INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET EN AUTOMATIQUE

Project-Team Ariana

Inverse Problems in Earth Observation and Cartography

Sophia Antipolis - Méditerranée

Theme : Vision, Perception and Multimedia Understanding

Activity Report

2010

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1. Team

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Ian H. Jermyn [Senior Researcher CR1, INRIA, he left to Durham University, United Kingdom, in September 2010]
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Elena Zhizhina [Prof. Zhizhina (IITP Moscow, Russia) was funded by Associated Team ODESSA and Poncelet Laboratory for 1 month in November]
Zoltan Kato [Prof. Kato (University of Szeged) was funded by French Space Agency (CNES) one week in July and one week in November]
Serguei Komech [Dr. Komech (IITP Moscow, Russia) was funded by INRIA (DRI) for 3 weeks and by Associated Team ODESSA for 1 week in November]
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Boris Zaleski [Prof. Zaleski (United Institute of Informatics, Minsk, Belarus) was funded by Associated Team ODESSA 2 weeks in November]

Administrative Assistants

Laurie Vermeersch [INRIA, 50% in the project, She finished in July 2010]
Christine Foggia [INRIA, 60% in the project, from August 2010]
Micheline Hagneré [CNRS, 10% in the project]

Others

Grégoire Kerr [Mr Kerr was a Masters intern from April 2010 to September 2010 and an expert engineer in November 2010, funded by the EADS Foundation]

Adrien Morvan [Mr Morvan was a Masters intern from April 2010 to September 2010]

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2. Overall Objectives

2.1. Introduction

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

- Extention of 2 patents in collaboration with Galderma.
- Two prizes for Ariana students.
- Ian Jermyn (CR1) left INRIA at the end of August 2010 to take up a position as Reader in Statistics at the University of Durham in the UK.

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 undeterminated 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.

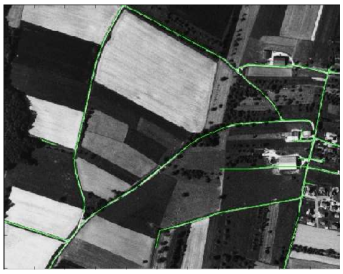
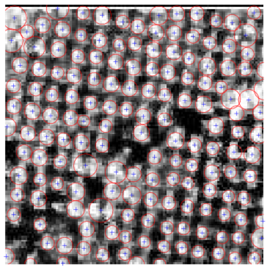

Figure 3. Left: road network extraction; right: tree extraction.

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.

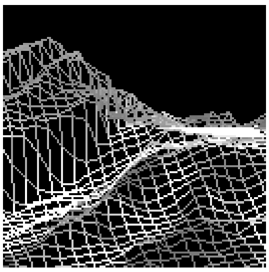
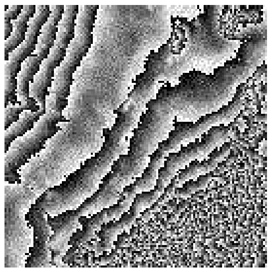

Figure 4. Left: DEM; right: interferometry.

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.

5. Software

5.1. Software

5.1.1. Transfers

- The software SARDecoder V1.1 was transfered to French Space Agency (CNES).
- The software PHASEFLOW V1.0 was transferred to French Space Agency (CNES).

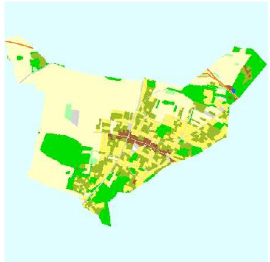

Figure 5. Image registration for the evaluation of retrieval systems. Left: mosaicked aerial image data; right: registered ground truth classification.

- The software Blinde V2.0 was transferred to German Space Agency (DLR).
- The software GRENAT V2.0 was transferred to CIRAD in Montpellier.

5.1.2. Deposits

- Two patents (OA09437 and OA09438) were extended jointly with GALDERMA at the end of 2010.
- The software ASOE V1.0 was deposited with the APP in November 2010. It was developped for extracting multiple arbitrary shaped objects using stochastic multiple birth-and-death dynamics and active contours.
- The software ThinBlinDe V1.0 was deposited with the APP in August 2010. It deals with blind deconvolution for confocal laser scanning microscopy for thin specimens.
- The software PHASEFLOW V1.0 was deposited with the APP in March 2010. It deals with the extraction of directed networks from remote sensing images, based on a nonlocal phase/vector field model. The number of the parameters is estimated automatically.
- The software SARDecoder V1.1 was deposited with the APP in January 2010. It was developed for classifying high resolution Single-Pol and Dual-Pol Synthetic Aperture Radar (SAR) images, in collaboration with G. Moser and S. Serpico from the University of Genoa in Italy, and V. Krylov from Moscow State University in Russia.

6. New Results

6.1. Probabilistic models

6.1.1. Markov random field models of multiple overlapping objects

Participant: Ian Jermyn [contact].

This work was performed in collaboration with Professor Zoltan Kato of the University of Szeged, Hungary [http://www.u-szeged.hu/english/].

The phase field higher-order active contour framework for shape modelling developed in the EPI Ariana lends itself to a probabilistic interpretation, the phase field energies being taken as the Gibbs energies of a Markov Random Field (MRF). This opens the way to parameter and model estimation, stochastic algorithms, and much else [30]. However, one significant limitation of the original framework remains: the inability to represent overlapping objects. The representation used in the phase field framework and its MRF equivalent, is of a *region*, not a set of objects. In this work we overcome this limitation in the case of near-circular objects, but it is clear that the mechanism used extends to any model in the phase field/MRF shape modelling framework.

We take the binary MRF model from [30] and extend it by adding 'layers', *i.e.* the MRF becomes a map from the image domain to $\{\pm 1\}^n$, where $n > 1$. The number n is the size of a maximal cluster of mutually overlapping objects. Thus each layer has an associated binary field that specifies a region corresponding to objects, while overlapping objects are represented by regions in different layers. The model assigns high probability to object configurations in the image domain consisting of an unknown number of possibly touching or overlapping near-circular objects of approximately a given size. This is achieved by keeping from [30] the long-range interactions favouring connected components of approximately circular shape within each layer, while regions in different layers that overlap are penalized by overlap area. If two nearby objects exist on different layers, the mutual repulsion produced by the long-range interactions is eliminated and replaced by the short range overlap penalty.

Used as a prior coupled with a suitable data likelihood, the model can be used for object extraction from images, *e.g.* cells in biological images or densely-packed tree crowns in remote sensing images. The first row of figure 6 show ground states for various numbers of layers ℓ and overlap penalty κ. As the number of layers increases, more and more objects can be packed into the image domain, because the mutual repulsion between neighbouring objects can be eliminated if they live on different layers. As the overlap penalty increases, the objects overlap less in the ground state. The next row shows segmentation results obtained on several synthetic images of circular 'objects' with different degrees of overlap. Note how even extremely overlapping objects can be segmented as distinct. The bottom row shows results obtained on cell imagery by the University of Szeged.

6.1.2. Shape descriptors based on shape entropy

Participant: Xavier Descombes [contact].

This study was supported by INRIA Associated Team ODESSA [http://www-sop.inria.fr/ariana/Projets/Odessa/index.html]. It was conducted in collaboration with Serguei Komech, IITP in Moscow [http://www.iitp.ru].

In this work, we address shape classification. A shape $S \in \mathcal{S}$ is a convex bounded set in $\mathbb{R}^2$. We consider a basic descriptor $\tau_0(S)$ defined as the ratio of the volume of the ϵ-neighbourhood of the shape to the shape volume. The initial shape is then transformed by a map, parameterized by an angle θ, which extends the shape along the direction θ by a factor λ and contracts the shape along the orthogonal direction by a factor $\frac{1}{\lambda}$. We thus obtain a function for our descriptor $\tau(S, \theta)$. We have defined a metric on this descriptor space. We have shown that this metric is continuous with respect to the Haussdorf metric in the initial shape space. We have tested this metric for shape retrieval on the MPEG-7 database (see figure 7 and table 1) and on the Kima database. The results are convincing for discriminating complex shapes.

