PhD– Image compression and reconstruction methods dedicated to optical imaging

Background and Objectives– Optical imaging techniques have known a prodigious development in recent decades. In particular, optical microscopy (e.g. confocal systems, two-photon, etc.) has revolutionized our understanding of the Living enabling to visualize biological structures at high resolution (few hundred nm) in thin samples (a few hundred microns). Thanks to optical fluorescence tomography, thick tissues (above one centimeter) can also be imaged. This technique allows the three-dimensional localization of fluorescent markers in thick living organisms at the cost of a relatively low resolution (several millimeters) due to scattering.

We wish to propose new methods of data processing that will enable the three-dimensional imaging of biological tissues at intermediate depths– between one millimeter and one centimeter. At present there are no available techniques in this regime.

Keywords– Optical imaging of biological tissue, image compression method, inverse problem.

Work Plan– The objective is especially ambitious because of light scattering that requires complex algorithms reconstruction. A successful approach should involve physical models of light propagation, image compression technique, image reconstruction algorithms, and optimisation of experimental parameters. These points are interrelated and must be integrated within a general method. We will consider an approach in which we address two simpler intermediate problems. Each of these intermediate problems is itself of interest.

The first step will be to provide a direct (without three-dimensional reconstruction) time-resolved low-cost imaging that can perform a high temporal resolution as well as a good spatial resolution. This will be made possible thanks to the development of new method dedicated to the exploitation of signals from new sensors. Methods falling within the framework of *zerotree coding* and/or *compressed sensing* will be of particular interest.

In a second step, the direct images obtained at the first step will be used to reconstructing the internal structure of tissues at depth greater than one centimeter. The traditional tomography regime will be considered here, but this work should result in fast low-cost reconstructions of fluorescence lifetimes.

Finally, we will address our final goal, extending the previously developed algorithms at smaller depths for which traditional models of light propagation are no longer valid.

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Collaboration– The thesis will under the joint supervision of the CREATIS laboratory and the Department of Physics of the *Politecnico di Milano*. The PhD student will mainly carry out his research work at CREATIS and is expected to do some visits in Milan (one year in total, organization to be defined). The Milan group that was one of the precursors of fluorescence lifetime imaging will supervise the experimental part. The team 4 of CREATIS laboratory, which has a recognized expertise in medical imaging and reconstruction methods, will supervise the signal processing part.

Funding– This PhD project is funded by a doctoral fellowship for 2014-2017.

Candidate Background– Signal processing, image processing, applied mathematics. A good knowledge of Matlab is required. A good knowledge of optics would be an asset.

How to apply? The following documents are to be sent to Nicolas Ducros (nicolas.ducros @ creatis.insa-lyon.fr), Cosimo d'Andrea (cosimo.dandrea@polimi.it) and Françoise Peyrin (peyrin@esrf.fr) **as soon as possible** and before 8th September :

- cover letter
- detailed CV
- transcript of records of the Master degree or equivalent
- two references with email and telephone number

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