PhD proposal

Unknown Non-circular trajectory Computed Tomography: Joint estimation of the trajectory and image reconstruction

In some Non Destructive Testing (NDT) industrial applications of X ray Computed Tomography (CT) the trajectory of the detectors may not be on a perfect circular one. The reconstruction results which are mainly based on Radon or X-ray Transform may then be greatly altered. The estimation of trajectory then becomes important. One solution is to estimate first this trajectory from the projections and then do the necessary corrections before applying a standard Filtered Back-Projection (FBP) method for reconstruction. The second approach to estimate jointly the trajectory and the image in an iterative way.

This problem is also mathematically equivalent to a moving object CT in medical imaging. In fact, the movement of the object with fixed detectors and movement of the detectors with fixed object are mathematically equivalent and so, the proposed methods can also be used for medical imaging applications.

In this PhD, first the first approach will be explored to propose fast methods for practical applications, in particular when the number of projections are very important and so the image reconstruction part can be done via the classical FBP methods.

In the second part, we will extend this to new needs in CT where the number of projections are limited and dose reduction is important. Then, we propose to consider the Bayesian estimation approaches to joint estimation of the body movement or equivalently the detector trajectory and the image. This is due to the fact that this approach has the appropriate tools for combining a priori information as well as taking account for the measurement noise and modeling errors and giving an estimate and some measures of remaining uncertainties in the reconstruction results.

In L2S we have gained very high knowledge both in the main Bayesian approaches as well as in parallel implementation of the proposed algorithms on many core processors such as GPUs.

The main subject of this PhD proposal is, in a first step, to implement some of the main methods of the first approach for immediate applications.

In a second step, we want to replace the classical FBP by the Bayesian image reconstruction methods developed (Gauss-Markov prior modeling and MAP estimation) in our group and implemented on GPU to evaluate the performances of these methods. In a third step, we want to adapt these methods to NDT applications, we have to use more appropriate priors such as Gauss-Markov-Potts or Infinite Gaussian Mixture (IGM) models. Then, the main difficulty becomes the computational costs. We need then to use Variational Bayesian Approximation (VBA) tools to be able to do fast computations. However, for real size 3D applications, we need to use muli-GPU and great amount of memory transfer optimization.

This PhD subject will be co-supervised by Ali Mohammad-Djafari who is a Research Director at CNRS and Nicolas Gac who is an Assistant Professor at the University of Paris Sud, Orsay. The main work will be done at Signal and system Laboratory (L2S) which is located at SUPELEC. The PhD is part of Doctoral program of “Université Paris Sud, Orsay”

Who can candidate :

A motivated Master level student with good backgrounds on Applied Mathematics, Signal and image processing, Bayesian estimation methods and having skills in parallel computational algorithms and programming languages (C and Matlab).

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