projection function *G* is classically specified using both parametric models and regularity assumptions on the leaf Inclination distribution function (LIDF). The aim of this internship is firstly, to define Bayesian hierarchical models for LIDF with associated numerical estimation procedures and secondly, to extend this model to account for spatial dependencies and clustering patterns using hidden Markov random fields with Bayesian nonparametric priors on parameters (Lu *et al.*, 2019).

The different models will be compared based on the difference of estimated local LADs using our models and measured transmittance values obtained at forest plot scale.

Prerequisites:

Multivariate statistical analysis, programming. Knowledge in Bayesian statistics is a plus.

Related Master programs and tracks: MSIAM Data Science (research)

This work may be continued as a PhD thesis, depending on the team's success in obtaining fellowships.

Remark: the intern will have to spend two weeks approximately at AMAP, Montpellier, to work with co-supervisors (expenses covered by our labs).

References:

Lu H, Arbel J, Forbes F. Bayesian nonparametric priors for hidden Markov random fields (2019). hal-02163046v2. https://hal.archives-ouvertes.fr/hal-02163046v2

Pimont F, Allard D, Soma M, Dupuy J-L (2018) Estimators and confidence intervals for plant area density at voxel scale with T-LiDAR. Remote Sensing of Environment 215:343–370 . https://doi.org/10.1016/j.rse.2018.06.024

Pisek J, Sonnentag O, Richardson AD, Mõttus M (2013) Is the spherical leaf inclination angle distribution a valid assumption for temperate and boreal broadleaf tree species? Agricultural and Forest Meteorology 169:186–194 . https://doi.org/10.1016/j.agrformet.2012.10.011