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Activity Report 2011

Project-Team ARIANA

Inverse Problems in Earth Observation and Cartography

IN COLLABORATION WITH: Laboratoire informatique, signaux systèmes de Sophia Antipolis (I3S)

RESEARCH CENTER
Sophia Antipolis - Méditerranée

THEME
Vision, Perception and Multimedia Understanding

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Project-Team ARIANA

Keywords: Image Processing, Inverse Problem, Markovian Model, Stochastic Geometry, Sensors, Environment

Ariana is a joint project-team of INRIA, and of CNRS and the University of Nice-Sophia Antipolis via the Computer Science, Signals and Systems Laboratory (I3S) in Sophia Antipolis (UMR 6070). It was created in 1998.

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2. Overall Objectives

2.1. Overall Objectives

Ariana is a joint project-team of INRIA, and of CNRS and the University of Nice-Sophia Antipolis via the Computer Science, Signals and Systems Laboratory (I3S) in Sophia Antipolis (UMR 6070). It was created in 1998.

The Ariana project-team aims to provide image processing tools to aid in the solution of inverse problems arising in a wide range of concrete applications, mainly in Earth observation and cartography, for example cartographic updating, land management, and agriculture, while at the same time advancing the state of the art in the image processing methods used to construct those tools. Certain applications in biological and medical imaging are also considered, using the same tools as in remote sensing.

2.2. Highlights of the year

- Ariana research team will be closed at the end of 2011 after 14 years of successful research work.
- Saima Ben Hadj got the second best young author prize (sponsored by the French Space Agency (CNES) and the French Geographical Institute (IGN)) from the French Society of Photogrammetry and Remote Sensing for her paper published in RFPT [8].

3. Scientific Foundations

3.1. Probabilistic approaches

Following a Bayesian methodology as far as possible, probabilistic models are used within the Ariana project-team, as elsewhere, for two purposes: to describe the class of images to be expected from any given scene, and to describe prior knowledge about the scene in the absence of the current data. The models used fall into the following three classes.

3.1.1. Markov random fields

Markov random fields were introduced to image processing in the Eighties, and were quickly applied to the full range of inverse problems in computer vision. They owe their popularity to their flexible and intuitive nature, which makes them an ideal modelling tool, and to the existence of standard and easy-to-implement algorithms for their solution. In the Ariana project-team, attention is focused on their use in image modelling, in particular of textures; on the development of improved prior models for segmentation; and on the lightening of the heavy computational load traditionally associated with these techniques, in particular via the study of varieties of hierarchical random fields.

3.1.2. Wavelets

The development of wavelets as an alternative to the pixel and Fourier bases has had a big impact on image processing due to their spatial and frequency localization, and the sparse nature of many types of image data when expressed in these bases. In particular, wavelet bases have opened up many possibilities for probabilistic modelling due to the existence of not one but two natural correlation structures, intra- and inter-scale, leading to adaptive wavelet packet models and tree models respectively. In Ariana, attention is focused on the use of tree models for denoising and deconvolution; adaptive wavelet packet models for texture description; and on the use of complex wavelets for their improved translation invariance and directional selectivity.

3.1.3. Stochastic geometry

One of the grand challenges of computer vision and image processing is the expression and use of prior geometric information. For satellite and aerial imagery, this problem has become increasingly important as the increasing resolution of the data results in the necessity to model geometric structures hitherto invisible. One of the most promising approaches to the inclusion of this type of information is stochastic geometry, which is a new and important line of research in the Ariana project-team. Instead of defining probabilities for different types of image, probabilities are defined for configurations of an indeterminate number of interacting, parameterized objects located in the image. Such probability distribution are called 'marked point processes'. For instance, two examples that have been developed in Ariana use interacting cuboids of varying length, width, height and orientation for modelling buildings; and interacting line segments of varying length and orientation for modelling road and other networks.

3.2. Variational approaches

3.2.1. Regularization and functional analysis

The use of variational models for the regularization of inverse problems in image processing is long-established. Attention in Ariana is focused on the theoretical study of these models and their associated algorithms, and in particular on the Γ-convergence of sequences of functionals and on projection algorithms. Recent research concerns the definition of and computation in a function space containing oscillatory patterns, a sort of dual space to BV space, which captures the geometry of the image. These variational methods are applied to a variety of problems, for example image decomposition.

3.2.2. Contours and regions

In addition to the regularization of inverse problems, variational methods are much used in the modelling of boundaries in images using contours. In Ariana, attention is focused on the use of such models for image segmentation, in particular texture segmentation; on the theoretical study of the models and their associated algorithms, in particular level set methods; and on the incorporation of prior geometric information concerning the regions sought using higher-order active contour energies.

3.2.3. Wavelets

Wavelets are important to variational approaches in two ways. They enter theoretically, through the study of Besov spaces, and they enter practically, in models of texture for segmentation, and in the denoising of the oscillatory parts of images.

3.3. Parameter estimation

One of the most important problems studied in the Ariana project-team is how to estimate the parameters that appear in the models. For probabilistic models, the problem is easily framed, but is not necessarily easy to solve, particularly in the case when it is necessary to extract simultaneously from the data both the information of interest and the parameters. For variational models, there are few methods available, and the problem is consequently more difficult.

4. Application Domains

4.1. Denoising and deconvolution

These are perhaps the most basic of the applications with which Ariana is concerned, and two of the most studied problems in image processing. Yet progress can still be made in these problems by improving the prior image models used, for example, by using hidden Markov trees of complex wavelets or by decomposing the image into several components. Ariana is also interested in blind deconvolution.

Figure 1. Left: denoising; middle: a degraded (blurred and noisy) image; right: its restoration.

4.2. Segmentation and classification

Many applications call for the image domain to be split into pieces, each piece corresponding to some entity in the scene, for example, forest or urban area, and in many cases for these pieces to be assigned the appropriate label. These problems too are long-studied, but there is much progress to be made, in particular in the use of prior geometric information.

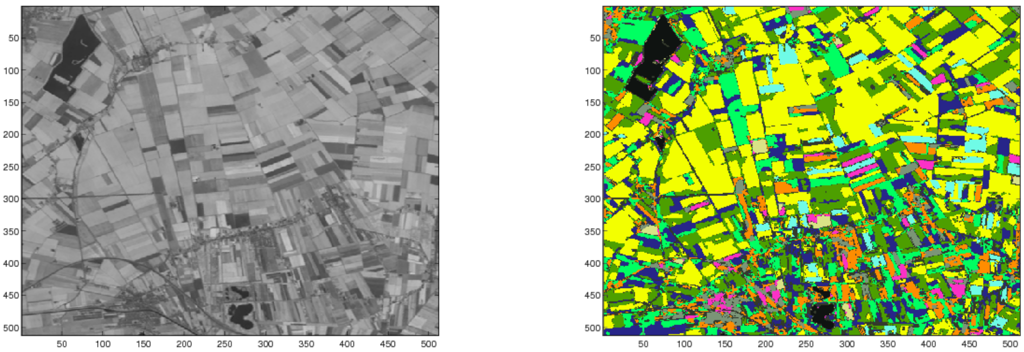


Figure 2. Left: a satellite image; right: its classification.

4.3. Extraction of structures

As the resolution of remote sensing imagery increases, so the full complexity of the scene comes to the fore. What was once a texture is now revealed to be, for example, an arrangement of individual houses, a road network, or a number of separate trees. Many new applications are created by the availability of this data, but efficient harvesting of the information requires new techniques.

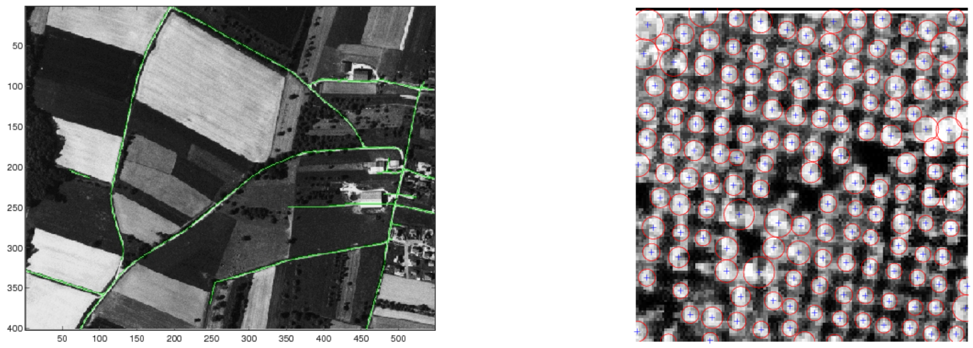


Figure 3. Left: road network extraction; right: tree extraction.

4.4. 3D modelling

Earth observation and cartography is not solely concerned with 2D images. One important problem is the construction of 3D digital elevation models (DEMs) from high-resolution stereo images produced by satellites or aerial surveys. Synthetic aperture radar (SAR) imagery also carries elevation information, and allows the production of more accurate DEMs thanks to interferometry techniques, for example.

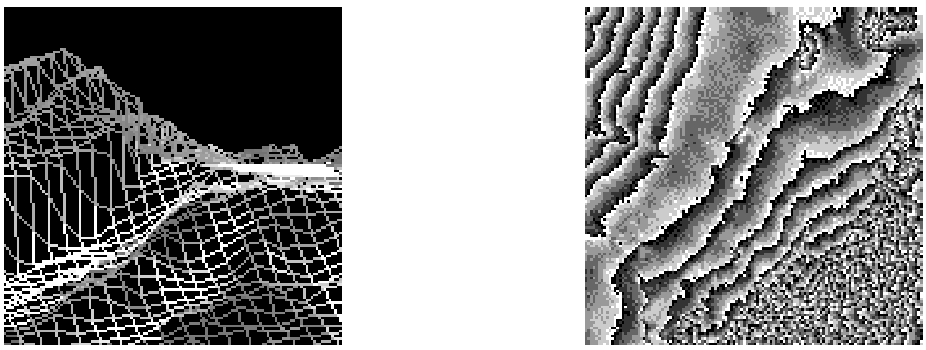


Figure 4. Left: DEM; right: interferometry.

4.5. Information mining and database retrieval

Every day, vast quantities of data are accumulated in remote sensing data repositories, and intelligent access to this data is becoming increasingly problematic. Recently, the problem of retrieval from large unstructured remote sensing image databases has begun to be studied within the project.

Figure 5. Image registration for the evaluation of retrieval systems. Left: mosaicked aerial image data; right: registered ground truth classification.

5. Software

5.1. Software

5.1.1. Deposits

- The software WAIHEKE was deposited with the APP in October 2011. It was developped for classifying 3D-point data generated from airborne lidar systems or multi-view imagery. The input point cloud is labeled into four classes of interest (building, ground, vegetation and clutter).
- The software SIKORA was deposited with the APP in October 2011. It was developped for extracting 3D-segments, planes, cylinders, cones, spheres and tori by region growing from 3D-point clouds.
- The software MOJOPIN was deposited with the APP in October 2011. It was developped for perfoming planimetric arrangements of urban components, including roof sections and trees, from labeled point clouds.
- The software SCOMBO v1.0 and Hierarchical SCOMBO v1.0 were deposited with the APP in December 2011. It deals with the supervised classification of multiband optical images by using Markov random fields and hierarchical Markov random fields, respectively.

