Program

- Monday 9th

Monday morning is free

12:30 : Lunch at “la maison des séminaires”

Image processing, applications in astrophysics

14h - 14h45 : J. Bobin - Component separation in astrophysics
14h45 - 15h30 : F.X Dupe - Different approach for the 3D weak-lensing
Coffee break
16h - 16h45 : E. Deriaz - Wavelets, Helmholz decomposition and weak lensing mass map reconstruction
16h45 - 17h15 : S. Beckouche- Dictionary learning and astronomical image restoration

19:30 pm : Welcome cocktail at “la maison des séminaires”

- Tuesday 10th

Sparse modeling and methods

9h15 - 10h00 : J. Fadili - DeQuantizing Nonuniformly Quantized Compressed Sensing
10h00 - 10h30 : S. Vaiter - Robust Sparse Analysis Regularization
Coffee break
11h - 11h45 : P. Chainais - An introduction to Bayesian non parametric approaches
11h45- 12h15 : C. Deledalle - Proximal Splitting Derivatives for Risk Estimation

12:30 : Lunch at "la maison des séminaires"

Open discussions

19:30 : Conference dinner at "la maison des séminaires"

- Wednesday 11th

Texture analysis/synthesis and optimal transportation

9h00 - 9h45 : G. Peyre - Introduction to optimal transport
9h45 - 10h30 : J.Rabin - optimal transport of point clouds and its application to image manipulation
Coffee break
11h - 11h30 : S. Ferradans - Non-gaussian texture models for stochastic shape from shading
11h30- 12h00 : Guisong Xia - optimal transport of Gaussian distribution, and its application to dynamic texture modeling
12h00- 12h30 : G. Tartavel - Texture synthesis using constraint sparse decomposition in a dictionary

12:30 : Lunch at “la maison des séminaires”

Open discussions

- Thursday 12th

Inverse problems

9h15 - 10h00 : G. Tzagkarakis - Compressive Video Sensing in Remote Surveillance
10h00 - 10h30 : A. Woiselle - To be announced
Coffee break
11h - 11h45 : S. Becker - A class of quasi-Newton methods for non-smooth/constrained problems
11h45 - 12h15 : G. Nardi - A coarea-type formula for the relaxation of a generalized elastica functional

12:30 : Lunch at “la maison des séminaires”

Open discussions

- Friday 13th

Imaging methods, applications in bio/medical imaging

9h15 - 10h00 : JM Mirebeau - Efficient and Accurate Anisotropic Fast Marching on cartesian grids

10h00 - 10h30 : J. Rapin - Robust Non-Negative Matrix Factorization for Multispectral Data with Sparse Priors
Coffee break
11h - 11h30 : H. Raguet - To be announced
11h30- 12h00 : R. Prevost - Simultaneous segmentation and registration on medical imaging

12:30 : Lunch at “la maison des séminaires”

Open discussions

END

Abstracts :

Image processing, applications in astrophysics

J. Bobin - Component separation in astrophysics

In the last decade, blind source separation has taken the lion share for the analysis of multispectral data in fields ranging from biomedical imaging to remote sensing. In the field of astrophysics, the most recent sky surveys all provides multi-wavelengths data which need to be analyzed efficiently. A particular challenging example is the extraction of the cosmological microwave background (CMB) from the microwave data provided by the ESA/Planck space mission. The CMB is an incredibly rich source of information for the cosmologists. However, its estimation from multi-

wavelength data requires solving a (blind) source separation of unprecedented complexity: i) the data are heterogenous (they do not share the same resolution), ii) the noise is non-stationary and correlated, iii) astrophysics leads to non-stationary mixtures. We will show how the paradigm of sparse signal representation can be beneficial to efficiently model and solve blind source separation from heterogenous and non-stationary mixtures.

