CONACYT program 2015

PhD project proposal form

Discipline
Engineering Sciences

Doctoral School
422 - Sciences and Technologies for Information, Telecommunications and Systems

Thesis subject title

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

- **Laboratory name** Laboratory of Signal and Systems (L2S)
  - **Laboratory web site** https://www.l2s.supelec.fr/

PhD supervisor (contact person)

- **Name** **Ali Mohammad-Djafari**
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Co-supervisor

- **Name Nicolas Gac**
- **Position** **Assistant Professor**
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- **Thesis proposal (max 1500 words)**

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.

This PhD subject will be supervised by Ali Mohammad-Djafari who is a Research Director at CNRS and 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"

- **Publications of the laboratory in the field (max 5)**

1. **Gac N.**, Vabre A, **Mohammad-djafari A.**, Buyens F, Accélération sur serveur multi-GPUs de la reconstruction 3D d'une mousse de nickel par méthodes itératives algébriques régularisées - Conference: 23ème colloque GRETSI sur le traitement du signal et des images (Bordeaux, FR, 2011-09-05) - Publiées: Actes du 23e colloque GRETSI en traitement du signal et des images, vol. p.id455 (2011) - Link to HAL
2. **Gac N.**, Vabre A, **Mohammad-djafari A.**, Multi GPU parallelization of 3D bayesian CT algorithm and its application on real foam reonconstruction with incomplete data set - Conference: Forum on recent developments in Volume Reconstruction techniques applied to 3D fluid and solid mechanics (Poitiers, FR, 2011-11-29) - Publiées: Proceedings FVR 2011, vol. p.35-38 (2011) - Link to HAL
3. **Ayasso H.**, **Mohammad-djafari A.**, Joint NDT Image Restoration and Segmentation Using Gauss-Markov-Potts Prior Models and Variational Bayesian Computation - *(Article)* Publié in IEEE Transactions on Image Processing, vol. 19 p.2265 - 2277 (2010) - Link to HAL
4. **Mohammad-Djafari, A.**, Gauss-Markov-Potts priors for images in computer tomography resulting to joint optimal reconstruction and segmentation, International J. of Tomography and Statistics (IJTS), vol. 11 chap. p. 76-92 (2008)
5. **Humblot, F. and Mohammad-Djafari, A.**, Super-resolution using hidden Markov model and Bayesian detection estimation framework, EURASIP Journal on Applied Signal Processing, vol. 2006 chap. p. 1-16 (2006), download
6. **Cai C.**, **Rodet T.**, Legoupil S, **Mohammad-djafari A.**, A full-spectral Bayesian reconstruction approach based on the material decomposition model applied in dual-energy computed tomography - *(Article)* Publié in Medical Physics, vol. 40 p.111916-111931 (2013) - Link to HAL

- **Specific requirements to apply, if any**

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

We strongly advise candidates to get a 4 year fundings : 1 year of Master Research in our lab in order to improve signal and image processing knowledge and French skills and then 3 years of PhD thesis.