6. New Results

6.1. Optical imagery for remote sensing

6.1.1. Phase Field-Higher Order Active Contours for Object Modelling and Image Segmentation

Participants: Ikhlef Bechar, Josiane Zerubia [contact].

This work is done in collaboration with Dr Ian Jermyn of Durham University (United Kingdom) and was funded by a contract with the EADS foundation [http://www-sop.inria.fr/ariana/Ikhlef.Bechar/hoacs/index.html].

The problem of object segmentation from imagery is an essential preliminary task for many applications (target recognition, automated navigation, organ segmentation in medical imaging, etc). The problem of adding prior knowledge about objects to the image segmentation process has received a lot of interest since recently, and active contours [38] provide us with such a tool.

We consider a new class of active contours called Higher Order Active Contours (HOACs) introduced initially in [41], and which consider an optimal contour as the one which minimizes an energy involving three additive terms; namely the length of a contour, its area and a term of interaction between all possible pairs of its points via an interaction function $\Psi(t)$. The three terms being weighed by means of three scalar parameters. The main advantage of HOACs over traditional segmentation methods is that they offer an unprecedented means for including shape prior about an object via the interaction function $\Psi(t)$.

The HOAC set up has been applied successfully to various object extraction problems such as the extraction of networks [40], circular shapes [37], etc, using a specific family of the $\Psi(t)$'s. Our main task in the framework of this project is to extend their work to more general shapes.

Our contributions so far have been in the numerical computation of the optimal HOAC parameters for a given shape. We have shown indeed that the HOAC energy can be fully made linear with respect to $\Psi(t)$, which then makes it easy to solve for $\Psi(t)$ numerically (cf. Fig.6). This is achieved by first choosing a linear basis to represent $\Psi(t)$ and using K-K-T (Karush-Kuhn-Tucker) optimality criteria to express the fact that a target contour is a local minimum of the energy. Consequently, looking for the optimal values of the coefficients for a given shape amounts first to solve an eigen value problem, and second, to find the linear combinations of the found eigen vectors that satisfy both K-K-T minimality criteria. The computation being carried out in the Fourier domain for sake of computational efficiency. We are currently testing the proposed model on simple shapes such as the butterfly one shown in figure 6.

6.1.2. Optimization of the compression-restoration chain for satellite images

Participants: Mikael Carlavan, Laure Blanc-Féraud [contact].

This project involves the French Space Agency (CNES) and the CESBIO, on collaboration with TAS and I3S (Marc Antonini).

This work concerns the study of the optimal imaging chain in the context of satellite imaging. The main goal of this study is to propose a new method to address the problem of decoding-deconvolution-denoising and consists in a characterization and optimization of the compression/restoration processes considering the instrumental characteristics (FTM, noise, sampling). A theoretical study first showed that current processes of compression and restoration are better fitted if the restoration is performed on-board before the compression. Indeed, current restoration algorithm is designed to remove the blur and the instrumental noise but does not take into account the coding noise, and it is well-known that compression algorithms do not perform properly on noisy data. More generally, we concluded that the image should be the closest possible to the real image before the step of coding, encouraging, thus, to move the restoration step on-board before the compression. Figure 7 shows the global distortion w.r.t. the coding rate if the restoration step is done either before (on-board) or after (on-ground) the compression. We see that using an on-board restoration leads to a quality improvement of the final image regardless the coding rate. For example, at the usual coding rate of 2.5 bits/pixel, using an on-board restoration improves the quality of the final image about 0.5 dB.

6.1.3. Aerial Image Restoration

Participants: Daniele Graziani, Laure Blanc-Féraud [contact].

This project involves as partners: ATE, Coreti, and Gilles Aubert from the J.A.D. Laboratory at the University of Nice Sophia Antipolis.

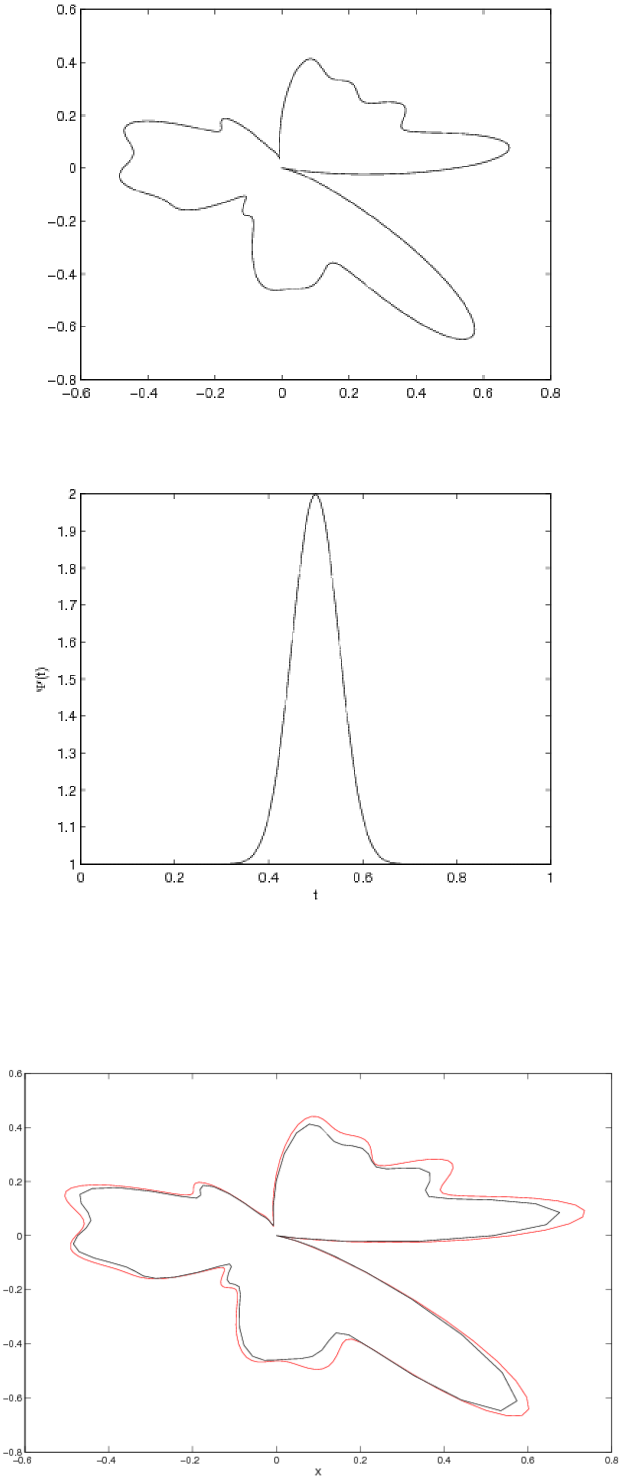


Figure 6. An example of estimation of the Ψ function for a given shape. (a) An example of a butterfly-like shape ; (b) The numerical estimation of its optimal Ψ function ; (c) The result of a gradient descent algorithm on the HOAC energy with Ψ of figure (b) until convergence (in black the original shape, and in red the shape found by the gradient descent algorithm). One can see that the estimated Ψ makes the HOAC energy achieve a local minimum at a shape which is very close to the target shape of figure (a).

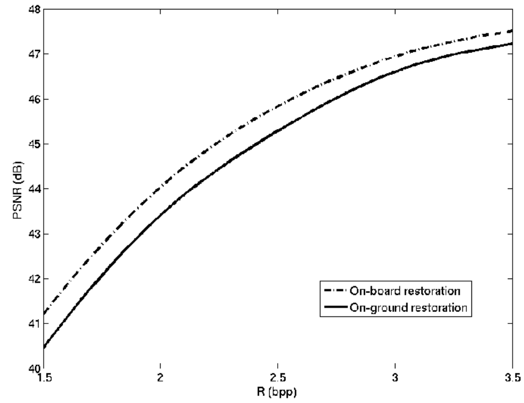


Figure 7. Global distortion w.r.t coding rate. The solid line is the global distortion with the restoration step done on-ground after the compression and the dashed line is the global distortion if the restoration is performed on-board before the compression.

The goal of the project is to built an airborne camera system, and our part is to process aerial images provided by ATE: restoration, microscanning, video, color images. We investigate a convex variational framework to compute high resolution images from a low resolution video. We analyze the image formation process to provide a well designed model for warping, blurring, downsampling and restoration. The microscanning is modeled as a convex minimization problem, which is solved with a domain decomposition technique based on the recent work of M. Fornasier, A. Langer and C. Schonlieb. ("A convergent overlapping decomposition method for total variation Minimization", Numeriske Math. to appear), which allows parallel computing and a realization of a real time algorithm.

6.1.4. Contribution of object recognition on forest canopy images to the building of an allometric theory for trees and natural, heterogeneous forests

Participants: Jia Zhou, Xavier Descombes, Josiane Zerubia [contact].

This work is done in collaboration with Dr. Pierre Couteron and Christophe Proisy at IRD, UMR AMAP, Montpellier.

Individual tree detection methods are more and more present, and improve, in forestry and silviculture domains with the increasing availability of satellite metric imagery. Automatic detection on these very high spatial resolution images aims to determine the tree positions and crown sizes. The mathematical model based on marked point processes has showed advantages w.r.t. several individual tree detection algorithms for plantations. We used this detection method to analyze natural mangrove forests in French Guiana, eucalyptus plantations in Brazil, and other types of tropical forests. The simulated optical images were also used to improve the method and calibrate the detection parameters. To analyze a eucalyptus plantation in Brazil [23], we used 2 optical images acquired by the WorldView-2 satellite. A tentative detection simultaneously with 2 images of different dates (multi-date) was tested for the first time, which estimates individual tree crown variation during these dates. In this work, we tried to find the trees localizations and crown sizes in order to provide a plantation map, and estimate the tree crown growth during the period between 2 images, and compared these results with the field measurements and expected dynamics of corresponding populations. An example of multi-date detection result is showed in figure 9.

Figure 8. Left bottom: noisy and blurred frame. Right bottom: restored image

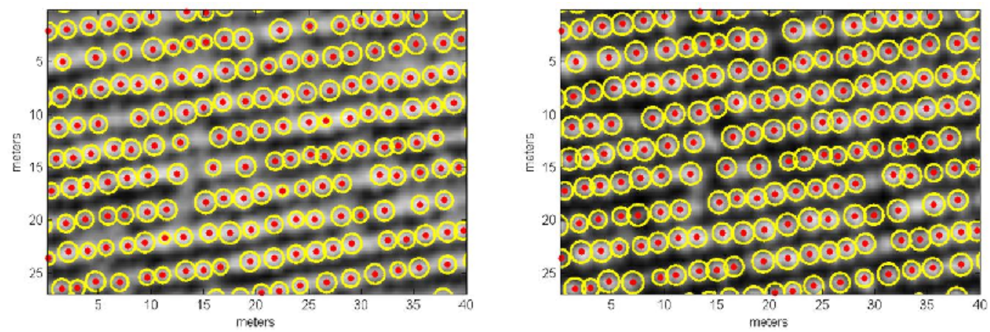


Figure 9. Results of a multi-date detection on 2 images at different dates: in May (left) and in August (right)

The detection method was also applied on simulated optical DART (Discrete Anisotropic Radiative Transfer) images, where exact field inventory could be provided on large surfaces. We assessed the detection results with these "ground-truth" maps.