F.X Dupe - Different approach for the 3D weak-lensing

Weak gravitational lensing is a probe of dark matter, but reconstructing the clusters of matter from observation is a difficult task. By taking a compressed sensing point of view, we are able to show that we can reconstruct the clusters. Moreover when compare to state of art method, we improve the line-of-sigh resolution, allowing us to consider the reconstruction of several cluster along one line of sight. In this work, we present different methods for reconstructing the clusters using a sparsity constraints, with for each its pro and cons. We will also show some experimental results on simulated data.

E. Deriaz - Wavelets, Helmholz decomposition and weak lensing mass map reconstruction

We show how Helmholtz decomposition allows the separation of E/B modes of shear maps. Divergence-free wavelets and curl-free wavelets provide the computational basis for this purpose. Moreover, adding constraints on the wavelet Helmholtz decomposition enforces the properties of the E and B modes to be reconstructed. We also draw some perspectives for this work: dealing with the noise, with the missing data and the geometry, and passing from 2D reconstructions to 3D reconstructions.

S. Beckouche- Dictionary learning and astronomical image restoration

State of the art denoising algorithms that use fixed basis like wavelets or curvelets have shown some limitations when processing images containing complex texture features. We propose to use recently developed dictionary learning techniques to overcome those limitations.

We address here the problem where a white gaussian noise is to be removed from an image. The original image is assumed to be sparsely represented in a dictionary which is learned during the denoising. Patch averaging has proven to be an efficient way to combine local sparsity constrain and a global Bayesian treatment and is applied here to process astrophysical image compared to classic wavelet shrinkage and associated techniques.

Sparse modeling and methods

J. Fadili - DeQuantizing Nonuniformly Quantized Compressed Sensing

In this work we study the problem of reconstructing sparse or compressible signals from compressed sensing measurements that have undergone non-uniform scalar quantization. In such a case, quantization distortion closely resembles heteroscedastic uniform noise, with variance depending on the observed quantization bin. Generalizing our previous work on uniform quantization, we show that for non-uniform quantizers described by the "compander" formalism, quantization distortion may be better characterized as having bounded weighted lp-norm (p > 2), for a particular weighting. We develop a new reconstruction approach, termed Generalized Basis Pursuit DeNoise (GBPDN), which minimizes the sparsity of the reconstructed signal under this weighted lp-norm fidelity constraint. We prove that given a budget of B bits per measurement and under the oversampled scenario, if the sensing matrix satisfies a proposed generalized Restricted Isometry Property, then, GBPDN provides a reconstruction error of sparse signals which decreases like O(2^{-B}/\sqrt{p + 1}). Finally, we describe an efficient numerical procedure for computing GBPDN via a primal-dual convex optimization scheme, and demonstrate its effectiveness through extensive simulations.

This is a joint work with L. Jacques and D. K. Hammond.

S. Vaiter - Robust Sparse Analysis Regularization

This talk is about the properties of L1-analysis regularization for the resolution of linear inverse problems. Most previous works consider sparse synthesis priors where the sparsity is measured as the L1 norm of the coefficients that synthesize the signal in a given dictionary. In contrast, the more general analysis regularization minimizes the L1 norm of the correlations between the signal and the atoms in the dictionary. The corresponding variational problem includes several well-known regularizations such as the discrete total variation and the fused lasso. We give a sufficient condition to ensure that a signal is the unique solution of the analysis regularization when there is no noise in the observations. The same criterion ensures the robustness of the sparse analysis solution to a small noise in the observations. We also define a stronger sufficient condition that ensures robustness to an arbitrary bounded noise. In the special case of synthesis regularization, our contributions recover already known results, that are hence generalized to the analysis setting. We illustrate these theoretical results on practical examples to study the robustness of the total variation and the fused lasso regularizations.