Table 1. Retrieval scores on the MPEG-7 database

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Bonefull	95	70	85	85	90	85	85	85	70	75
Heart	100	100	100	100	100	100	95	95	95	100
Glas	100	100	100	100	100	100	100	90	100	95
Fountain	100	100	100	100	100	100	100	100	100	100
Key	100	100	95	100	95	95	90	90	95	95
Fork	95	90	65	70	65	75	65	75	70	60
Hammer	95	95	80	30	30	35	30	40	35	15

6.1.3. 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 has been made in collaboration with Pierre Couteron and Christophe Proisy from IRD Montpellier [http://www.mpl.ird.fr/], and was partially supported by AAP INRA/INRIA [http://www.inra.fr/].

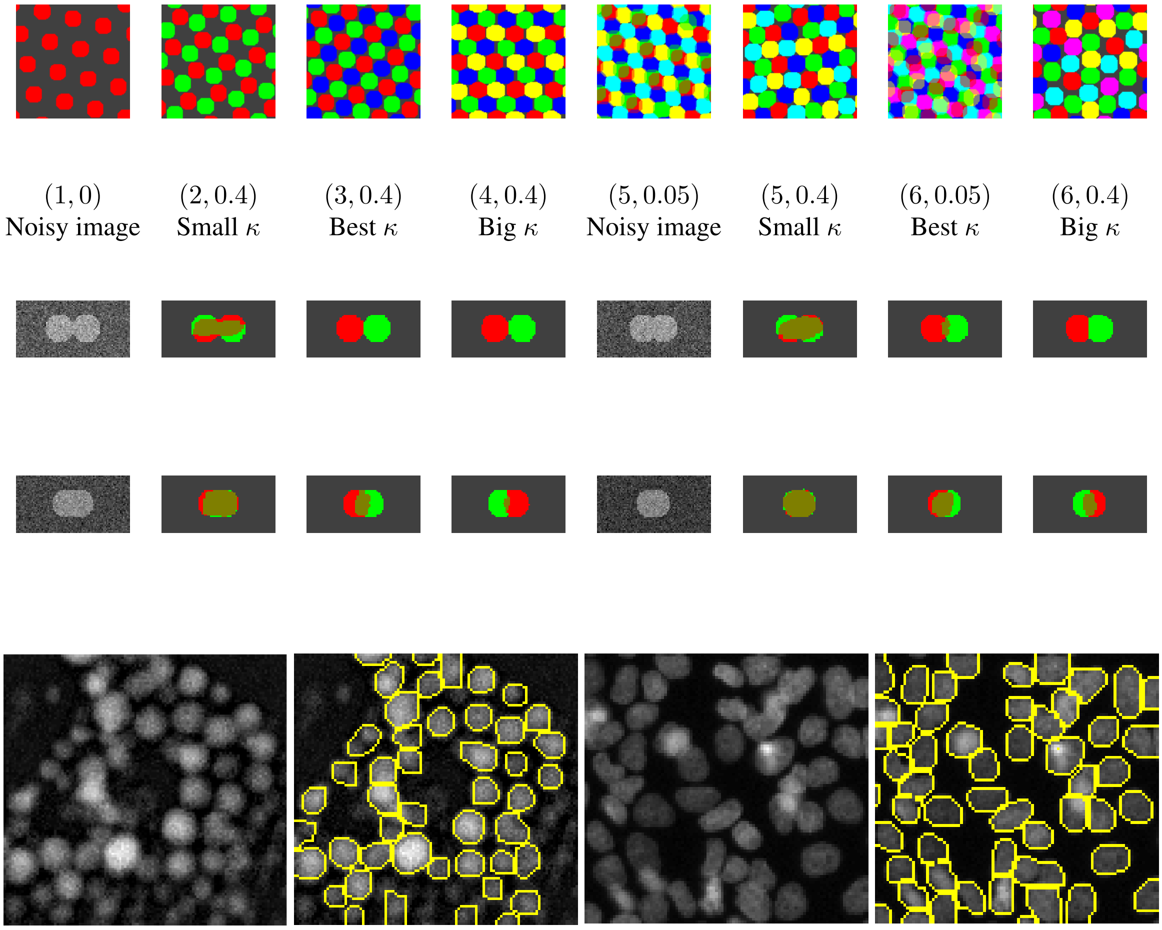

Figure 6. Top row: examples of ground state configurations for various numbers of layers ℓ and overlap penalty κ, in form (ℓ,κ). Middle row: examples of results obtained on synthetic noisy images. Bottom row: results obtained on cell imagery by the University of Szeged.

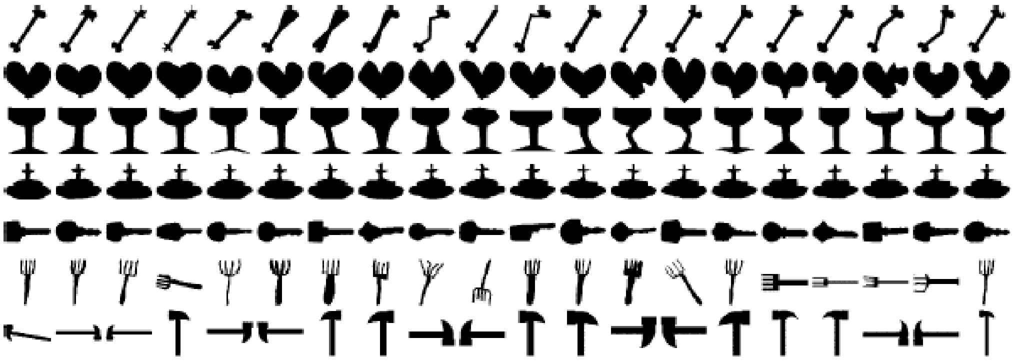

Figure 7. The MPEG-7 CE Shape-1 Part-B data set

The use of remote sensing information for studying large areas of heterogeneous forest arises new interest because of the increasing availability of data at very high spatial resolution (VHR), including optical data and LiDAR altimeter data of the canopy. On the other hand, the theoretical reflection on allometries and functions of scales involving the biomass, which attracts significant interest in integrative biology, has not previously benefited from the contribution of remote sensing and has faced only a very limited field data measurements in terms of trees (especially concerning the height and the sizes of crowns) and spatial structures of populations. This work lies at the interface between ecological modeling and pattern recognition in remote sensing images at very high spatial resolution (metric). The objective is to use and adapt the pattern recognition and identification of objects, including algorithms from stochastic geometry, to acquire a sufficiently broad and precise view of endogenous structuring of tropical forests through the visible structures in canopy (crown types, gaps, etcâ¦) on spatial imagery. This knowledge will be an essential contribution to the development of analytical models on both algometric properties of individual trees as the emergence of complex structures through interactions between trees. This is an interdisciplinary work combining image analysis and modelling form of plants. The main approach concerning image analysis is based on marked point processes, previously developed by EPI Ariana, and the alternative approaches are considered by global characterization of texture developed by UMR AMAP [http://amap.cirad.fr/en/presentation.php]. An example of detection of trees with their canopy size through an optical image of mangrove forest is shown in figure 8.

6.1.4. Detection and counting tree crowns in tropical forests from panchromatic and/or multispectral images and LIDAR data

Participants: Ihsen Hedhli, Xavier Descombes, Josiane Zerubia [contact].

This work has been made in collaboration with Pierre Couteron and Christophe Proisy from IRD Montpellier [http://www.mpl.ird.fr/], and was partially supported by AAP INRA/INRIA [http://www.inra.fr/].