6.2. SAR imagery for remote sensing

6.2.1. Stochastic modeling for very high resolution SAR image processing

Participants: Aurélie Voisin, Vladimir Krylov, Josiane Zerubia [contact].

This work is done in collaboration with DIBE, University of Genoa, with Dr Gabriele Moser and Prof. Sebastiano B. Serpico [http://spt.dibe.unige.it/] with partial financial support of the French Defense Agency, DGA [http://www.defense.gouv.fr/dga/]. The data are provided by the Italian Space Agency, ISA [http://www.asi.it/en].

We deal with the environmental risk assessment by addressing the problem of classifying SAR images of urban areas. Several difficulties need to be considered to address the SAR classification problem. The first one is related to the inherent multiplicative noise known as speckle, which degrades appreciably the registered imagery. Another difficulty is the heterogeneity of urban areas on very high resolution (VHR) images that leads to heterogeneous statistical modeling, reflecting the different ground materials such as asphalt, concrete, metal, etc. We propose a hierarchical statistical Bayesian supervised classification approach that consists of two steps. The first step deals with the SAR amplitude statistical modeling for each target class (e.g. vegetation, urban, etc.) by using a finite mixture model, estimated by resorting to a dictionary-based stochastic expectation maximization (DSEM) algorithm. More specifically, the SAR amplitude probability density functions (PDFs) are assumed to be mixtures of K PDFs automatically chosen inside a predefined dictionary of SAR-specific distribution families. Such mixtures are intended to take into account the above mentioned VHR SAR statistics heterogeneity. We further consider an additional source of information obtained by extracting a textural feature map from the original SAR image in order to optimize the detection of urban areas. Typically, the textural feature is generated by using a Grey Level Co-occurrence Matrix (GLCM)-based method. The marginal PDFs of the original SAR image and the textural feature are combined via copulas, leading to a joint PDF for each class. On the second step the classification map is generated, using the joint copula-based statistics. To improve the robustness with respect to speckle noise, we consider a contextual model based on Markov random fields (MRFs), and, more specifically, a hierarchical MRF, which offers the possibility to take into account the multi-scale information and to deal with multi-resolution imagery [28]. A variety of algorithms were proposed to estimate the labels on hierarchical graphs. The consideration of a specific graph, here a quad-tree, allows to benefit from its good properties (e.g. causality) and to apply non iterative algorithms. Among the different algorithms employed in the literature, we chose to take into account an exact estimator of the marginal posterior mode (MPM). The cost function associated to this estimator offers the possibility to penalize the errors according to their number and the scale at which they occur: an error at the coarsest scale is stronger penalized than an error at the finest scale. Moreover, we introduce a prior estimation update that experimentally leads to improved results and is less affected by speckle noise when compared to a predefined prior [35]. The challenge of the problem considered here is that our given input is a single-polarized SAR image at a single resolution. To improve the classification, we extract an extra information in the form of a multi-scale wavelet decomposition from the initial image. Then, at each level, the textural feature map is obtained from each image in the decomposition stack. Finally, at each level, the wavelet image is combined with the textural image by using copulas, as described previously in Ariana activity reports. The hierarchical method was tested on real COSMO-SkyMed images. We illustrate the obtained results with an example of a SAR acquisition of the Port-au-Prince quay (Haiti). Spatially disjoint training and test areas were manually annotated. The classification is done following 3 classes: urban areas, natural landscape and wet areas. The results are shown qualitatively in figure 10. The computation of numerical results gives an average accuracy of 95.65 percent for the considered test areas.

Our previous work was based on single-scale MRF, thus the hierarchical approach is a direct extension. Part of our work was dedicated to the comparison of these two methods [35], [28], and we also compared the MRF-based model to a novel products of experts approach [18].

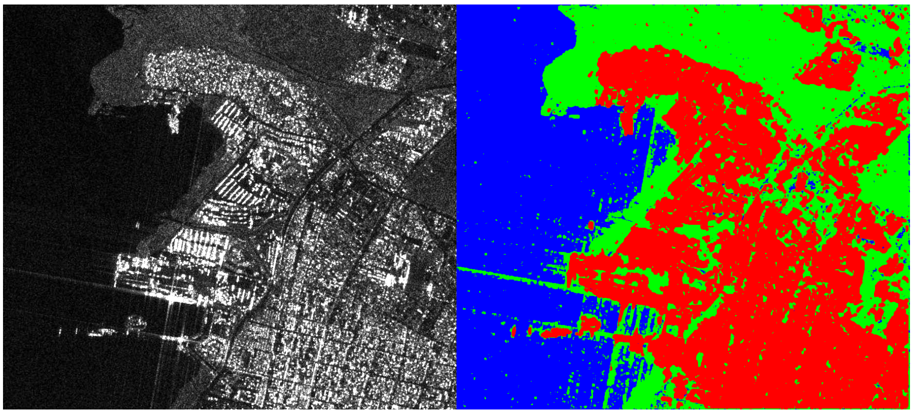


Figure 10. Left: Initial SAR image of Port-au-Prince (Haiti) (©ISA, 2009). Right: Classification map obtained with the hierarchical method for the 3 classes (Blue: water; Green: vegetation; Red: urban area).

6.2.2. Parameter estimation procedures for HR SAR image classification

Participants: Vladimir Krylov, Josiane Zerubia [contact].

This work is conducted in collaboration with DIBE, University of Genoa with Dr. Gabriele Moser and Prof. Sebastiano Serpico [http://spt.dibe.unige.it/] with the support of the Italian Space Agency, ASI [http://www.asi.it/en].

Parameter estimation of probability density functions is one of the major steps in the mainframe of statistical image and signal processing. We have explored the properties and limitations of the recently proposed method of logarithmic cumulants (MoLC) parameter estimation approach which is an alternative to the classical maximum likelihood (ML) and method of moments (MoM) approaches. We have derived the general sufficient condition of strong consistency of MoLC estimates which represents an important asymptotic property of any statistical estimator [33]. We have demonstrated the strong consistency of MoLC estimates for a selection of widely used distribution families originating (but not restricted to) synthetic aperture radar (SAR) image processing. We have then derived the analytical conditions of applicability of MoLC to samples generated from several distribution families in our selection. We have conducted various synthetic and real data experiments to assess the comparative properties, applicability and small sample performance of MoLC notably for the generalized gamma and K family of distributions. The synthetic-data experiments have demonstrated a competitive accuracy of MoLC estimates and a reliable behavior of this estimator for small samples which is a critical issue in applications. We have performed real-data image processing experiments to the problem of supervised classification applied to high resolution satellite SAR imagery. These experiments confirmed the stability of MoLC estimator with respect to sample size and at the same time illuminated the critical side of MoLC given by applicability restrictions. The experiments suggested the efficiency of use of the MoLC estimator for finite-mixture estimation problems [3], [19], and ML-based classification approaches [4], [28], [35].

6.2.3. Unsupervised amplitude and texture based classification of SAR images with multinomial latent model

Participants: Koray Kayabol, Aurélie Voisin, Vladimir Krylov, Josiane Zerubia [contact].

The participants would like to thank the Italian Space Agency (ASI) for providing the COSMO-SkyMed images. The TerraSAR-X images are provided from http://www.infoterra.de/.

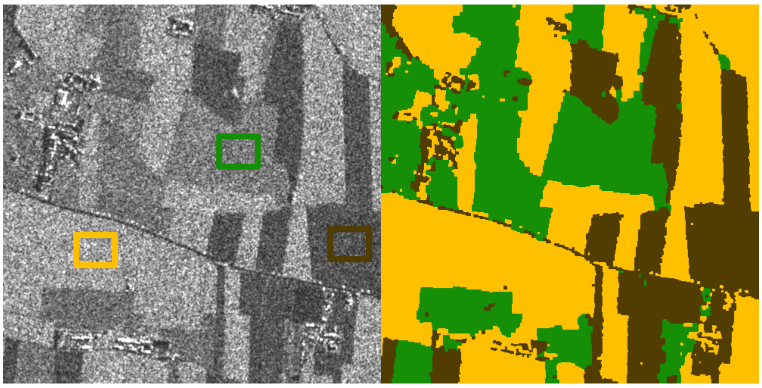


Figure 11. SAR image of field area (with learning areas in rectangles) of Piemonte, Italy (COSMO-SkyMed SAR sensor, ©ASI, 2008), 1000×1000 *pixels, and supervised field classification results obtained by the Generalized Gamma Distribution with parameters estimated by MoLC.*

We combine both amplitude and texture statistics of the Synthetic Aperture Radar (SAR) images using Products of Experts (PoE) approach for classification purpose. We use Nakagami density to model the class amplitudes and a non-Gaussian Markov Random Field (MRF) texture model with t-distributed regression error to model the textures of the classes. A non-stationary Multinomial Logistic (MnL) latent class label model is used as a mixture density to obtain spatially smooth class segments. The Classification Expectation-Maximization (CEM) algorithm is performed to estimate the class parameters and to classify the pixels [18]. Determining the necessary number of classes to represent the data and initialization are some drawbacks of the EM type algorithms. In [17] and [32], we combine hierarchical agglomeration, CEM and Integrated Classification Likelihood (ICL) criterion to get rid of the drawbacks of EM. We obtained some classification results of water, land and urban areas in both supervised and unsupervised cases on TerraSAR-X, as well as COSMO-SkyMed data [18], [17], [32]. The proposed unsupervised ATML-CEM (Amplitude and Texture density mixtures of MnL with CEM) method provides significantly better results, see Fig. 12, compared to the corresponding results obtained with K-MnL and its performance is close to supervised ATML-CEM.

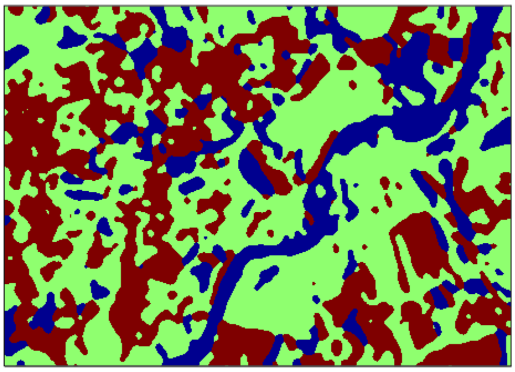
6.3. 3D-modelling of urban scenes

6.3.1. Buiding reconstruction from aerial LiDAR data

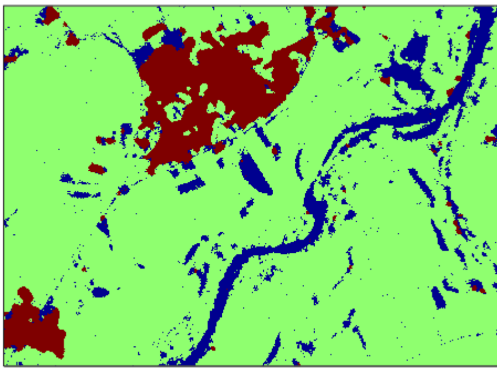
Participants: Yannick Verdie, Florent Lafarge [contact], Josiane Zerubia.

