

**Discipline**

Engineering Sciences

**Doctoral School**

422 - Sciences and Technologies for Information,  
Telecommunications and Systems

**Thesis subject title**

Blind or Myopic Imaging and Deconvolution

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

**PhD supervisor (contact person)**

- **Name** Ali Mohammad-Djafari
- **Position** Research Director
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▪ **Thesis proposal (max 1500 words)**

In many inverse problems in imaging systems for real applications (Geophysics, medical imaging, industrial imaging, radioastronomy, hyperspectral imaging, Radar and SAR imaging), we may model the forward problem as  $\mathbf{g} = \mathbf{H} \mathbf{f} + \mathbf{e}$  where  $\mathbf{g}$  is the observed data,  $\mathbf{e}$  represents the errors,  $\mathbf{f}$  is the unknown signal or image and  $\mathbf{H}$  is the forward operator.

We know that even when the system  $\mathbf{H}$  is exactly known, the inverse problem of inferring on  $\mathbf{f}$  is difficult (commonly said ill-posed). However, nowadays there are many regularization based (deterministic or Bayesian probabilistic) methods which have been proposed and used efficiently for those problems.

When more than one set of data are available the relation can be written as  $\mathbf{G} = \mathbf{H} \mathbf{F} + \mathbf{E}$  where the columns of the matrices  $\mathbf{G}$ ,  $\mathbf{F}$  and  $\mathbf{E}$  contain the corresponding vectors.

Blind imaging systems inverse problems are those when  $\mathbf{H}$  is not exactly known and we want also to determine it. Thus, those problems are much harder and need appropriate prior knowledge to be able to propose satisfactory and efficient solutions.

Between the blind inverse problems the Blind Deconvolution has been studied since many years. Deconvolution is a particular case where  $\mathbf{H}$  is a translation invariant (convolution) operator  $\mathbf{g}=\mathbf{h}*\mathbf{f}+\mathbf{e}$  which is defined by an impulse response  $\mathbf{h}$  (in imaging systems it is also called the Point Spread Function). So the Blind Deconvolution problem consists in determining both  $\mathbf{h}$  and  $\mathbf{f}$  from the data  $\mathbf{g}$ .

In this PhD thesis, the first objective is to analyze the existing state of the art methods and to compare their relative performances. In a second step, the candidate will focus on the probabilistic methods and in particular the Bayesian framework. As the main step in a Bayesian framework is the selection of an a priori model for the unknowns (here the impulse response and the input), we will examine all the possibilities from simple Gaussian, Gamma, Beta to Markovian model Gauss-Markov and those more complex: hierarchical with hidden variables such as Gauss-Markov-Potts or Infinite Gaussian Mixture (IGM) models or non parametric priors. Then, the main difficulty becomes the computational costs. As we want to propose practical methods for real world applications, we need to propose fast and accurate computational methods such as the Variational Bayesian Approximation (VBA) methods which can also be implemented on parallel computers such as GPU and multi-GPU.

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. **Mohammad-djafari A.**, Bayesian approach with prior models which enforce sparsity in signal and image processing - (*Article*) Publié in EURASIP Journal on Advances in Signal Processing, vol. 2012 p.19p. (2012) - [Link to HAL](#)
2. **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](#)
3. **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)
4. **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](#)
5. **Mohammad-Djafari, Ali and Qaddoumi, Nasser and Zoughi, Reza**, A blind deconvolution approach for resolution enhancement of near-field microwave images, vol. 3816 chap. p. 274-281, Mathematical modeling, Bayesian estimation and Inverse problems, SPIE 99, Denver, Colorado, USA, Pr{ê}teux, F. and Mohammad-Djafari, Ali and Dougherty, E. (1999)

▪ **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.