Master in Photonics – "PHOTONICS BCN"
Master ERASMUS Mundus "EuroPhotonics"

MASTER THESIS PROPOSAL

Starting full time from April 2025
Presentation at the end of July or beginning of September 2025

Laboratory: Polarized Light Applications and Technologies / Wavefront Engineering
Institution: Universitat de Barcelona
City, Country: Barcelona

Title of the master thesis:
Seeing Beyond the Haze: Integral Imaging and Polarimetry for Enhanced Turbid Media Visualization.

Name of the master thesis supervisor and co-supervisor:
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Keywords: Mueller Matrix Polarimetry, 3D Integral Imaging, Pattern Recognition in Turbid Media

Summary of the subject (maximum 1 page):

3D integral imaging is a technique used to capture and display three-dimensional (3D) scenes. The capture process requires the use of a microlenses array or a matrix of cameras to record multiple perspectives of the scene. The recorded information is used to generate the so-called light field. Integral imaging allows us to numerically manipulate the light field to select a particular in-focus plane, deal with occlusions, or improve contrast in poorly illuminated scenes.

Imaging in turbid media, such as underwater environments or biological tissues, is a challenging problem because light is affected by scattering, which reduces the visibility of the scene. There is a general consensus that polarized light can improve the imaging capabilities of optical systems in such difficult conditions. Conventional polarimetric metrics, such as the degree of polarization or the Stokes parameters, in combination with statistical methods, are used to help improve the quality of the recorded images. More advanced and insightful information can be obtained by measuring the components of the Mueller matrix, as it provides a complete polarimetric description of the scene [1]. 3D Mueller matrix imaging has been demonstrated using a light field camera [2]. The combination of both procedures can represent an important advancement in the polarimetric analysis of scenes in turbid media using three-dimensional information.

Objectives:

In this project, we propose to build an integral imaging system with a polarimetric camera, using the synthetic aperture paradigm [3], to measure 9 of the 16 components of the Mueller matrix in scenes located in turbid media. It is expected that the three-dimensional polarimetric information provided by this system will produce improved contrast and spatial resolution, reduced sensitivity to scattering, and improved light efficiency.

References:

[1] H. Li, I. Pardo, O. Arteaga. "Underwater Mueller Matrix De-Scattering Imaging Under the Influence of Natural Light". Preprint available at SSRN: https://dx.doi.org/10.2139/ssrn.4953839

[2] Carnicer, S. Bosch, and B. Javidi, "Mueller matrix polarimetry with 3D integral imaging," Opt. Express **27**, 11525-11536 (2019).

[3] Ju-Seog Jang and Bahram Javidi, "Three-dimensional synthetic aperture integral imaging," Opt. Lett. **27**, 1144-1146 (2002).

Additional information (if needed):

Required skills: Excellent laboratory skills, very good knowledge of Python / Matlab and Labview.