The generation of 3D representations of urban environments from aerial and satellite data is a topic of growing interest in image processing and computer vision. Such environments are helpful in many fields including urban planning, wireless communications, disaster recovery, navigation aids, and computer games. Laser scans have become more popular than multiview aerial/satellite images thanks to the accuracy of their measurements and the decrease in the cost of their acquisition. In particular, full-waveform topographic LIDAR constitutes a new kind of laser technology providing interesting information for urban scene analysis. We study new stochastic models for analysing urban areas from LIDAR data. We aim to construct concrete solutions to both urban object classification (i.e. detecting buildings, vegetation, etc.) and the 3D reconstruction of these objects. Probabilistic tools are well adapted to handling such urban objects, which may differ significantly in terms of complexity, diversity, and density within the same scene. In particular, jump-diffusion based samplers offer interesting perspectives for modelling complex interactions between the various urban objects. We investigated a first approach aiming at producing accurate, watertight and compact meshes from planar patches under planar constraint especially designed for urban scenes. The LiDAR point cloud is classified through a non-convex

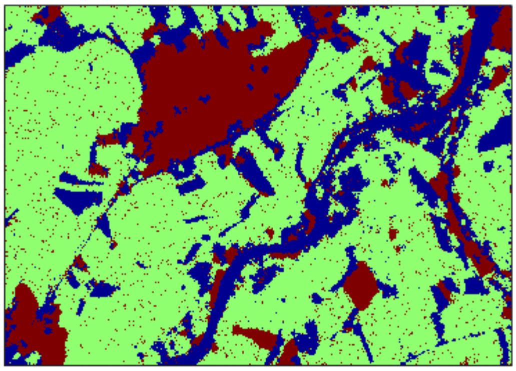
(a) CSK1 image



(b) K-MnL classification



(c) Supervised classification



(d) Unsupervised classification

Figure 12. (a) The original SAR image (COSMO-SkyMEd, ©ASI), (b), (c) and (d) classification maps obtained by K-MnL, supervised and unsupervised ATML-CEM methods. Blue, red and green colors represent water, urban and land areas, respectively.

energy minimization problem. The planar structures are extracted and connected to generate a compact, and watertight mesh of the building. Experiments highlight the potential of our method in term of performance, compactness, and accuracy. This work has been published in [22]. We illustrated our results in figure 13.

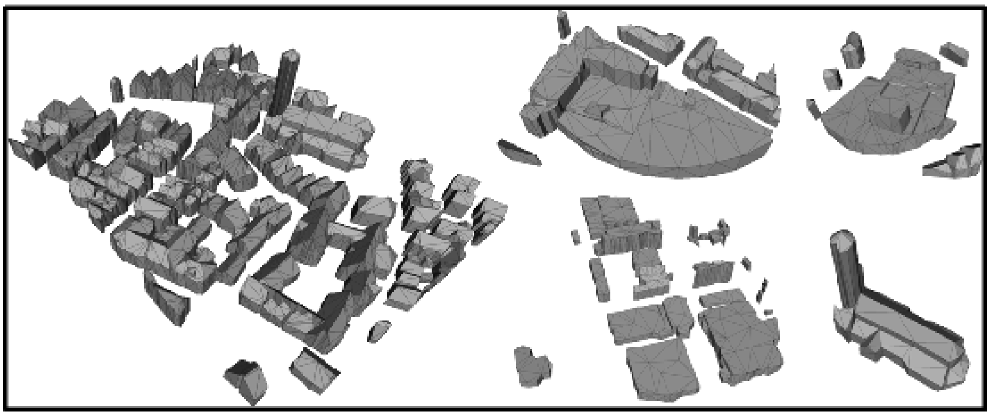


Figure 13. Results of 3D urban reconstruction by the framework described in [22].

6.3.2. Modeling large urban environments from unstructured point clouds

Participant: Florent Lafarge [contact].

We present a robust method for modeling cities from unstructured point data. Our algorithm provides a more complete description than existing approaches by reconstructing simultaneously buildings, trees and topologically complex grounds. Buildings are modeled by an original approach which guarantees a high generalization level while having semantized and compact representations. Geometric 3D-primitives such as planes, cylinders, spheres or cones describe regular roof sections, and are combined with mesh-patches that represent irregular roof components. The various urban components interact through a non-convex energy minimization problem in which they are propagated under arrangement constraints over a planimetric map. We experimentally validate the approach on complex urban structures and large urban scenes of millions of points as illustrated on Figure 14.

6.3.3. Parallel Monte Carlo sampler for point processes

Participants: Yannick Verdie, Florent Lafarge [contact], Ioan Dragan.

We designed a new parallel scheme for Markov point processes. These probabilistic models exploit random variables whose realizations are configurations of parametric objects, each object being assigned to a point positioned in the scene. The number of objects is itself a random variable. Another strength of Markov point processes is their ability to take into account complex spatial interactions between the objects and to impose global regularization constraints. Moreover, we proposed to use space-partitioning tree such as quadtree (for 2D data) or octree (for 3D data) for non-homogeneous measure adapted to the problem. We illustrate the results in figure 15.

6.4. Biological imagery

6.4.1. Regularizing parameter estimation with Poisson noise

Participants: Mikael Carlavan, Laure Blanc-Féraud [contact].

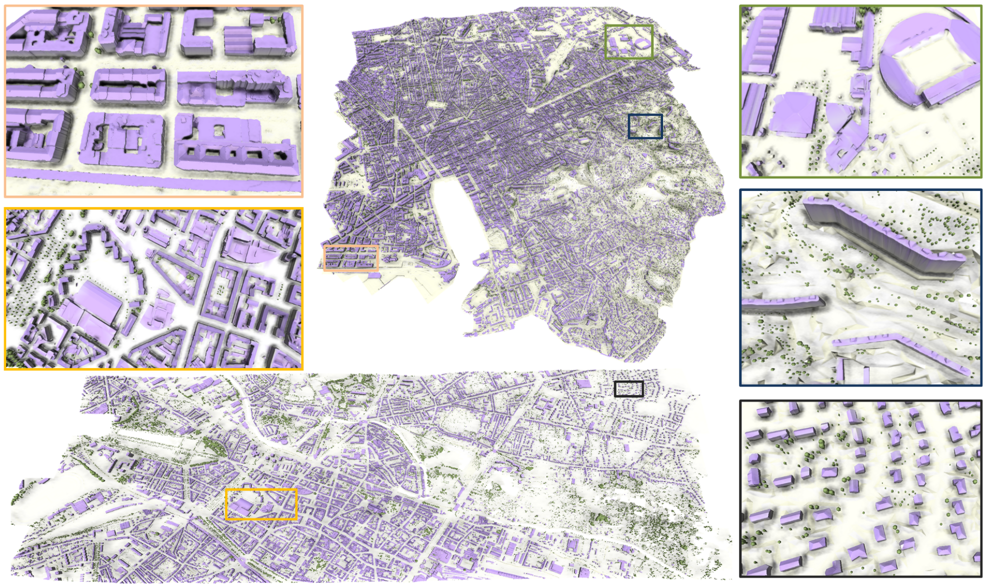


Figure 14. Reconstruction of the cities of Marseille and Amiens, France, from Lidar point cloud.

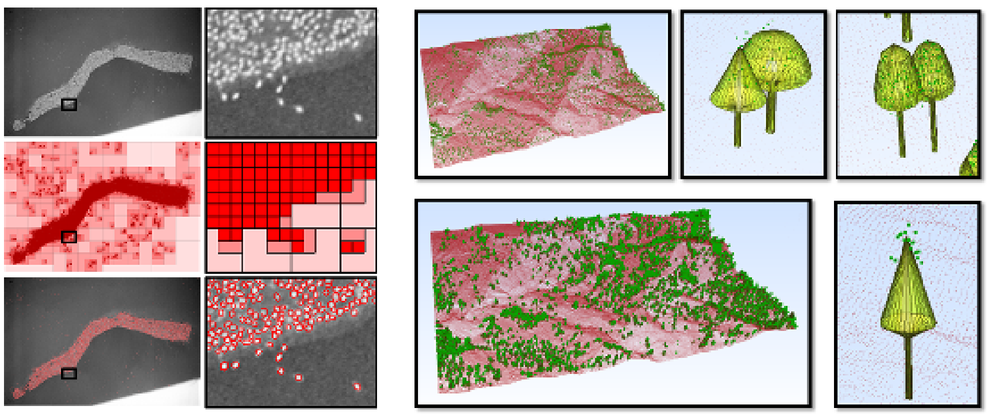


Figure 15. Results of the new Marked Point process on (left) 2D data, and (right) LiDAR data.

The problem is to automatically estimate the regularizing parameter in Poisson noisy image deconvolution using the L_1-norm regularization as a total variation or frame coefficients. This problem is addressed using the discrepancy principle. The standard weighted criterion composed of a data term and a regularization term is rewritten as a constrained minimization problem. The constraint is designed on the data term using the discrepancy principle and a new estimation of the bound is proposed as well as an efficient algorithm to solve this constrained minimization problem. This work is published in [10], [24], [9].

6.4.2. Brain vascular network segmentation

Participant: Xavier Descombes [contact].

This work was conducted in collaboration with Franck Plouraboué and Abdelhakim El Boustani from IMFT Toulouse and Caroline Fonta from CerCo Toulouse. It has been partially supported by a PEP II project from CNRS.

Micro-tomography produces high resolution images of biological structures such as vascular networks. We have proposed a new approach for segmenting vascular network into pathological and normal regions from considering their micro-vessel 3D structure only. We consider a partition of the volume obtained by a watershed algorithm based on the distance from the nearest vessel. Each region is characterized by its volume and the local vascular density. The volume and density maps are first regularized by minimizing the total variation. Then, a new approach has been proposed to segment the volume from the two previous restored images based on hypothesis testing. Results are presented on 3D micro-tomographic images of the brain micro-vascular network (see Fig. 16).