In a previous work [39], a first model for detecting tree crowns in popular plantations has been developed . This model is based on marked point processes. It consists in estimating a configuration of discs, optimal with respect to an energy function defined by a prior, penalizing overlapping between objects, and a data term, based on a radiometric distance between pixels inside an object and in its neighborhood. The optimal solution is obtained by a simulated annealing algorithm based on a multiple birth and death dynamics. Then, we have shown that this approach can be generalized to the case of tropical forests, by using either IKONOS images, GEOEYE images or LIDAR data. The main goal of this work is to revisit the data term in order to take into account information issued from different sensors and more generally to take into account multiple information layers simultaneously. Data fusion tools will be investigated and incorporated into the marked

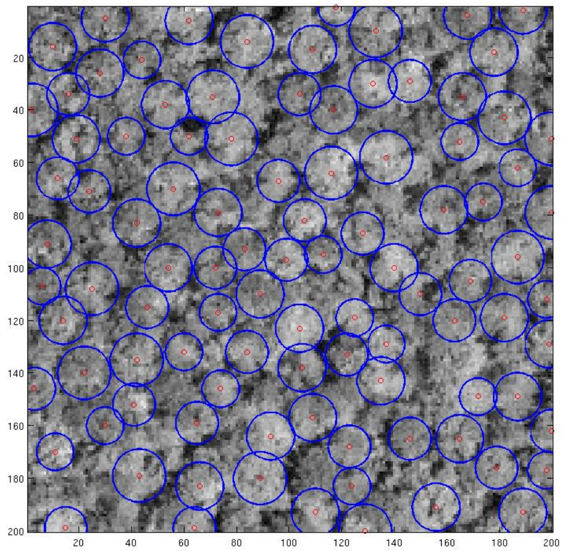

Figure 8. Detection of trees with their canopy size superposed to an optical high resolution satellite image.

point process modeling. Moreover, we will study different strategies to validate the results by using relevant statistics.

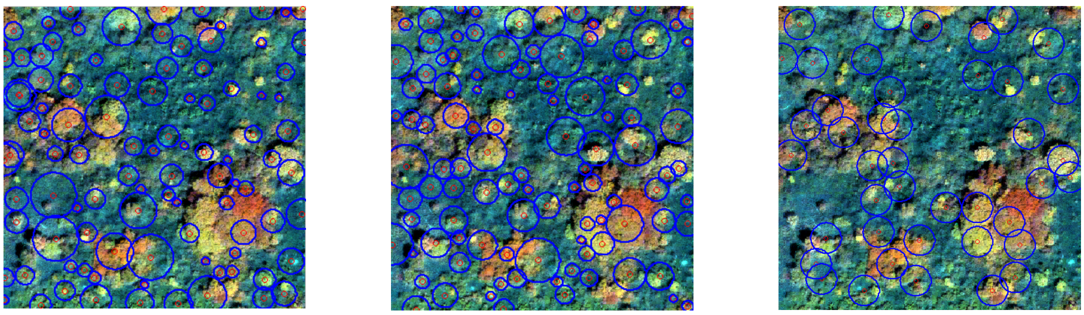

Figure 9. Result obtained on a ©GEOEYE image using different fusion operators on the three bands (a) minimum of energy, (b) maximum of energy, (c) 3D radiometric distance.

6.1.5. Stochastic modelling of 3D objects applied to penguin detection and counting

Participants: Ahmed Gamal-Eldin, Xavier Descombes, Josiane Zerubia [contact].

This work is being performed in collaboration with Dr. Michel Gauthier-Clerc from La Tour du Valat [http://www.tourduvalat.org/] and Prof. Yvon Le Maho from Institut Hubert Curien [http://iphc.in2p3.fr/] and French Academy of Sciences [http://www.academie-sciences.fr/].

This work is divided into two parts. The first part focused on 3D object extraction from hand held camera applied to the counting of penguins in a colony. We proposed an object based method founded on the Marked Point Process (MPP) theory because it easily allows modeling scenes made of geometrically specified objects. The MPP is based on the definition of a configuration space composed of object sets, to which is attached a Gibbs energy function. Minimizing this energy function leads to the detection of our objects of interest. We use the recently developed Multiple Birth and Death algorithm for the energy minimization due to its speed advantage. The main contribution of this work is a novel treatment of occlusions. We introduce a new parent-child dependency which extends the existing MPP using a mixed graph, this extra dependency is due to occlusions. Most of previous works *e.g.* on pedestrians, object (human) geometry is approximated either using a rectangle or an ellipse. We propose to use a fine quality 3D geometrical model for objects (penguins), and the usage of OpenGL for projection, taking advantage of the graphics card GPU. We validated our model on semi-synthetic images.
The second part of this work consists in the introduction of a new optimization method for MPP, that we call Multiple Birth and Cut (MBC) [17]. This method is based on the multiple birth and death algorithm and the popular graph cut algorithm. The birth part consists of proposing configuration of non-overlapping *e.g.* ellipses, for which a data term and prior term is calculated. From the proposed configuration, in the death step of the algorithm, we keep good object and remove non fitting ones, based on the cut of a special graph. We validated our model on the flamingo counting inside colonies, showing that our method overcomes the detection obtained by the MBD algorithm 10. Moreover, we avoid the non trivial task of tuning the simulated annealing parameters.

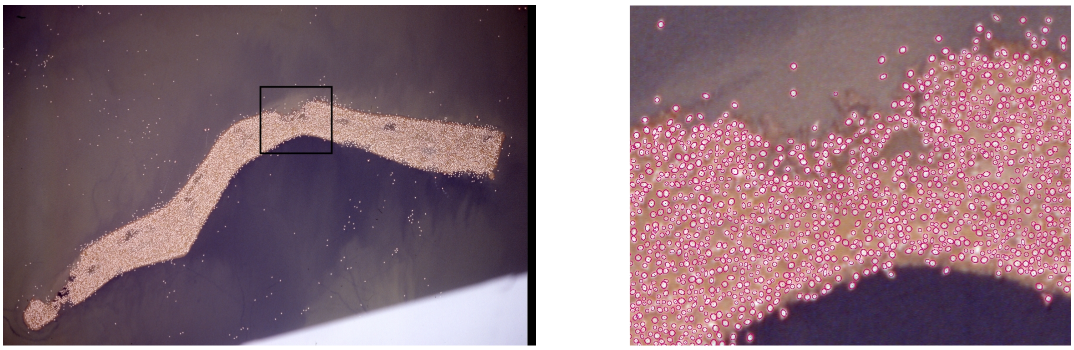

Figure 10. (a) A full flamingo colony, with a highlited rectangle, (b) The detection result on the highlited rectangle.

6.1.6. Global reconstruction of urban scenes by marked point processes

Participants: Athanasios Georgantas, Florent Lafarge, Josiane Zerubia [contact].

This work is being performed in collaboration with Mathieu Brédif and Marc Pierrot-Deseilligny from Matis laboratory, IGN [http://www.ign.fr].

The automatic detection and reconstruction of the urban vegetation is of major interest in urban planning. Climate, noise probation and other environmental models used in modern urban planning demand, as input data, information about the tree areas of cities. This work proposes a new fully automatic approach for simultaneous detection and extraction of building footprints and tree crowns in a dense urban environment. Elevation data provided from a photogrammetricaly derived Digital Elevation Model (DEM) and radiometric information from color infrared orthophotos are used as input. The buildings are extracted as rectangles and the tree crowns as circles with a Multi-Marked Point Process (MMPP) sampled by a Reversible Jump Monte Carlo Markov Chain sampler (RJMCMC) coupled with a simulated annealing process in order to optimize an energy function. The method allows the simultaneous and automatic modeling of complex environments without any prior knowledge about the number or the position of the different elements that constitute the urban environment. This approach allows the representation of various forms of building and trees in a simplified yet efficient way. Some primilinary results of the algorithm are presented on both a DEM and an NDVI image in Figure 11.

