Title : Early Detection and Identification of Diseased Vegetal Tissues Using Visible / Infrared Polarimetric Microscopy Combined with Conventional and AI-based Image Treatment and Analysis

First Name : Razvigor | **Name** : OSSIKOVSKI | **Laboratory** : LPICM

Email : razvigor.ossikovski@polytechnique.edu

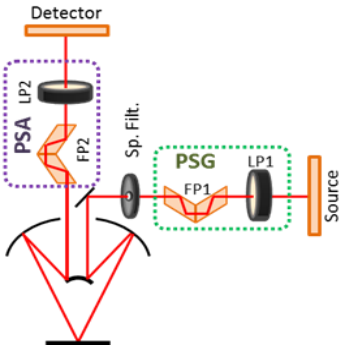
Webpage :

Research Area Biophysics (primary) and Optics (Secondary)

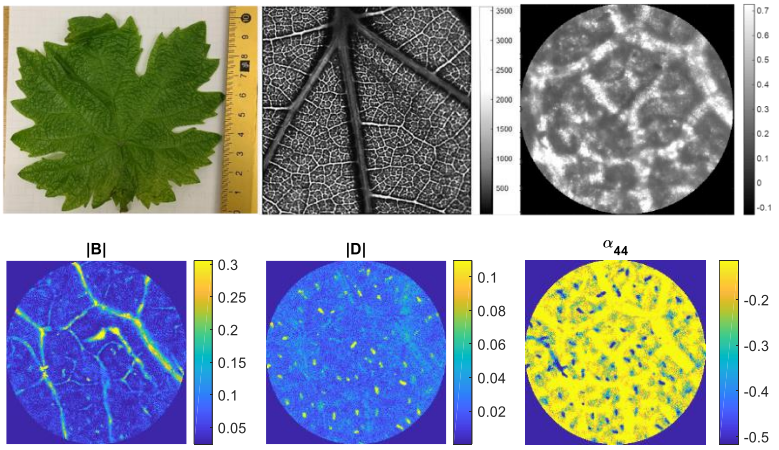
Methods: Improvement and use of an existing infrared polarimetric microscope, use of an existing polarimetric microscope in the visible and the infrared, application of algebraic methods to obtain physical observables, use of AI-based numerical approaches to process the polarimetric data

PhD track subject

First, the work will focus on the use of an innovative multimodal polarimetric microscope operated in reflection and in transmission in wide spectral range from the infrared (10 µm) to the visible (500 nm). The microscope will be applied to the study of vegetal tissues (leaves, roots). Polarimetric imaging can discriminate between healthy and diseased tissues, early detection of diseases being of prime importance for the efficiency of treatment. In plants, polarimetry can be decisive for detecting microbial infections. The work will take place in a stimulating collaboration with Universidad Autónoma (Barcelona) and Synchrotron Soleil.



Schematic representation of the multimodal infrared microscope mounted in reflection configuration. The generator (PSG) and analyzer (PSA) of polarization states and shown



Images showing (top row from left to right) a vine leaf, same leaf seen in transmission (low magnification) and (high magnification) respectively with green light. (Bottom column from left to right) Polarimetric observables highlighting the presence of veins (observable |B|), and small crystals called raphides within the leave (observables|D| and α_{44}).

References

1. B. Al Bugami, Y. Su, C. Rodríguez, A. Lizana, J. Campos, M. Durfort, R. Ossikovski, E. Garcia-Caurel," Characterization of vine, *Vitis vinifera*, leaves by Mueller polarimetric microscopy", Thin Solid Films **764**, 139594 (2022).
2. A. Van Eeckhout, E. Garcia-Caurel, T. Garnatje, J. C. Escalera, M. Durfort, J. Vidal, J. J. Gil, J. Campos, A. Lizana, "*Polarimetric imaging microscopy for advanced inspection of vegetal tissues*", Scientific Reports **11**, 1-12 (2021).
3. C. Rodríguez, A. Van Eeckhout, L. Ferrer, E. Garcia-Caurel, E. González-Arnay, J. Campos, A. Lizana, "*Polarimetric data-based model for tissue recognition*", Biomed. Opt. Express **12**, 4852-4872 (2021).
4. S. H. Yoo, R. Ossikovski, E. Garcia-Caurel, "*Experimental study of thickness dependence of polarization and depolarization properties of anisotropic turbid media using Mueller matrix polarimetry and differential decomposition*", Appl. Surf. Sci. **421**(B), 870-877 (2017).
5. E. Garcia-Caurel, A. Lizana, G. Ndong, B. Al Bugami, C. Bernon, E. Al-Qahtani, F. Rengnez, and A. De Martino, "*A mid-infrared Mueller ellipsometer with pseudo-achromatic optical elements*", Appl. Opt. **54**, 2776-2785 (2015).