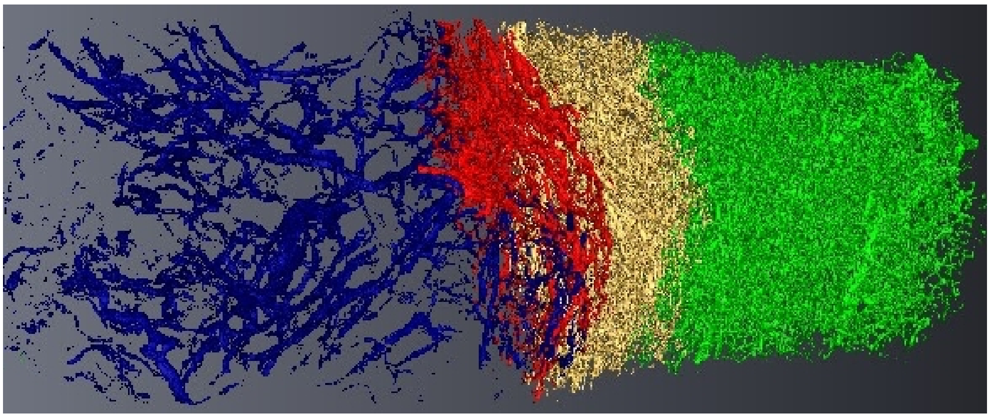
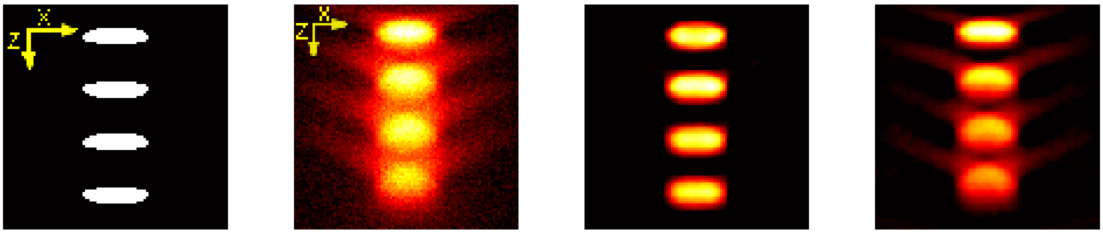


Figure 16. Brain micro-vascular network segmentation

6.4.3. Blind restoration of 3D biological image

Participants: Saima Ben Hadj, Laure Blanc-Féraud [contact].

Fluorescence microscopy is a powerful imaging technique providing three-dimensional images of biological living specimen. However, these images are degraded by a depth variant blur due to light diffraction phenomenon as well as refractive index mismatch between the different mediums composing the system and the biological sample. They are also distorted with noise from non-ideal imaging conditions. In order to provide biologist with more suitable images for quantitative studies, many restoration methods were developed. In most of them, the blur function, called Point Spread Function (PSF) is assumed to be piecewise constant in order to avoid the intensive computing time when using a pointwise varying PSF. However, this usually leads to blocking effect in the restored image. In our work, we extend the Space varying (SV) blur model previously proposed in [39] for 2D astronomical images to 3D microscopy images. In that model, the degraded image is a convex combination of convolutions with a space-invariant (SI) PSF. Furthermore, we fit to that model two restoration procedures which are basically developed for a SI PSF. On the one hand, we use the Richardson-Lucy method with Total Variation regularization which is carried out under Poisson noise assumption in order to restore confocal microscopy images. We employ another method with total variation regularization adapted to images with an additive Gaussian noise in order to restore Wide Field Microscopy images. For that, we rely on a fast optimization method based on a domain-decomposition technique [36]. In particular, we study its convergence properties when using the SV blur model [31], [27]. To illustrate the interest of the proposed method, we show in Fig 17 some results obtained on a simulated bead image of Wide Field Microscopy.



(a) (b) (c) (d)

Figure 17. (X,Z) slices of the (a) original image, (b) degraded image (c) restored image using a SV blur model, and (d) restored image with a space-invariant PSF.

6.4.4. Axon imaging

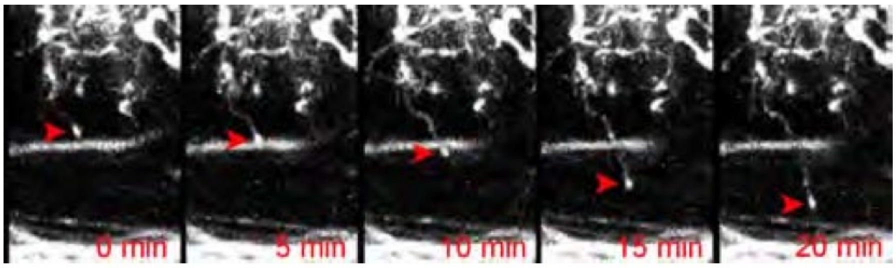
Participant: Florence Besse [contact].

During brain development, neurons extend cellular processes (dendrites and axons) to connect to specific targets and establish functional networks. Understanding how axonal processes migrate to reach their targets and how they form new branches to build up a complex axonal tree is thus key. To characterize the properties of axonal trees, we have generated a collection of confocal 3D pictures of normal and mutant single axons labeled using a fluorescent protein. To analyze the formation of axonal trees in real-time, we have developed a protocol to dynamically image growing axons within intact Drosophila brains. In this protocol, entire brains are cultured in conditions where they can undergo cell differentiation and maturation. Axons are labeled by the fluorescent molecule GFP and are imaged over 12h, with very low-photobleaching and no associated phototoxicity, using an ultra-sensitive 2-photon microscope. Several image sequences corresponding to the growth of axons in normal conditions have been acquired (see Fig. 18).

6.4.5. Detection of Axons in Neuronal Images

Participants: Alejandro Mottini, Florence Besse, Xavier Descombes [contact].

Imaging techniques such as confocal and two-photon microscopy provide an efficient way of analyzing supra-cellular structures. It is known that the precise shape of these objects provides information on their functioning and allows the characterization of pathological states. Therefore, the analysis of the morphological differences between normal and pathological structures is of paramount importance. In particular, the analysis of neuronal axon topologies allows biologists to study the causes of neurological diseases such as Fragile X Syndrome and Alzheimer's disease. For this purpose biologists have acquired static 3D images of mature neuron axons using fluorescent confocal microscopy.



Images extracted from a time-lapse movie obtained from an intact pupal brain. Red arrowheads point to the tip of a growing γ axon labelled by GFP (201Y-Gal4, UAS-mGFP).

Figure 18. Axon growth imaging

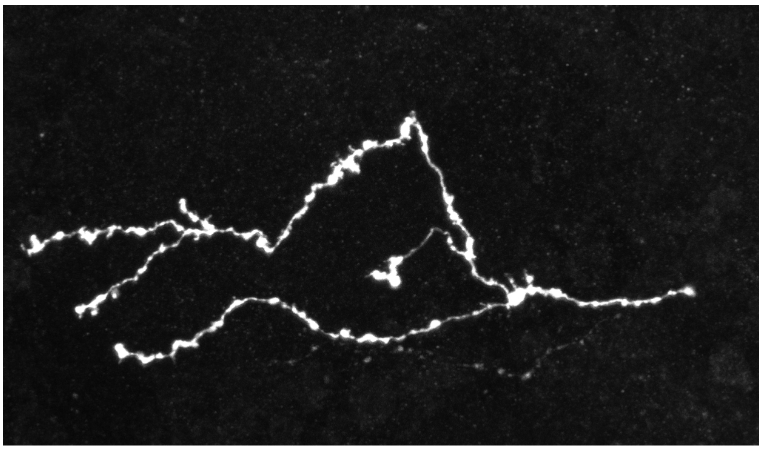


Figure 19. Static axon images (2D maximum intensity projection).

Due to the high volume of generated image data and the tortuous nature of the axons, manual processing is infeasible. Therefore, it is necessary to develop techniques for the automatic extraction and analysis of the neuronal structures. However, since both types of images present different characteristics, two different methodologies need to be developed. The main objective of the static case is the study of the length and number of bifurcation points of the two populations of neurons. On the other hand, the focus in the dynamic case is put on the tracking of the axonal tips. The automatic extraction of axons from confocal microscope images is a key problem in the field of neuron axon analysis. In this work we propose a solution which combines algorithms for the denoising, binarization, skeletonization, gap filling, point detection and statistical analysis in a pipeline capable of extracting the axons. Furthermore, these algorithms were incorporated in a software, developed in Matlab, which includes an easy to use GUI along with functionalities to facilitate high data throughput analysis. The software was evaluated on several 3D confocal microscope images of normal and mutated axons. Our results support the potential use of the software in helping biologist perform automatic morphological analysis of axons in fluorescent confocal microscopy images.

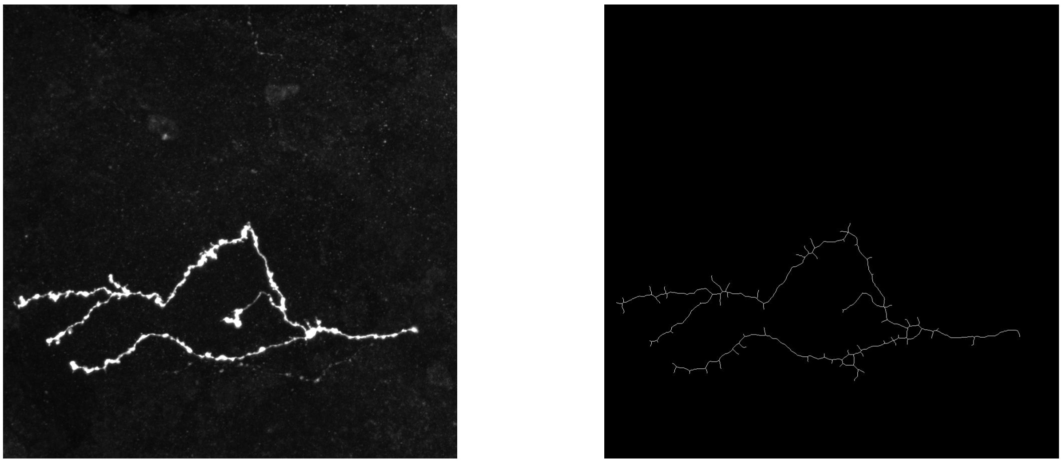


Figure 20. Original (left) and extracted (right) normal axon image (2D maximum intensity projection).

6.4.6. Axons tracking

Participants: Alejandro Mottini, Huei-Fang Yang, Florence Besse, Xavier Descombes [contact].

This work was funded by project ARC-DADA (INRIA/CNRS/UNSA) [http://www-sop.inria.fr/members/Xavier.Descombes/DADA/home.html]. It is done in collaboration with Serpico team at INRIA Bretagne (C. Kervrann, P. Houllier)

To study axon growth process biologists have acquired dynamic 3D+t image sequences of developing neurons using fluorescent two-photon microscopy.