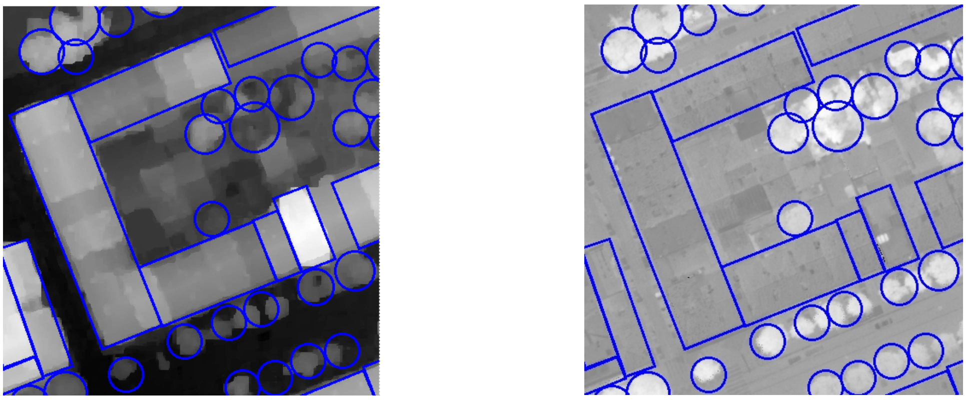

Figure 11. Building footprints and tree crowns in a DEM image (left), and a Normalized Difference Vegetation Index (NDVI) image (right)

6.1.7. 3D building reconstruction by solving the direct problem

Participant: Xavier Descombes [contact].

This study was supported by INRIA Associated Team ODESSA [http://www-sop.inria.fr/ariana/Projets/Odessa/index.html] and an ECONET project. It was conducted in collaboration with P. Lukashevich, A. Krauchonak, and B. Zalesky from the UIIP in Minsk [http://www.uiip.bas-net.by/index-eng.html], E. Zhizhina from the IITP in Moscow [http://www.iitp.ru], and J.D. Durou from IRIT in Toulouse [http://www.irit.fr/?lang=en].

In this project, we aim at reconstructing buildings in 3D from one or several aerial or high resolution satellite images. The main idea is to avoid solving the so-called inverse problem. We will simulate configurations of buildings and test them with respect to the data. The generation of configurations will be performed using multiple birth-and-death dynamics [32]. A Gibbs point process is defined including prior information about building configurations. To define the data term, the building configuration is projected into the data plane(s), using models of shading and shadows. This projection is performed using OpenGL for a fast 2D rendering of the scene. The data term is based on the consistency of shadows in the image and on the configuration projection in the image plane, whereas the prior penalizes building overlaps. The preliminary results are encouraging. The next steps consist of refining the data model by embedding information about gradients, and improving the convergence speed by defining proper birth maps for generating new buildings.

6.1.8. Semantized Digital Elevation Models from LIDAR data

Participants: Marouene Amri, Florent Lafarge [contact], Josiane Zerubia.

This work is conducted in collaboration with Matis laboratory, IGN [http://www.ign.fr].

This work consists in generating high resolution Digital Elevation Models (DEM) from Lidar point clouds by taking into account urban knowledge on the observed scenes. The generation of such semantized DEMs is lead by a point cloud classification which separates buildings facets, building edges, vegetation, ground and urban details such as cars, chimneys. This labeling problem is solved by using a Markov Random Field formulation. The optimal labeling is found by Graph-Cuts. Then, the obtained point cloud classification is used to create a dense and semantized Digital Elevation Model by locally adapting the regularization procedure with respect to the expected urban objects.

6.1.9. 3D reconstruction of urban areas from LIDAR data

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

This work is done in collaboration with Matis laboratory, IGN [http://www.ign.fr].

The generation of 3D representations of urban environments [36] 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 [37]. We study new stochastic models for analysing urban areas from LIDAR data (see Figure 12). 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.

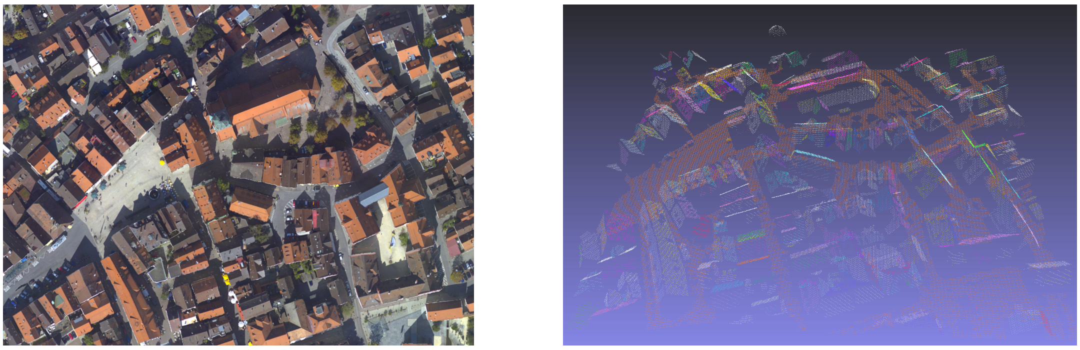

Figure 12. Aerial image of an urban area ©Toposys (left) and the segmented full wave LIDAR scan (right).

6.1.10. Unsupervised marked point process approach for shape extraction from satellite and aerial images

Participants: Saima Ben Hadj, Xavier Descombes, Josiane Zerubia [contact].

This work was partially funded by French Space Agency (CNES)[http://www.cnes.fr/].

The problem of feature extraction from high resolution remote sensing images has been addressed in several fields using different approaches. One of the most successful approaches is marked point process modeling. In fact, in a marked point process framework, the objects of the image are represented by a set of interacting geometric shapes. This object set is governed by two types of energy: a data energy term which links the objects to the features to be extracted and a regularizing energy term which controls the repartition of objects in the scene. This model incorporates some parameters which allow us to model strong connections between objects according to the processed image. In order to achieve unsupervised object extraction, we need to develop an estimation method of those parameters.

Previously, an estimation method based on the Stochastic Expectation-Maximization algorithm was studied and proved its relevance for estimating these parameters. It was only validated on a simple model of a marked point process of circles.

We have first extended this estimation procedure to more general geometrical shapes such as ellipses and rectangles [12]. Different types of objects have been successfully extracted namely flamingos, tree crowns and building footprints.

Then, we have dealt with the problem of boat counting using an ellipse model and the detection of refugee tents using a rectangle model. We have proposed new prior and data terms for boat detection. In fact, boats in a seaport are very close and aligned, which makes their discrimination difficult using the model proposed in [31]. Moreover, we have modified the data energy component for tent detection since the considered model is based on the object geometry and does not take into account other type of information such as the object color [28], [12]. Figure 13 shows the result obtained for boat detection.

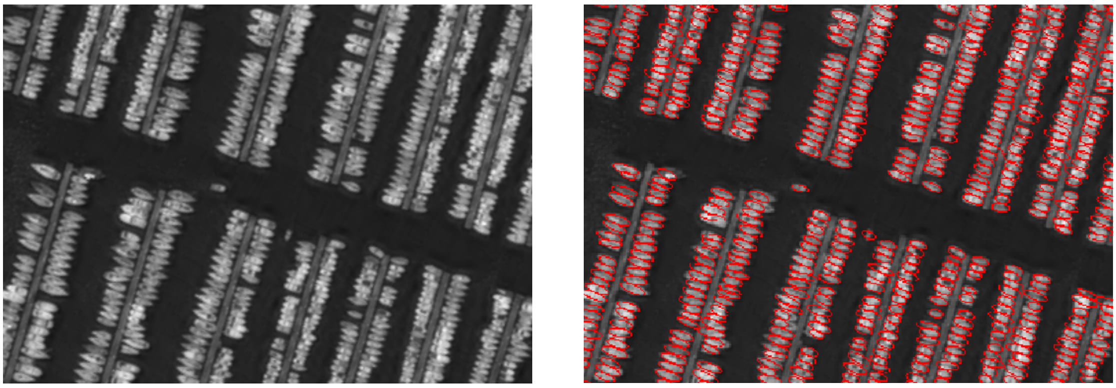

Figure 13. Boat detection using a marked point process of ellipses, (left) Boat image ©CNES, (right) Boat extraction result, 523 detected boats.

6.1.11. Advanced image-processing for very high resolution SAR and optical images

Participants: Aurélie Voisin, Josiane Zerubia [contact].

