M2 Research internship proposal

Inverse problems in Stokes imaging. Application to biological imaging.

supervision: J. Flamant (CRAN) and R. Stoica (IECL)

**Internship research project**  Imaging techniques that exploits polarization properties of light are becoming increasingly popular in biology, as polarimetric imaging enables many insights that are inaccessible to other conventional imaging methods [1]. Polarization information is typically described by Stokes parameters, which need to be estimated from multiple intensity measurements, defining a so-called Stokes inverse problem, see Fig. 1.

![Figure 1: Reproduced from [2]. Different scenes are shown column-wise. Top: 4 intensity images to be inverted to obtain Stokes parameters; middle: standard $S_0$ image corresponding to conventional (polarization-insensitive) imaging; bottom: $S_3$ Stokes parameter (circular polarization) that reveals physical properties of the scene inaccessible to conventional imaging.](image)

The first aim of this internship is to study the Stokes inverse problem for two noise models (additive Gaussian, Poisson) arising in imaging and develop efficient algorithms for its resolution. Two key points need to be investigated: (i) compare the merits of different measurement schemes proposed in the literature [3]–[5] w.r.t. reconstruction error and (ii) understand the role played by the Stokes physical admissibility constraint and its implementation [6]–[8] w.r.t. convergence properties. The Stokes imaging segmentation problem will then be studied and formulated within a Bayesian framework [9], [10], focusing on developing Markov Random Field (MRF) models [11] for polarimetric data.

The second aim of this internship will be to apply the proposed methodology to the study of the polarimetric properties of cells. Part of this work will be done in collaboration with biologists from CRAN and constitutes an exploratory research direction. This internship can be followed by a PhD position depending on the results and motivation of the candidate.
Prerequisites and funding  The candidate should be enrolled in a M2 and have a M1 in either mathematics, applied mathematics or electrical engineering (signal processing), together with good oral and written English skills. The internship offers also a grant (around 550 euros per month w.r.t. the French rules). The internship is 6 months length, and it may start anytime during the period of 01/02 - 01/04/2020.

Location  The candidate will be working mainly at Centre de Recherche en Automatique de Nancy (CRAN), located on the Faculté des Sciences et technologies campus in Vandoeuvre-lès-Nancy, France.

Supervision  This internship falls within a collaboration between CRAN and Institut Elie Cartan de Lorraine (IECL campus de Nancy) which are located a few hundred meters apart on the campus. The candidate will be jointly supervised by researchers of both institutions:

<table>
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<tr>
<th>Julien Flamant</th>
<th>Radu S. Stoica</th>
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<tbody>
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<td>CNRS, CRAN</td>
<td>Université de Lorraine and IECL Nancy</td>
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References