Live cell two-photon microscopy is an effective tool for the analysis of dynamical processes occurring in living samples that, when combined with fluorescence, allows the detection of objects of interest in 3D space and time. These labeled objects appear as bright spots which need to be detected. The low resolution and signal-to-noise-ratio (SNR) make this analysis difficult even for experienced biologists. As a consequence, automatic detection techniques need to be robust and flexible. To this end, the Marked Point Process (MPP) detection framework was selected. Since axonal extremities appear either as circular objects or as ending points of thin filaments, we proposed two different MPP models. These models were formulated using a Gibbs energy function and optimized with Multiple Births and Deaths, a newly proposed algorithm which guarantees a fast

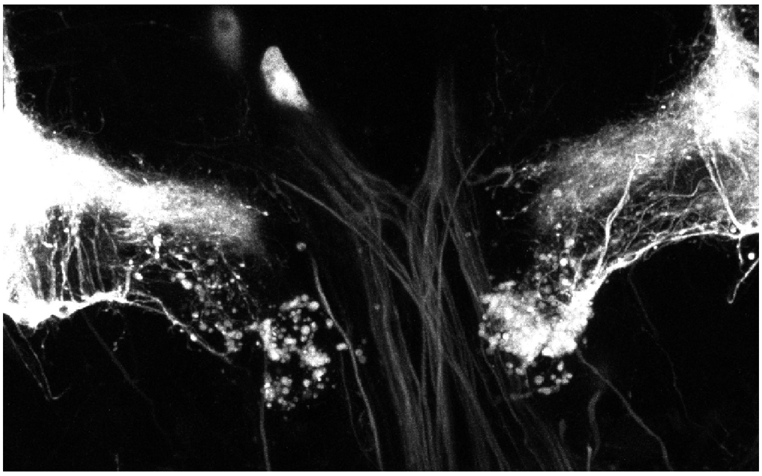


Figure 21. Dynamic images (2D maximum intensity projection).

convergence to the global minimum. The first model is designed to detect spheres or disks and the second filaments (both in 3D). Both models were tested on several 3D static images. To evaluate the performance of the detection, results were compared against images labeled by an experienced biologist.

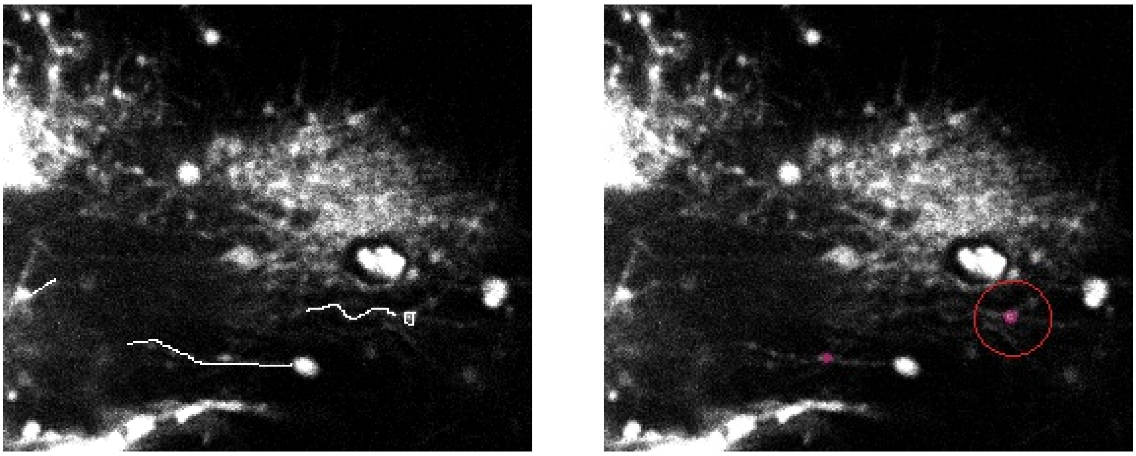


Figure 22. Original (left) and resulting (right) images (detected disks in pink). The true axonal tip is circled in white (original image) and red (result). In the original image, axons are labeled in white.

Figure 22 shows the results obtained on one frame of a video sequence (the shown image is a slice of the 3D frame) for the disk/sphere model. One can appreciate that the axonal tip marked by the biologist (in white, left) was detected. However, a false positive is also present.

Figure 23 shows the result obtained on one of the slices (for the same video frame) for the filament model. Although the good filament was detected, many false positives are also present in the image. Similar results where obtained for other images.

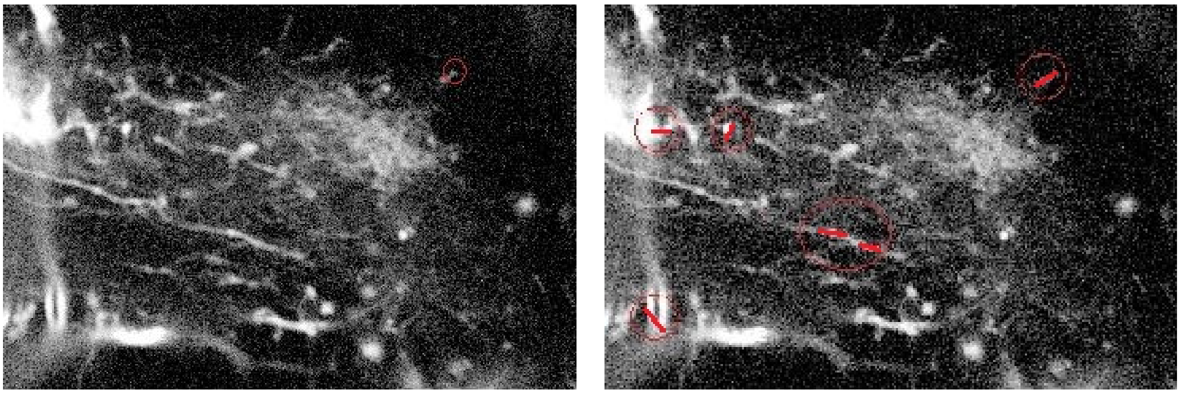


Figure 23. Original image (left) (targeted filament circled in red) and result (right) (detected filaments in red, circled in red).

Once the detection of the extremities in each frame of the video has been solved, the solution should be embedded into a tracking algorithm to obtain an estimation of the axon's trajectory during the growing stage. To this end, the particle filtering technique was considered. This technique consists in estimating the posterior distribution of the current state x_t of the target of interest at time t based on the measurements $z_{1..t}$:

$$p(x_t|z_{1..t}) \propto p(z_t|x_t) \int p(x_t|x_{t-1})\, p(x_{t-1}|z_{1..t-1})\, dx_{t-1}, \tag{1}$$

where $p(x_t|x_{t-1})$ is the transition distribution, and $p(z_t|x_t)$ is the likelihood. In the current implementation, a simple kinematic model is used for the transition distribution, and a color histogram is applied to the computation of the likelihood. Figure 24 shows the preliminary results obtained by applying the particle filtering technique on the coronal KESM (Knife-Edge Scanning Microscopy) sections of the mouse cerebellum, where the green rectangles indicate the tracked objects.

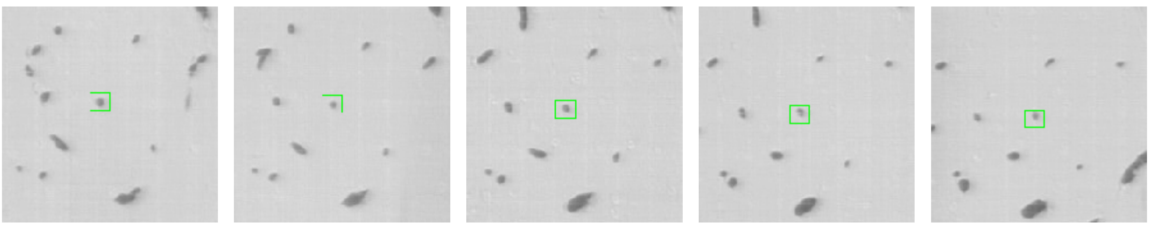


Figure 24. Tracking results on the coronal KESM sections of the mouse cerebellum. The green rectangles are the tracked objects. The user gives an initial starting region on the first image, and the algorithm tracks the region of interest in the subsequent images. Note that the images are cropped for a better view.

The next step will be to design a more sophisticated transition distribution and likelihood model that are suitable for tracking the trajectories of axons during their growth.

6.5. Dermatology

6.5.1. Statistical analysis of skin pigmentation under treatment

Participants: Sylvain Prigent, Xavier Descombes, Josiane Zerubia [contact].

This work was partially funded by a contract with Galderma R&D [http://www.galderma.com/RampD.aspx].

One of the steps to evaluate the efficiency of a therapeutic solution is to perform measurements on a series of patients who received the studied treatment. In parallel another treatment is tested on another group of people or on the same group of patients on another skin area. This second treatment is the reference one for the studied pathology or a placebo. We will call it ‘vehicle’.

For facial hyper-pigmentation, for each studied treatment, a group of N_e patients receives the treatment on one cheek and the vehicle on the other. To this end, patients are selected to have the same hyper-pigmentation severity on the two cheeks. Then multi-spectral images are taken at different times t along the treatment period. We propose a methodology to estimate the efficiency of a treatment by calculating a spectral criteria that maximizes the visibility of the disease comparatively to a healthy reference area. To design such a criterion, we compare three approaches. The first one gives weights to spectral bands in order to get an equivalent of the luminance from the $CIEL*a*b$ decomposition. This is the standard measure in dermatology. We compare this spectral measurement to a spectral signature obtained by ICA (Independent Components Analysis) in a whole study, and a criterion that searches for the highest contrasted band.

Once a criterion is designed, we compute the hyper-pigmentation severity of a patient by normalizing the pathological area with the healthy area and the active treatment measurement by the vehicle. That gives severity measurement distributions from patients at different times. A Student paired test allows to determine if an active treatment has an effect between two measurement times. The experiments done on 3 treatments and their associated vehicles brought to the following conclusion: The severity measure based on the selection of an optimal band allows to detect a treatment effect sooner than the two other approaches. The severity measurements obtained by the optimal band method is illustrated in figure 25.

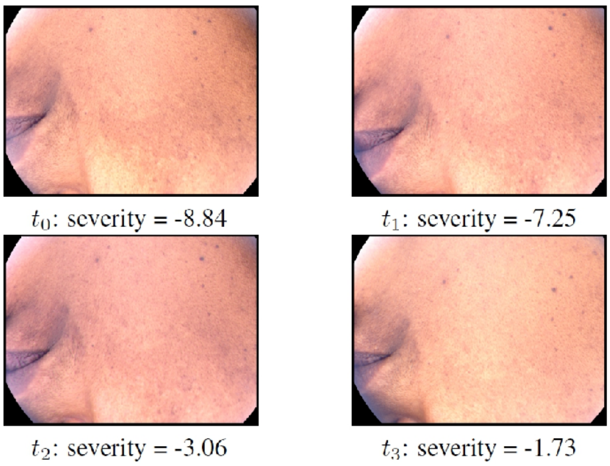


Figure 25. Evolution of skin pigmentation in the time and its quantification.

7. Contracts and Grants with Industry

7.1. Industrial contracts

7.1.1. Galderma Sophia-Antipolis

Participants: Sylvain Prigent, Xavier Descombes, Josiane Zerubia [PI].

Contribution of multi and hyperspectral imaging to skin pigmentation evaluation. Contract #4383.

7.1.2. LIRA Consortium

Participant: Josiane Zerubia [PI].

