Theme: BRICKS **Axis:** Systems **Project code:** B/S/4

Title: Computational imaging.

Summary: Advanced information processing techniques allowing to produce accurate images of unobservable structures (e.g., inner parts of opaque bodies) from indirect measurements.

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Context:
From the conception steps to the validation and testing steps, modern production systems require fast imaging methods to get accurate 3D descriptions of scenes, structures or parts. Yet, only partial and indirect physical measurements are often available, either because the inspected object is opaque to visible light, or because a full-coverage measurement system would be too slow, too expensive, or simply infeasible. In such situations, our ambition is to develop fast and precise numerical inversion techniques to get a virtually reconstructed object or scene from measured data of various nature: acoustical, mechanical, electromagnetic, etc, in obvious connection with projects B/Pr/1, B/P/1 and B/P/3. Achieving such a goal not only demands an efficient solver for the forward problem, i.e., for physical modelling and simulation, but also (i) a suited regularisation framework to cope with the incomplete and imperfect character of the measurements ; (ii) innovative numerical strategies to estimate objects or scenes within an acceptable time and given reasonable computing ressources.

Research project:
We will mainly address regularisation and computation issues in particularly difficult cases of primary interest in the FACTORY context. Our project relies on strong skills in statistical modelling, inference and nonlinear programming. In particular, all imaging problems addressed in our project involve huge data sets and/or unknown variables to estimate, and sparse approximations and adaptive representations will be at the heart of our contributions (a shared feature with project B/S/3). Blind source separation applied to acoustic emission is an example of data processing approach involving sparse representations that we will focus on within the project.

On the other hand, one of our main goals will be to propose faster and yet reliable algorithms for 3D diffraction tomography problems, with potential applications to ultrasonic imaging, acoustical holography, impedance tomography, microwave tomography. A crucial aspect of our contribution will be to make use of an accurate forward model, while it is often proposed to invert a surrogate model based on a precomputed database obtained by forward simulation. In order to save time and computer ressources, we will devise iterative optimisation based inversion algorithms that avoid repeated, exact solving of the forward problem, while still being provably convergent.

We will also investigate spectral estimation of irregularly sampled velocity data issued from Laser Doppler Anemometry (LDA) measurements. LDA is a well established flow velocity imaging tool that combines non-intrusitivity, accuracy and fast response times. However, specific difficulties arise due to the random nature of the sampling process. The originality of our approach will be to tackle the statistical nature of the problem in a fully coherent inversion framework.

Another part of our project will be devoted to X-ray tomography, and more specifically to the efficient reconstruction of 3D volumes from microtomographic data to study the topological evolution of materials at the microstructural scale at different steps of a manufacturing process.

For more details and extra references please refer to **www.xxx.xxx.fr**