This work is done in collaboration with DIBE, University of Genoa with Gabriele Moser and Sebastiano Serpico [http://spt.dibe.unige.it/] with partial support of the French Defense Agency, DGA [http://www.defense.gouv.fr/dga/] and the Italian Space Agency, ASI [http://www.asi.it/en].

Synthetic Aperture Radar (SAR) techniques improved, and it is now possible to acquire very high resolution (VHR) images. This high resolution (around 1 m) combined with a short revisit time (up to 12 hours) are precious information so as to monitor urban areas and infrastructures, especially critical with respect to natural disasters. The main problems of SAR imagery are the speckle noise and the shadows, that is why good optical images classification methods are not adapted to SAR ones, above all in urban areas. The developed method combines the Markov Random Field (MRF) approach to Bayesian supervised classification and the Dictionary-based Stochastic Expectation Maximization (DSEM) approach to SAR amplitude Probability Density Function (PDF) estimation.

The first step of the method consists in modeling the SAR amplitude statistics as a finite mixture of parametric components automatically drawn from a dictionary of SAR specific PDFs. When applied to each class-conditional PDF in a VHR image, DSEM represents a natural model for the related heterogeneity, leading to a mixture estimate where distinct components may be interpreted as the contributions of different ground materials (e.g., roofs, concrete, water, grass). The second step deals with the classification itself. In order to incorporate contextual information and gain robustness against speckle, a hidden MRF approach is considered. Spatial regularization parameters in Potts energy function are estimated by an accelerated simulated annealing algorithm. In order to generate the output classification map, the energy function is minimized by a modified Metropolis dynamics algorithm.

Texture features such as GLCM (Grey Level Co-occurrence Matrix) textures, extracted from the original SAR image, turn out to discriminate quite well the urban areas (see figure 14). To combine both SAR amplitude and textural feature data, a copula-theoretic approach is used to estimate their joint statistics. Specifically, the flexibility of DSEM, granted by its essentially nonparametric formulation, makes it feasible to estimate the marginal PDFs of both the amplitude and the texture feature. Copula functions allow a joint bivariate PDF to be modeled, given the related marginal PDFs. The resulting joint PDF estimates are plugged into the MRF model considered above.

The method was tested on real COSMO-SkyMed images [24]. We illustrate the obtained results with an example of a SAR acquisition in the region of Cavallermaggiore (Italy). 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 14. The computation of numerical results gives an average accuracy of 98.9 percent for the considered test areas.

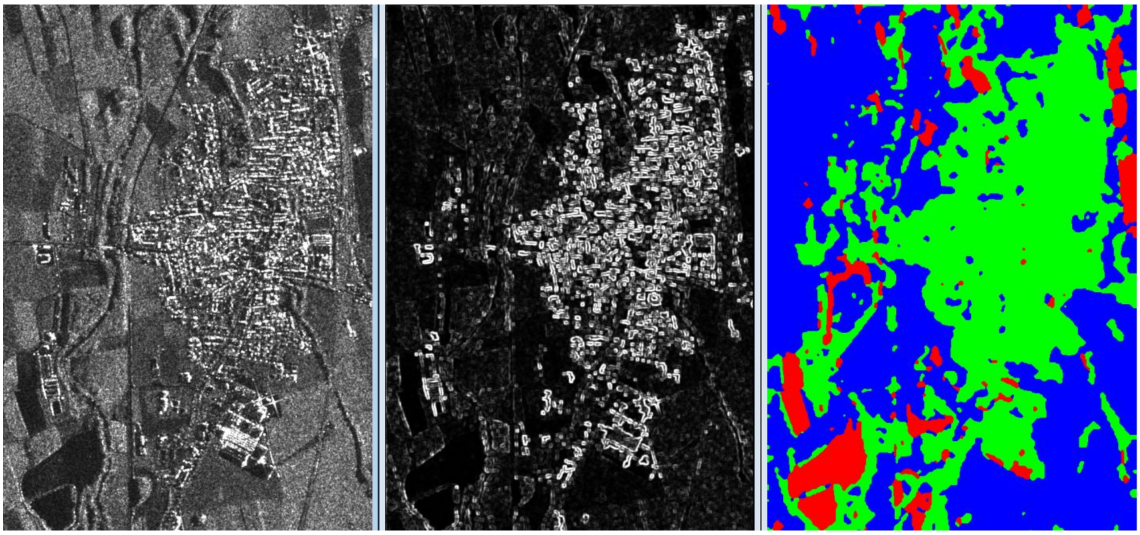

Figure 14. Left: Initial SAR image, Cavallermaggiore (Italy) (COSMO-SkyMed, ©ASI), Middle: Texture feature extracted from the image, Right: Classification result for the 3 classes (Red: water; Green: urban ;Blue: land).

6.1.12. Multichannel SAR Image Classification by Finite Mixtures, Copulas and Markov Random Fields

Participants: Vladimir Krylov, Josiane Zerubia [contact].

This work is conducted in collaboration with DIBE, University of Genoa with Gabriele Moser and Sebastiano Serpico [http://spt.dibe.unige.it/] with the support of the French Space Agency, CNES [http://www.cnes.fr], the Italian Space Agency, ASI [http://www.asi.it/en], the Poncelet laboratory in Moscow [http://www.mccme.ru/lifr/] and INRIA-DRI.

The last decades have witnessed an intensive development and a significant increase of interest to remote sensing, and, in particular, to Synthetic Aperture Radar (SAR) image processing. The research here focused on the supervised SAR image classification, which is one of the fundamental SAR image processing problems. Recently, various models have been proposed for modeling the single channel statistics of SAR data, however, none of them general and flexible enough to model the joint probability density function (PDF) in case of D-channel SAR, $D \geqslant 3$. We propose a joint PDF model for multichannel SAR, based on finite mixture modeling for marginal PDFs estimation and copulas for multivariate distribution modeling [18]. We apply this model to medium and high resolution multichannel SAR amplitude image classification by combining it with a contextual Markov Random Field approach (MRF) that allows to take into account the contextual information and to gain robustness against the inherent noise-like phenomenon of SAR known as speckle. The finite mixture modeling is done via a recently proposed SAR-specific Dictionary-based Stochastic Expectation Maximization (DSEM) approach, that is applied to class-conditional amplitude probability density function estimation separately to all the SAR channels. For modeling the class-conditional joint distributions of multichannel data the statistical concept of copulas is employed, and a dictionary-based copula selection method is proposed. The contribution of this study is the generalization of the recently considered DSEM - MRF classification approach to D-channel SAR, $D \geqslant 3$, via copulas.

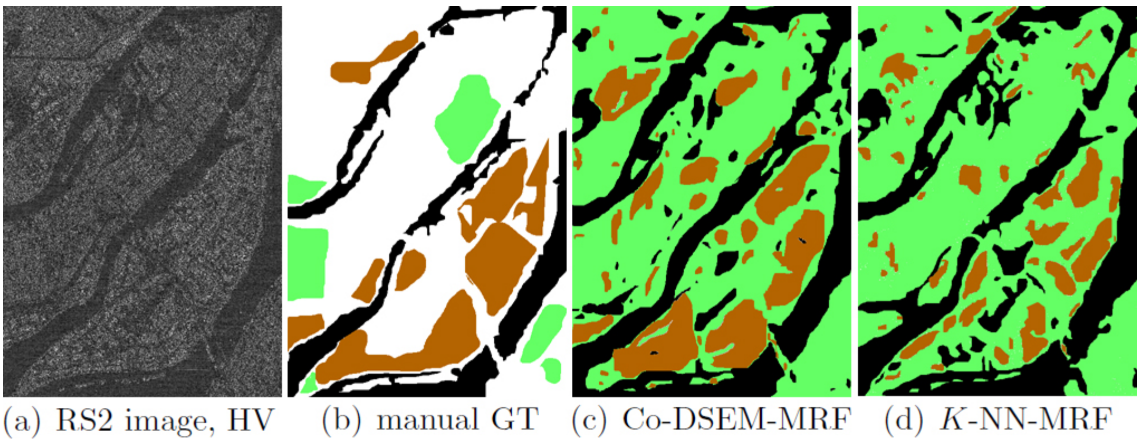

Figure 15. (a) Quad-pol RADARSAT-2 (©MacDonald, Dettwiler and Associates Ltd., 2008 - All Rights Reserved.) image (500×700 pixels) in HV pol, (b) manually created ground truth (GT) and classification maps obtained by: (c) Copula-DSEM-MRF and (d) K-NN-MRF on HH/HV/VV. Here pixels outside GT (white), water/wet (black), vegetation (green), urban (red). Classification accuracy by Copula-DSEM-MRF (K-NN-MRF): water/wet 98.04% (98.85%), vegetation 90.33% (89.02%), urban 71.49% (62.89%).