P. Chainais - An introduction to Bayesian non parametric approaches

Many works on inverse problems in image processing (denoising, deconvolution, inpainting ...) are described as penalized optimization problems. A wide family of algorithms have been proposed, some of them dealing with dictionary learning. Bayesian approaches often permit a more precise modeling of the problem and offer a complementary framework. In recent years, Bayesian non parametric approaches have been introduced, first in machine learning and then in signal and image processing. The main interest of non parametric approaches is their ability to finely take into account the notion of parcimony in a Bayesian framework. We will present some important tools such as Dirichlet processes and the Chinese restaurant, as well as Beta processes and Indian Buffet Processes as priors that promote parcimony. We will also evoke some inference techniques in this non parametric setting.

C. Deledalle - Proximal Splitting Derivatives for Risk Estimation

We develop a novel framework to compute a projected Generalized Stein Unbiased Risk Estimator (GSURE) for a wide class of sparsely regularized *solutions of inverse problems. This class includes arbitrary convex data fidelities with both analysis and synthesis mixed L1-L2 norms. The GSURE necessitates to compute the (weak) derivative of a solution w.r.t. the observations. However, as the solution is not available in analytical form but rather through iterative schemes such as proximal splitting, we propose to iteratively compute the GSURE by differentiating the sequence of iterates. This provides us with a sequence of differential mappings, which, hopefully, converges to the desired derivative and allows to compute the GSURE. We illustrate this approach to automatically select the regularization parameter on total variation regularization with Gaussian noise and to choose the optimal size of block for structural sparse regularization.*

Texture analysis/synthesis and optimal transportation

G. Peyre - Introduction to optimal transport

S. Ferradans - Non-gaussian texture models for stochastic shape from shading

In this talk, I will present a novel method to synthesize a micro-elevation texture from a given rendered textured image. We model the surface using a probabilistic framework that assumes the elevation to be a stationary Gaussian field. We further assume the reflectance to be purely Lambertian and the exemplar picture to be obtained with an orthogonal perspective with respect to the surface plane. This enables us to setup a shape-from shading inverse problem to recover the surface distribution's parameters from a single exemplar. This inverse problem is solved by minimizing a non-convex energy. I will show promising early results of this approach on natural rendered textures.

J.Rabin - optimal transport of point clouds and its application to image manipulation

Guisong Xia - optimal transport of Gaussian distribution, and its application to dynamic texture modeling

This work addresses the problem of modeling stationary color static and dynamical textures with Gaussian processes. First, we recall and discuss the Gaussian models for texture modeling. In particular, we detail two classes of Gaussian processes for dynamic textures that are parametrized by a small number of compactly supported linear filters, so-called dynamical textons (dynTextons). Secondly, we tackle the problem of mixing Gaussian models of color textures learned from an input database. We derive the barycenter and geodesic path between models according to optimal transport. This allows the user to navigate inside the set of texture models, and perform texture synthesis from the obtained interpolated models. Numerical examples on a library of exemplars show the ability of our method to generate arbitrary interpolations among unstructured natural textures. Moreover, experiments on a database of stationary textures shows that the methods, despite their extreme simplicity, provide state of the art results to synthesize space stationary dynamical texture.

Inverse problems

G. Tzagkarakis - Compressive Video Sensing in Remote Surveillance

Remote sensing systems, such as unmanned aerial vehicles and terrestrial-based sensor networks, have been increasingly used in surveillance and reconnaissance both at the civilian and battle-group levels. Nevertheless, the existing solutions do not adequately accommodate modern remote imaging systems since limited power, processing and bandwidth resources is a major issue, where coping with growing compression ratios may result in poor image quality, while a requirement for enhanced quality often results in increased data transfer rates, which may be prohibitive in case of lightweight sensing devices. In this presentation, the potential of integrating the framework of compressive sensing (CS) to existing video coding systems is examined. The analysis of the parameters affecting the performance of a compressive video sensing (CVS) architecture along with the satisfaction of the limitations mentioned above are encouraging, indicating that the proposed approach can achieve comparable performance to that of widely used video coding standards for *remote sensing applications (e.g., MPEG, MJPEG) often with significantly reduced memory and bandwidth consumption. Considering that the combined sampling and compression operations of a CS approach may benefit the design of novel coding systems with limited resources, the present analysis serves as a significant step towards understanding the advantages of CS to video coding systems.*