This consortium has been created in October 2011 between Philips, Fraunhofer Institutes and INRIA. It deals with skin care based on (cosmeto) dermatological imagery.

7.1.3. EADS Foundation

Participant: Josiane Zerubia [PI].

Detection of objects in infrared imagery using phase field higher-order active contours. Contract # 4643.

7.1.4. DGA/MRIS Bagneux

Participants: Aurélie Voisin, Marc Berthod, Josiane Zerubia [PI].

Development of advanced image-processing and analysis methods as a support to multi-risk monitoring of infrastructures and urban areas. Grant from the French Defense Agency, DGA.

7.1.5. CNES Toulouse - TAS Cannes

Participants: Mikael Carlavan, Laure Blanc-Féraud [Ariana PI].

Optimization of the compression-restoration chain for satellite images. Grant from CNES and TAS.

7.1.6. FUI Gyrovision, Salon de Provence

Participants: Daniele Graziani, Laure Blanc-Féraud [Ariana PI].

Airbone devices for survey and detection. In collaboration with ATE (PI), Dronexplorer, Nexvision, Coreti. This project has been labelled by the ‘pôle Pegase’.

7.1.7. ISA/DIBE

Participants: Aurélie Voisin, Vladimir Krylov, Josiane Zerubia [Ariana PI].

Development of stochastic models for environmental risk management using high resolution SAR data. In collaboration with G. Moser and S.Serpico[PI], from the University of Genoa (DIBE) and the Italian Space Agency (ISA).

8. Partnerships and Cooperations

8.1. National Actions

8.1.1. ARC DADA : Description et Analyse Dynamique de la Croissance Axonale.

Participants: Xavier Descombes [PI], Laure Blanc-Féraud, Alejandro Mottini, Huei-Fang Yang, Florence Besse.

In collaboration with Serpico, INRIA Rennes - Bretagne Atlantique (C. Kervrann, P. Houllier).

8.1.2. ANR DIAMOND

Participants: Saima Ben Hadj, Laure Blanc-Féraud, Josiane Zerubia [PI].

In collaboration with the Pasteur Institute, the MIPS laboratory of Université de Haute Alsace, the LIGM of Université Paris-Est, and INRA Sophia-Antipolis. Web site: http://www-syscom.univ-mlv.fr/ANRDIAMOND

8.1.3. ANR MOTIMO

Participants: Gilles Aubert, Didier Auroux, Xavier Descombes, Eric Debreuve, Laure Blanc-Féraud [contact].

In collaboration with l'Institut de Mathématiques de Toulouse, l'INRA, l'Institut de Mécanique des Fluides de Toulouse, le Laboratoire d'Informatique, Signaux et Systèmes de Sophia-Antipolis, et IMV Technologies (PME).

8.1.4. PEP II : Analyse morphométrique des réseaux micro-vasculaires et neuronaux

Participants: Florence Besse, Eric Debreuve, Laure Blanc-Féraud, Xavier Descombes [PI].

In collaboration with IBDC (Nice), CerCo (Toulouse) and IMFT (Toulouse).

8.1.5. PEPII M2S

Participants: Xavier Descombes, Eric Debreuve, Giles Aubert, Didier Auroux, Laure Blanc-Féraud [contact].

In collaboration with l'Institut de Mathématiques de Toulouse, l'INRA, le Laboratoire d'Informatique, Signaux et Systèmes de Sophia-Antipolis.

8.1.6. GDR ISIS young researcher project on "scene analysis from Lidar"

Participant: Florent Lafarge [PI].

In collaboration with Clément Mallet and Bruno Vallet from MATIS Laboratory, IGN [http://www.ign.fr].

9. Dissemination

9.1. Conferences, seminars and meetings

- The Ariana project-team organized numerous seminars in image processing during 2011. 11 researchers were invited from the following countries: China, France, Germany, Russia, USA. For more information, see the Ariana project-team web site.
- Members of the Ariana project-team participated actively in the visits to INRIA Sophia Antipolis of students from the Grandes Écoles (ISAE/SUPAERO, ENS Cachan); helped students of the Classes Préparatoires with TIPE in France; and gave information on remote sensing image processing to high school students in Mauritius.
- Saima Ben Hadj presented a poster at the conference GRETSI'11 in Bordeaux in September, and at the GDR Ondes in Nice in October. She attended the summer school EIT ICT Labs Health Retreat on computational biology during June 6-10 in Helsinki, Finland where she presented her work. She also presented a paper on automatic object extraction from aerial and satellite in Strasbourg where she got the second best student paper award of RFPT in May.
- Ikhlef Bechar was visiting Dr Ian Jermyn at Durham University from the 6th of November 2011 until the 26th of November 2011.
- Florence Besse presented posters and gave talks at: SIFRARN meeting, Dourdan, France; Cell biology of the neuron EMBO workshop, Heraklion, Greece; 10ème congrès de la Société des Neurosciences, Marseille, France; 11th HFSP Awardees Meeting, Montreal, Canada; RNA localization and translation meeting, EMBO/FASEB workshop, Barga, Italy; EDRC meeting, Lisbon, Portugal. She gave invited seminars at IBDML, Marseille, IGDR, Rennes and IGBMC, Strasbourg .

- Laure Blanc-Féraud attended and presented posters at the conférences ISBI'11 and at ICASSP'11 where she also presented and chaired a session on the new trends in biological imaging. She attended and presented posters at Gretsi conference. She attended the workshop organized by the ANR Diamond in November at Mulhouse, she attended the general assembly of the GDR ISIS in Saint George de Didonne in May, she gave a talk at the scientific workshop organized by GDR MOA and MSPC in La Londe les Maures in June.
- Mikael Carlavan attended a school entitled 'Ecole de Printemps en Traitement d'Image' in Martel, France. He presented a paper at the conference NCMIP'11, Cachan, in May. He presented a paper at the conference ICIP'11 in Brussels and at the conference GRETSI'11 in Bordeaux, both in September.
- Xavier Descombes visited the Dobrushin Laboratory (IITP, Russian Academy of Science) for one week in August. He presented one paper in ISBI'11 in Chicago and two papers in GRETSI'11 in Bordeaux. He was invited to give a tutorial at EGCM'12 in Tanger (Marocco) in November. He regularly took part in meetings with Galderma and IRD. He gave a talk in IBDC in January.
- Daniele Graziani presented a paper at ICASSP'11 in Prague.
- Koray Kayabol presented a paper at the conference ICIP'11 in Brussels, Belgium in September.
- Vladimir Krylov presented a paper at the conference COMCAS'11 in Tel Aviv, Israel, and gave an invited talk at ELTA Aerospace Industries in Ashdod, Israel, both in early November. He gave invited talks at the Southwest Jiaotong University, Chengdu, China, during a 7-days visit at the end of November.
- Florent Lafarge gave seminars at the University of Bonn, Germany, and at GDR ISIS meeting, Saint-Georges De Didonne, France. He presented his work at ICCV'11, Barcelona, Spain.
- Sylvain Prigent presented a paper at the conference ICIP'11 in Brussels, and gave a talk at the GDR ISIS meeting in Paris, in October.
- Yannick Verdie presented his work at the conference ICIP'11 in Brussels.
- Aurélie Voisin presented a paper at the conference Gretsi'11 in Bordeaux (France) in September. She also presented her work during the Summer School on Image Processing (SSIP) in Szeged (Hungary) in July.
- Josiane Zerubia visited ACRI ST in Sophia Antipolis in January. In February she participated in the CNES Research and Technology Day in Labege and she also visited Astrium EADS and Sanofi Aventis Toulouse. In March, she visited Philips in Eindhoven to attend the first LIRA Consortium meeting. In April she attended the Editorial Board meeting of SFPT at CNES in Paris. In May she was invited by the IEEE Icelandic Section to give a keynote at the University of Iceland in Reykjavik. She also gave a keynote at JDS'11 in Tunis http://jds2011.tn.refer.org/ invited by the French Society of Statistics and was part of two Masters committees at ENSI-Tunis. In June she went to IRD/UMR AMAP in Montpellier, organized a two day ANR DIAMOND meeting and a one day LIRA workshop both at INRIA SAM. In July, she went to CESBIO in Toulouse, and visited several research teams at INRIA in Bordeaux. In September, she attended GRETSI'11 in Bordeaux where she had one paper. She attended ICIP'11 in Brussels, Belgium, where she had 4 papers and chaired a session. She also participated to the IVMSP TC meeting in Brussels and was part of the organization committee of ICIP'11 as a publicity chair. She visited several teams at INRIA in Grenoble. In November, she gave a plenary talk at the IEEE/ISPRS Workshop on Computer Vision for Remote Sensing of the Environment at ICCV'11 in Barcelona http://recherche.ign.fr/isprs/CVRS/ and attended the SPECIF/Gilles Kahn PhD thesis prize committee in Paris. She also attended the ANR DIAMOND workshop in Mulhouse where she gave a brief overview as a PI of this ANR. In December, she visited Gipsa lab form INRIA Grenoble. As a PI, she regularly organized and attended meetings with Galderma in Sophia-Antipolis and meetings with ANR DIAMOND in Sophia Antipolis and Paris. As a co-PI, she also organized and participated to several meetings with IRD at UMR AMAP in Montpellier and at INRIA Sophia-Antipolis.

- Jia Zhou presented a paper at ACPR'11 in November, Beijing, China.

9.2. Refereeing

- Florence Besse was a reviewer for EMBO reports and Cell Mol Life Sci. and for the University Pierre et Marie Curie (Projets Emergence).
- Laure Blanc-Féraud was a reviewer for the journal Signal Image and Video Processing, IEEE TMI, was associate editor for the journal Traitement du Signal. She was reviewer for program PEPII of CNRS and program LEFE/MANU of CNRS/INSU. She was reviewer of a PhD thesis at University of Liege, at University of Saint Etienne, at University of Grenoble, and reviewer for an HDR at Univeristy of Paris 13. She was member of the editorial committee of NCMIP 2011 and 2012, RFIA 2012. She is reviewer for IEEE ICASSP and IEEE ISBI.
- Xavier Descombes was a regular reviewer for IEEE TIP, IEEE TPAMI, IEEE TGARS, Traitement du Signal and GRETSI'11. He was a reviewer for the ANR . He was reviewer of two Ph.D. dissertations and one HDR dissertation.
- Daniele Graziani was a reviewer for the journal "Journal of Mathematical Imaging and Vision"
- Koray Kayabol was a reviewer for the journals IEEE TIP, Pattern Recognition, Pattern Recognition Letters, Digital Signal Processing, EURASIP Journal on Advances in Signal Processing, Signal Image and Video Processing.
- Vladimir Krylov was a reviewer for the journals IEEE TIP, IEEE TGRS, IEEE GRSL, IEEE JSTARS, Pattern Recognition Letters and Signal Processing.
- Florent Lafarge was a referee for IEEE TPAMI, ACM TOG, IEEE TIP, JPRS, PERS, DSP, IEEE CVPR'11, IEEE ICCV'11, IEEE ICIP'11, ICVNZ'11. He reviewed proposals for the Czech Science Foundation and the Romanian National Council for Development and Innovation.
- Josiane Zerubia was a regular reviewer for TS (Traitement du Signal) and SFPT (Revue Française de Photogrammétrie et de Télédétection). She was a reviewer and a program committee member for ICASSP'11, ISBI'11 and ICIP'11, as member of the IEEE BISP TC and IEEE IVMSP TC, and for SPIE-ISPRS'11 ('Image and Signal Processing for Remote Sensing'), ISPA'11, EMMCVPR'11, GRETSI'11, TAIMA'11, ICPRAM'12, ICASSP'12. She was a reviewer of one HdR and of 5 PhD theses in France and abroad, and member of one PhD committee. Furthermore, she was also reviewer of 4 PhD theses for the SPECIF Gilles Kahn PhD prize.

