MASTER IN PHOTONICS – "PHOTONICS BCN"
ERASMUS+ "EUROPHOTONICS"

MASTER THESIS PROPOSAL

Dates: April - September 2019

Laboratory : Optical Metrology & Image Processing Laboratory (MIP-OptiLab)
Institution: Universitat Autònoma de Barcelona
City, Country: Bellaterra, Spain.

Title of the master thesis: Polarimetric indicators for tissues characterization and recognition

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Keywords: Indices of polarimetric purity, polarization, degree of polarization, Mueller matrix, Stokes vector

Summary of the subject (maximum 1 page) :

Polarization is a physical property of light exploited in a large number of applications, as a complementary tool of other techniques, or constituting a completely different approach. In the last decades, a large number of works have highlighted the interest of analyzing the polarimetric print left by biological samples when interacting with polarized light [4]. As a consequence, polarimetric techniques are commonly incorporated in different fields to study and characterize biological samples. For instance, polarimetric methods are successfully used in some medical applications, as for example, to calculate the sugar concentration in blood for diabetes diseases, or for the earlier diagnosis of some types of cancers, as skin cancer, colon cancer, breast cancer, among others.

Most common polarimetric methods used for biological samples characterization can be arranged in two main groups: (1) Polarization Gatings (PG) methods; and (2) those based on merit functions depending on some coefficients of the Mueller matrix (MM) of studied samples. The former, PG methods, tries to optimize the polarization of the beam illuminating the sample, as well as the polarization analyser detecting the scattered light, in order to maximize the visualization of some structures in the sample. Controversy, MM of a sample encodes its

polarimetric content (retardance, diattenuation and depolarization), which can be synthetized by properly arranging the information in the MM coefficients.

Recently, our group has provided the potential of the Indices of Polarimetric Purity (IPPs), mathematical metrics devised to exploit and further synthetize the information of depolarizers, into the biological framework. We have provided a physical description of the IPPs through a series of basic experiments, experimentally showing how IPPs are related with the intrinsic depolarizing mechanisms in samples, and how they allow us to further discriminate between different kinds of depolarizers. We have also used the IPPs to study different tissues present in *ex-vivo* samples, and we observed a significant enhancement in the obtained image contrast, when compared with other commonly used polarimetric images.

In this project, the above-stated IPPs based qualitative approach will be extended to a quantitative analysis. The master student will study different tissues of significant number of *ex-vivo* samples by using multiple polarimetric indicators. Some of these metrics are well-known in polarimetric literature, and other are recently applied in the biomedical context and are awaken great interest. All these metrics will be used to study the samples from a quantitative point of view, and obtained data will be statistically treated to determine the sensitivity of the different polarimetric metrics to tissues recognition. From the whole database, combined figure of merits will be constructed, specially devised to the recognition of different biological structures, as bones, tendons, muscles, etc. Finally, we will also analyse the potential of the standard metrics (or the constructed figures of merit) to be used in automatized recognition protocols, through some machine-learning process.

Additional information:

* Required skills:
    - -Polarization knowledge, especially command of Stokes-Mueller formalism.
    - - Motivation to perform experimental work into an optical laboratory.
    - - Knowledge of Matlab software (or equivalent) and/or some virtual instrument language (as LabView).