The developed Copula-DSEM-MRF approach has been experimentally validated on several multichannel Quad-pol RADARSAT-2 images and compared with a benchmark "K-nearest neighbors" (K-NN) classification technique, combined with MRFs (K-NN-MRF), see, e.g., Fig. 15. These experiments demonstrate the developed model to be flexible and perform well on multichannel SAR and to significantly outperform the benchmark approach on urban class.

6.2. Variational models

6.2.1. Modelling complex shapes using higher-order active contours

Participants: Grégoire Kerr, Ian Jermyn, Josiane Zerubia [contact].

This work is done in collaboration with Prof. Anuj Srivastava, Dept. of statistics, Florida State University [http://www.fsu.edu/] and is funded by the EADS Foundation [http://www.fondation.eads.net/en/].

Shape modelling is a subject of great importance in image processing and computer vision: there are many segmentation problems for which prior knowledge of object shape is essential to solving the problem. Higher-order active contours (HOACs) [41] incorporate sophisticated shape information via long-range interactions between points of the region boundary. This allows a single model to describe a range of objects, eliminates pose estimation, and permits the detection of multiple object instances, while constraining object shape.

So far, the HOAC framework has been used to model simple shapes, e.g. networks for road segmentation [41] and circles for tree crown segmentation [35]. This work consists in developing a way to model more complex shapes within this framework, without losing its advantages. To model a particular shape, a stability analysis of the shape is performed. Perturbations of the shape are expressed in terms of Fourier components on its boundary, and the energy defining the HOAC model is expanded to second order in these perturbations. If parameter values exist such that every perturbation increases the second-order energy, then the shape is a local minimum and hence stable.

While modelling simple shapes, we have observed in numerical experiments the formation of other, more complex stable shapes. The first step is to verify that stable non-zero amplitudes exist via higher-order stability analysis of simple shapes. If they do exist, then HOACs can be used to model complex shapes by adjusting the long-range interactions to give preferred amplitudes to each Fourier component (see figure 16). The next step is to control these amplitudes by inverting the energy expansion to give the interaction function in terms of the amplitudes. These theoretical analysis will be compared to numerical experiments to test their consistency.

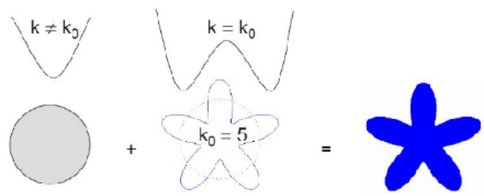

Figure 16. Example of circle perturbations that lead to a more complex shape.

6.2.2. Theoretical analysis of a phase field HOAC model of directed networks

Participants: Aymen El Ghoul, Ian Jermyn, Josiane Zerubia [contact].

This work is funded by a PACA regional grant and by INRIA via a contract with the French Space Agency [http://www.cnes.fr], in collaboration with Thales Alenia Space [http://www.thalesgroup.com].

This work concerns a new family of phase field models designed to model the shape of 'directed networks' in images (*e.g.* vascular networks in medical imagery and hydrographic networks in remote sensing imagery), and to be used for the segmentation of such networks [33]. The model extends existing phase field models of undirected networks (*e.g.* road networks) [34], [40], via the inclusion of a vector field representing the 'flow' running through the network, in addition to the usual scalar phase field describing the network via its smoothed characteristic function. The presence of the vector field allows the model to incorporate characteristic geometric properties of directed networks.

The directed network model has a large number of free, unphysical parameters, which makes parameter learning very difficult. In particular, the model can favour geometric configurations other than networks for significant parameter ranges. In this work, we analysed the stability of a directed (because the vector field is present) long, straight bar to perturbations of its boundary. The analysis yields constraints necessary for stability of the bar: the constraints eliminate some parameters, replace others by physical parameters such as bar width, and place bounds on the remainder. The parameters can thus be tuned to values that favour linear structures for network modelling. Figure 17 shows the results of the stability analysis leading to the parameter constraints, as well as segmentations of hydrographic networks from very high resolution images [15], showing that the directed network model outperforms the undirected network model.

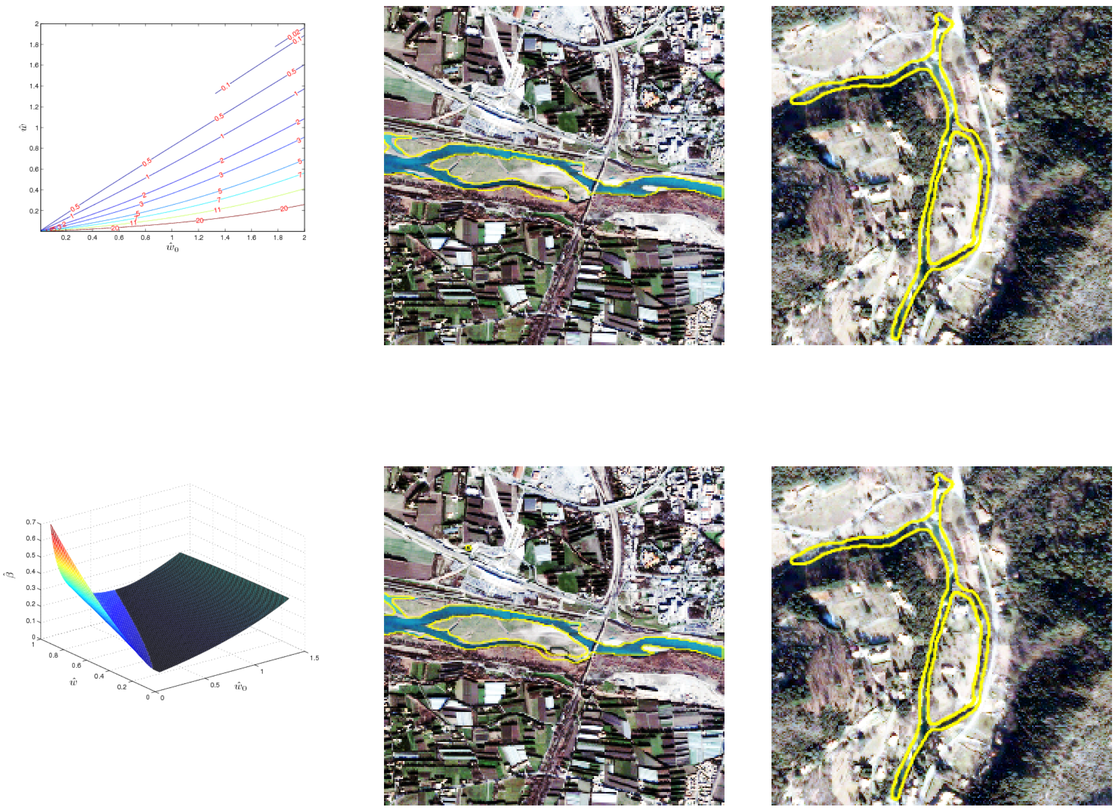

Figure 17. First column: parameter constraints producing stable networks. Second and third columns: segmentation results using the undirected network model [40] (top) and the directed network model (bottom) of hydrographic networks from VHR ©Quickbird images.