9.3. Organization

- Florence Besse was member of a recruitment committee (MCU position, section 69, position 214), member of a PhD defense committee (Paris XI University). She was co-organizer of the 2nd joint meeting of the French and British societies of developmental biology.
- Laure Blanc-Féraud is director of the French national Research group GDR ISIS (more than 120 laboratories and 20 industrial partners). She is a member of the IEEE BISP committee. Member of scientific councils of the Institutes INS2I and INSIS of CNRS. Member of scientific councils of the Institutes INS2I and INSIS of CNRS Member of AERES committees for laboratory expertises (XLIM 2011). She is a permanent member of the Organizing Committee of the Gretsi Peyresq annual Summer School. She is part of the Administrative Council of Gretsi, and is a member of its board. She is vice-team leader of EPI Ariana (I3S/INRIA), and from September team MORPHEME. She is Member of INRIA Sophia Antipolis comité des projets and member of its board. She is part of the CNECA 3. She was member of four PhD defense commitees and two HDR defense committees. She organized one scientific day in November in Rennes on biological imaging jointly with GDR microscopie fonctionnelle du vivant.

- Xavier Descombes is associate editor of Digital Signal Processing. He has been elected at the BISP (Biomedical Image and Sipgnal Processing) committee. He is a member of the scientific committee of the ‘Pôle de compétitivité Optitec’, and a member of the strategic committee of PopSud. He was computer systems coordinator for the Ariana project untill August. He is PI of a PEP II project, in collaboration with, IBDC, IMFT and CerCo. He is PI of the ARC DADA, in collaboration with Serpico team (INRIA Rennes - Bretagne Atlantique).
- Koray Kayabol is an Associate Editor of Digital Signal Processing.
- Florent Lafarge is a member of the comité de Suivi Doctoral (CSD) of INRIA Sophia Antipolis Méditerranée.
- Josiane Zerubia is an IEEE Fellow. She was publicity chair of IEEE ICIP’11 in Brussels [http://www.icip2011.org/] which is supported by INRIA and co-member of the organizing committee of ERCIM MUSCLE workshop in Pisa [http://muscle.isti.cnr.it/pisaworkshop2011/] which is supported by INRIA. She is a member of the Biological Image and Signal Processing Technical Committee and of the Image, Video and Multidimensional Signal Processing Technical Committee member of the IEEE Signal Processing Society. She is an Associate Editor of the collection ‘Foundation and Trends in Signal Processing’ [http://www.nowpublishers.com/sig]. She is a member of the Editorial Boards of IJCV, the Revue Française de Photogrammétrie et de Télédétection of SFPT and the journal ‘Traitement du Signal’. She is an Associate Editor of the electronic journal Earthzine [http://www.earthzine.org/]. She was a member of the CERT Committee, as one of 30 experts nominated by the Director of the French Space Agency (CNES) to evaluate the future research and development of CNES. She is principal investigator for the ANR DIAMOND, she is a deputy of Frederic Alexandre at the Executive Committee of LIRA Consortium (Philips), and a PI of an INRIA/DIBE/ISA project. She is a member of the ORFEO group (CNES). She is a consultant for Galderma R & D in Sophia Antipolis. Finally, she is a member of the new program committee of master 2 in computational biology and biomedicine at the University of Nice Sophia Antipolis in charge of sponsoring.

9.4. Teaching

- Saima Ben Hadj has done 64h of teaching service on C programming and data base management system at the computer science department at Nice-Sophia Antipolis University.
- Florence Besse supervised a master Student (M1 ; 6 months) and a third year Student (L3 ; 6 weeks).
- Laure Blanc-Féraud was teaching professor at the international master on Computational Biology and Medecine (12h CM) at the Engineer school EPU Sophia Antipolis (8h CM), and at Master IMEA, departement of Mathematics (8h CM and 8h TD).
- Mikael Carlavan was teaching assistant for ‘Traitement Numérique des Images’ (16h), ‘Applications’ (16h), ‘Compression’ (8h) and ‘Traitement Numérique du Signal’ (18h) at Poly’Tech Nice-Sophia Antipolis.
- Xavier Descombes taught ‘Image analysis’ (10h) at Poly’Tech Nice-Sophia, and ‘Image processing’ and ‘Advanced techniques in space imagery’ (20h) at ISAE/SUPAERO and ‘Marked Point Process in Image Analysis’ (3h) at ENS Lyon.
- Florent Lafarge taught Image analysis at Poly’Tech Nice-Sophia (6h) and at ENS Lyon (3h).
- Josiane Zerubia was director of the module ‘Deconvolution and denoising in confocal microscopy’ for the Masters 2 course BioComp at the University of Nice-Sophia Antipolis (24h of which 12 taught). She was director of the course ‘Advanced techniques for space imagery’ at ISAE/SUPAERO (40h, of which 20h taught). She taught the module 1 “Introduction to image processing” for master 1 students from ENS Lyon at University of Nice Sophia Antipolis (12h, of which 3h taught).
- Jia Zhou teaches mathematics (60h) at IUT Montpellier.

9.5. PhDs

9.5.1. In progress

1. Saima Ben Hadj: Blind restoration of 3D biological image, University of Nice-Sophia Antipolis. Defence expected in 2013.
2. Mikael Carlavan: Optimization of the compression-restoration chain for satellite images, University of Nice-Sophia Antipolis. Defence expected in 2012.
3. Alejandro Mottini: Axons tracking, University of Nice-Sophia Antipolis. Defence expected in 2014.
4. Sylvain Prigent: Contribution of multi and hyperspectral imaging to skin pigmentation evaluation, University of Nice-Sophia Antipolis. Defence expected in 2012.
5. Yannick Verdié: Urban scene analysis from unstructured point data, University of Nice-Sophia Antipolis. Defence expected in October 2013.
6. Aurélie Voisin: Development of advanced image-processing and analysis methods as a support to multi-risk monitoring of infrastructures and urban areas, University of Nice-Sophia Antipolis. Defence expected in October 2012.
7. Jia ZHOU: Contribution of object recognition on forest canopy images to the building of an allometric theory for trees and natural, heterogeneous forests, University Montpellier II. Defence expected in October 2012.

9.5.2. Defended in 2011

1. Ahmed Gamal-Eldin: 'Marked point processes models of 3D objects: an application to the counting of King Penguins, University of Nice-Sophia Antipolis. Defended in October 2011.

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[2] S. DESCAMPS, A. BÉCHET, X. DESCOMBES, A. ARNAUD, J. ZERUBIA. *An automatic counter for aerial images of aggregations of large birds*, in "Bird Study", 2011, p. 1-7.

[3] V. KRYLOV, G. MOSER, S. SERPICO, J. ZERUBIA. *Enhanced Dictionary-Based SAR Amplitude Distribution Estimation and Its Validation With Very High-Resolution Data*, in "IEEE Geosci. Remote Sens. Lett.", Jan. 2011, vol. 8, n^{o} 1, p. 148–152.

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[7] P. WEISS, L. FOURNIER, G. AUBERT. *On the illumination invariance of the level lines under directed light application to change detection*, in "SIAM journal on Imaging Sciences", 2011, vol. 4, n° 1, p. 448–471.

Articles in National Peer-Reviewed Journal

[8] S. BEN HADJ, F. CHATELAIN, X. DESCOMBES, J. ZERUBIA. *Approche non supervisée par processus ponctuels marqués pour l'extraction d'objets à partir d'images aériennes et satellitaires*, in "Revue Francaise de Photogrammétrie et de Télédétection (SFPT)", 2011, n° 194, p. 2-15.

International Conferences with Proceedings

[9] M. CARLAVAN, L. BLANC-FÉRAUD. *Regularizing parameter estimation for Poisson noisy image restoration*, in "International ICST Workshop on New Computational Methods for Inverse Problems", Paris, France, May 2011.

[10] M. CARLAVAN, L. BLANC-FÉRAUD. *Two constrained formulations for deblurring Poisson noisy images*, in "Proc. IEEE International Conference on Image Processing (ICIP)", Brussels, Belgium, September 2011.

[11] X. DESCOMBES, S. KOMECH. *Shape descriptor based on the volume of transformed image boundary*, in "Proc. PReMI", Moscow, Russia, 2011.

[12] X. DESCOMBES, F. PLOURABOUE, H. BOUSTANI, C. FONTA, G. LE DUC, R. SERDUC, T. WEITKAMP. *Brain tumor vascular network segmentation from micro-tomography*, in "International Symposium of Biomedical Imaging (ISBI)", Chicago, USA, April 2011.

[13] R. GAETANO, J. ZERUBIA, G. SCARPA, G. POGGI. *Morphological road segmentation in urban areas from high resolution satellite images*, in "International Conference on Digital Signal Processing", Corfu, Greece, July 2011.

[14] A. GAMAL ELDIN, X. DESCOMBES, G. CHARPIAT, J. ZERUBIA. *A fast multiple birth and cut algorithm using belief propagation*, in "Proc. IEEE International Conference on Image Processing (ICIP)", Brussels, Belgium, September 2011.

[15] A. GAMAL ELDIN, X. DESCOMBES, J. ZERUBIA. *A novel algorithm for occlusions and perspective effects using a 3d object process*, in "ICASSP 2011 (International Conference on Acoustics, Speech and Signal Processing)", Prague, Czech Republic, May 2011.

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[17] K. KAYABOL, V. KRYLOV, J. ZERUBIA. *Unsupervised classification of SAR images using hierarchical agglomeration and EM*, in "Proc. ERCIM MUSCLE Int. Workshop Computational Intelligence Multimedia Understanding", Pisa, Italy, December 2011.

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[24] M. CARLAVAN, L. BLANC-FÉRAUD. *Formulation contrainte pour la déconvolution de bruit de Poisson*, in "Proc. GRETSI Symposium on Signal and Image Processing", Bordeaux, France, September 2011.

[25] X. DESCOMBES, A. GAMAL ELDIN, F. PLOURABOUE, C. FONTA, R. SERDUC, G. LE DUC, T. WEITKAMP. *Extraction et caractérisation de régions saines et pathologiques à partir de micro-tomographie RX du système vasculaire cérébral*, in "Proc. GRETSI Symposium on Signal and Image Processing", Bordeaux, France, September 2011.

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