A. Woiselle - To be announced

S. Becker - A class of quasi-Newton methods for non-smooth/constrained problems

Among first-order methods, there is a remarkable disparity between smooth unconstrained minimization, which benefit from non-linear conjugate gradient and quasi-Newton techniques, and non-smooth constrained minimization, which are only amenable to gradient or sub-gradient techniques. This talks discusses a new approach to the non-smooth and/or constrained problem. For some very common non-smooth functions and constraint sets, we have a class of quasi-Newton methods that have an efficient update. The resulting limited memory SR1 algorithm shows very promising results.

G. Nardi - A coarea-type formula for the relaxation of a generalized elastica functional

Imaging methods, applications in bio/medical imaging

JM Mirebeau - Efficient and Accurate Anisotropic Fast Marching on cartesian grids

The Eikonal Equation is the level set formulation of an elementary front propagation model, where the front speed is locally dictated by a Finsler metric F on a domain U.
For each z in U, the local metric Fz is either proportional to the euclidean norm (Isotropic case), or given by a symmetric positive definite matrix (Anisotropic Riemannian case), or in the most general case is an arbitrary asymmetric norm (Finsler case).

The Fast Marching Algorithm is an extremely efficient first order method for solving numerically the Eikonal Equation in the Isotropic case.
The extension of this algorithm to the anisotropic setting is motivated, among other things, by applications to image processing, such as the segmentation of biological structures. A major challenge is the design of algorithms which accuracy and numerical complexity do not depend too much on the anisotropy of the metric.

A variant of the fast marching algorithm, recently introduced by the author, addresses the problem of large anisotropies when the eikonal equation is discretized on a cartesian grid. The numerical complexity is almost independent of the anisotropy ratio of the metric in the Riemannian case, and logarithmically dependent in the general Finsler case, in contrast with linear or polynomial complexity dependence in previous works. In the Riemannian case, the accuracy of our algorithm is also shown to be independent of the anisotropy, in an average sense over all anisotropy orientations. Numerical applications illustrate our results, based on the implementation of this algorithm into the ITK medical image segmentation toolkit.

J. Rapin - Robust Non-Negative Matrix Factorization for Multispectral Data with Sparse Priors

Recently the rapid development of multi-wavelength sensors in astrophysics or mass spectrometry for medicine has increased the need for dedicated efficient data analysis tools. Such kind of data is generally made of a collection of spectra of the same physical phenomena at different time or locations. It is customary to assume that the observed spectra are mixtures of elementary spectra representing physical components with varying concentrations along the temporal or spatial dimension. In the field of biology, these physical components can for instance represent proteins, which we need to identify.

In this setting, a classically used data analysis technique to extract the different physical components of the data is blind source separation. The model is that the data is a linear mixture of these sources, i.e. Y=AS, Y being the data, S the sources and A the mixing/weight matrix. Depending on the data, several properties can be used to disambiguate the sources, such as their sparsity, and the positivity of both A (if it represents *concentrations for instance) and S (which can represent an intensity). This last consideration led to Non-negative Matrix Factorization (NMF).*

In this work, we compare common sparse NMF algorithms with the Generalized Morphological Component Analysis (GMCA) using positivity constraints and sparsity in the direct domain, and a more robust version of it where the priors are more precisely handled through sub-iterations, which we will call r-GMCA. We will present preliminary results showing that r-GMCA is more robust to correlations between the sources than GMCA, and that both algorithms perform very well compared to other typically used algorithms for both clean and noisy data.

Finally, we work on adding more complex and structured priors such as sparsity in the wavelet domain, still combined with positivity in the direct domain, in order to better identify the sources. Our goal is to show that such a prior can greatly help separating sources under fairly realistic conditions.

H. Raguet - To be announced

R. Prevost - Simultaneous segmentation and registration on medical imaging