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

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

This work is funded by the French Space Agency, CNES [http://www.cnes.fr] and Thales Alenia Space [http://www.thalesgroup.com] in collaboration with Marc Antonini from I3S/UNS [http://www.i3s.unice.fr/I3S/presentation.en.html].

Current acquisition chain consists in sampling the image (giving N coefficients) and in compressing it to retain only K coefficients (with K << N). We have first focussed our work on the acquisition system and are currently investigating an acquisition chain which would directly give the K coefficients with the same idea as the Compressed Sensing (CS) method. Current acquisition system uses the sparsity of the Discrete Wavelet Transform (DWT), to compress the image. Compressed Sensing considers on the contrary transforms which give flat spectrum and use the property of sparsity to recover the image exactly with less coefficients than

Shannon. Following the idea of saving only these M coefficients, we are also investigating a wavelet transform which would give only the M higher coefficients (DWT method).

We are considering such transforms and use noiselets transform in the case of the CS method and a 3 level 9/7 wavelet transform for the DWT method. Results are shown in figure 18. The Peak Signal To Noise Ratio is used to compute the distortion between the retrieved and the original image while the rate specifies the number of bits needed to code the image. To get an upper bound of the efficiency of the methods, we consider the image to be sparse in the singular value decomposition which represents an ideal case as it supposes the knowledge of the decomposition matrices. The results are compared with the current method recommended by the Consultative Committee for Space Data Systems (CCSDS) which consists in a discrete wavelet transform, where all the coefficients are retained, followed by a coding step and an inverse transform. From a general point of view, it appears first that coefficients of Compressed Sensing method are not well suited to coding (too large distribution). However we get convincing results with this method, as shown in figure 18, if we are able to get a sparse representation of the image in some basis. Globally, we can see that both methods outperform the CCSDS method by taking less measurements than needed, the DWT method giving better results for many measurements. However, we get an interesting result if we can select only few coefficients. Indeed, with the CS method, only 10% of measurements of the image encoded at 3 bits/pixel allow to reconstruct an image with a PSNR of 60 dB. The same value of PSNR is reached by the CCSDS method only at 6 bits/pixel. These methods may thus be efficient for the limited resources of on-board satellite hardware.

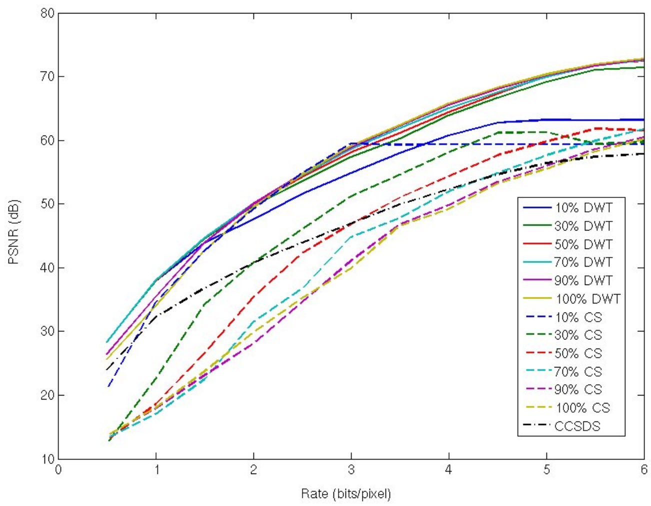

Figure 18. Evolution of the distorsion/rate curve for both methods and several number of measurements.

6.3. Applications to biology and medicine

6.3.1. Blind restoration of 3D biological image

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

This work is funded by the ANR Define Diamond in collaboration with Alain Dieterlen from UHA, Mulhouse [http://www.uha.fr/], Jean-Christophe Olivo-Marin and Praveen Pankajakshan from Pasteur Institute, Paris [http://www.pasteur.fr/ip/easysite/go/03b-00002j-000/en], Gilbert Engler from INRA, Sophia Antipolis, and Prof. Zvikam, Weizmann Institute, Rehovot, Israel.

During the last decade, biological imagery systems got a considerable advance providing biological specimen images at tissue and cellular level. One of the most common systems is the confocal laser scanning microscopy which allows a 3D visualization of living specimen at resolutions of about one hundred of nanometers. Although it offers higher resolution and better contrast compared to the wide field microscopy, it suffers from some artifacts. In fact, even under the most suitable imaging conditions, specimen images are affected by blur mainly due to the inherent diffraction limited of the optical system, spherical aberration, and the incoming out of focus light. Hence, such a problem can be viewed as a convolution of the real object and the Point Spread Function (PSF) of the optical acquisition system. In order to restore the original image, a previous study of blind deconvolution methods was carried out in a Bayesian framework [38]. A parametric model of the PSF was established under some approximations. The estimation of both the PSF parameters and the object is achieved by an Alternate Minimization (AM) scheme.

In this work, we develop a new restoration method of the original fluorescence image using another imaging technique. We use images obtained by an optical diffractive tomographic microscopy to regularize the estimated object. It offers indeed complementary details from the observed specimen. In fact, diffractive tomographic microscopy is a 3D imaging technique that allows to measure the refraction index distribution within the specimen. We thus look for models of image formation since biological specimens have heterogeneous refraction index distribution. Some aberrations are induced, observed images are therefore deformed.

6.3.2. Biological 3D image restoration

Participants: Adrien Morvan, Laure Blanc-Féraud [contact], Josiane Zerubia.

This work is performed in collaboration with Sebastien Schaub, head of the microscopy platform at IBDC [http://www.unice.fr/ibdc/].

The purpose of this work is to develop numerical restoration methods for 3D images from confocal microscopy. Even though confocal microscopy removes a lot of blur present in widefield microscopy images, the confocal images still show blurring in the depth direction in addition to Poisson noise due to the small number of photons. Restoration methods adapted to the Poisson statistics of these images have been developed in the past in the EPI Ariana. These methods are based on the Richardson-Lucy algorithm to which we add a priori information such as total variation.

In this work, we generalize Richardson-Lucy with total variation to take into account an additional observed image. It corresponds to specific acquisitions where we have two images, with two different noise realization of the same specimen. This leads to the minimization of a functional formed by two data fidelity terms and one regularization term.

$$\arg\min_{o} J_1(o) + J_2(o) + \lambda_{\mathrm{VT}} J_{\mathrm{VT}}(o)$$

The weights between the two data fidelity terms and the regularization term are difficult to set. Then we propose to minimize the regularization term under constraints on the observations given by the noise. We first developed a Gaussian approximation of the noise and solved the constrained minimization problem by minimizing the augmented Lagrangian in alternate directions after variable separation. The same idea is currently being studied in the case of Poisson noise.

Results of this generalized algorithm are shown Figure 20 using images of Figure 19.

6.3.3. Contribution of multi and hyperspectral imaging to skin pigmentation evaluation.

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

This work was partially funded by a contract with Galderma [http://www.galderma.com].

Figure 19. Synthetic images showing different degradations.

Figure 20. Results of Richardson-Lucy deconvolution using one image (on the left) and two images (on the right).

Spectral imaging of the skin is used to quantified as precisely and as quickly as possible the degree of a disease to evaluate the efficiency of a treatment. In this work, the studied disease is Melasma. It is a localized skin hyperpigmentation appearing on the face. For skin analysis, several methods had been proposed in the literature. Most of them, like the Stamatas algorithm, are based on models of chromophores absorbency depending on the wavelength.
Our approach is to use signal processing methods to quantify the hyperpigmentation of the skin [23], [22]. Then, the general treatment chain can be divided in three parts.
The first one, the shading compensation, is used to compensate the artefacts introduced by the volume of the pictured face. An empirical model and a model based on interferences and waves reflections on Lambertian areas have been studied.
The second step, the data reduction by projection pursuit, allows to reduce the quantity of spectral information by filtering the redundancy and therefore avoiding the Hughes phenomenon.
The third step, the classification, is done with a supervised Support Vector Machine (SVM). This classification scheme was compared to an ICA based method and the Stamatas algorithm in [22].
In order to automate the classification, we introduce a spectral analysis [23] step based on an index or distance. This index browses the spectrum to measure it variations. Then outliers of the spectral variation distribution are selected to train the SVM. Figure 21 shows the quantification map of hyperpigmentation obtained with the proposed methods based on SVM (AS-PP-SVM), an ICA based technique and the Stamatas algorithm. For the SVM based method, we assume that the distance between the SVM separating hyperplane and the pixel value is proportional to the hyperpigmentation degree. AS-PP-SVM provides as accurate disease quantification as the Stamatas algorithm and has the advantage of providing a threshold between the healthy and the hyperpigmented skin.

7. Contracts and Grants with Industry

7.1. Industrial

7.1.1. Galderma

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

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

7.1.2. EADS Foundation

Participants: Grégoire Kerr, Ian Jermyn, Josiane Zerubia [contact].

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

7.1.3. DGA/MRIS Paris

Participants: Aurélie Voisin, Florent Lafarge, 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.

7.1.4. CNES Toulouse

Participants: Saima Ben Hadj, Xavier Descombes, Josiane Zerubia [PI].

Parameter estimation of marked point processes for object extraction from high resolution satellite images. Contract #2150 part 1.

7.1.5. CNES Toulouse

Participants: Aymen El Ghoul, Ian Jermyn, Josiane Zerubia [PI].

Higher-order active contours with application to the extraction of networks (roads and rivers) from high resolution satellite images. Contract # 2150, part 2.

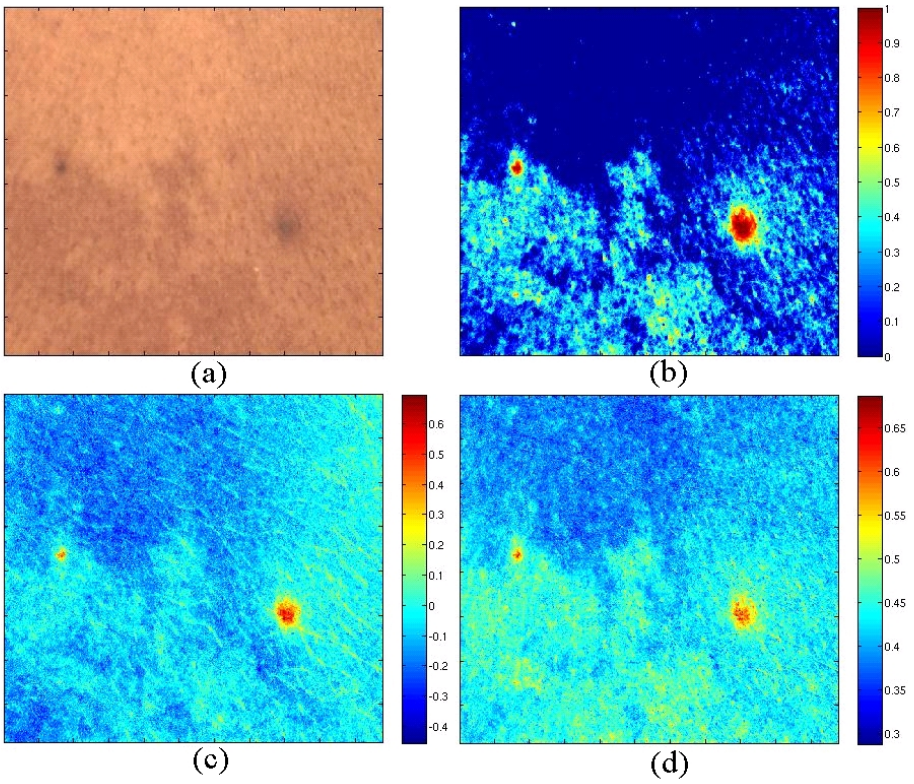

Figure 21. Comparison of methods to measure the skin hyper-pigmentation on multi-spectral data. Data contain 18 bands from 405 to 970 nm. a) Reconstructed color image, Hyper-pigmentation quantification map obtained by AS-PP-SVM method b), ICA based method c) and the Stamats algorithm d)

7.1.6. CNES Toulouse

Participants: Vladimir Krylov, Josiane Zerubia [PI].

Modelling of high resolution SAR image statistics. Contract # 4635

7.1.7. 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.

7.1.8. IGN, Saint Mandé

Participants: Athanasios Georgantas, Florent Lafarge, Josiane Zerubia [contact].

Global reconstruction of urban areas. Grant from IGN.

7.1.9. 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'.

8. Other Grants and Activities

8.1. Regional

8.1.1. PACA Region PhD grant

Participants: Aymen El Ghoul, Ian H. Jermyn, Josiane Zerubia [PI].

In collaboration with Thales Alenia Space (Toulouse).

8.2. National

8.2.1. ANR programme blanc: project 'DETECFINE'

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

In collaboration with the J. A. Dieudonné Laboratory of CNRS/UNS (Gilles Aubert, Luis Almeida, David Chiron, Laurence Guillot), the Pasteur Institute (Jean-Christophe Olivo-Marin), and SAGEM DS Argenteuil (Yann Le Guilloux, Daniel Duclos).

8.2.2. ANR programme blanc: project 'Micro-Réseaux'

Participant: Xavier Descombes [Ariana PI].

In collaboration with IMFT (F. Plouraboue (PI), R. Guibert), CERCO (C. Fonta), and ESRF (P. Cloetens, G. LeDuc, R. Serduc).

8.2.3. ANR programme Defis: DIAMOND

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

In collaboration with the Pasteur Institute (Jean-Christophe Olivo-Marin, Praveen Pankajakshan), the MIPS laboratory of Université de Haute Alsace (Alain Dieterlen, Bruno Colicchio), the LIGM of Université Paris-Est (Caroline Chaux, Jean-Chritophe Pesquet, Hugues Talbot), and INRA Sophia-Antipolis (Gilbert Engler). This project has been labelled by the "pôle Optitec" and "pôle BioValley". Web site: http://www-syscom.univ-mlv.fr/ANRDIAMOND.

8.2.4. 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].

8.2.5. AAP INRA/INRIA

Participants: Jia Zhou, Ihsen Hedhli, Xavier Descombes, Josiane Zerubia [Co-PI].

In collaboration with Pierre Couteron[PI], Christophe Proisy and Nicolas Barbier from UMR AMAP, IRD, INRA [http://www.mpl.ird.fr].

8.3. European

8.3.1. ISA/DIBE

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

In collaboration with G. Moser and S.Serpico[PI], from the University of Genoa (DIBE) and the Italian Space Agency (ISA).

8.4. International

8.4.1. INRIA/IIPT/UIIP Associated team 'ODESSA'

Participants: Josiane Zerubia, Xavier Descombes [PI].

In collaboration with the Dobrushin Laboratory of the Institute for Information and Transmission Problems of the Russian Academy of Science, Moscow (E. Zhizhina (PI), E. Pechersky, R. Minlos, S. Komech), the Image Processing and Pattern Recognition Laboratory of the United Institute of Informatics Problems of the National Academy of Science of Belarus, Minsk (B. Zalesky (PI), P. Lukaskevich, A. Krauchonak), and IRIT, Toulouse (J.D. Durou). Web site: http://www-sop.inria.fr/ariana/Projets/Odessa.

8.4.2. INRIA/FSU

Participants: Gregoire Kerr, Josiane Zerubia, Ian Jermyn [PI].

In collaboration with A.Srivastava, Department of Statistics, Florida State University, USA.

9. Dissemination

9.1. Conferences, Seminars, Meetings

- The members of the Ariana project-team participated actively in GdR ISIS and GdR MSPCV.
- The Ariana project-team organized numerous seminars in image processing during 2010. 13 researchers were invited from the following countries: Austria, France, Iceland, India, Hungary, Portugal, Romania, Switzerland. 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 (ENPC, ISAE/SUPAERO, ENS Cachan, KTH Stockolm), 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 attended a spring school entitled "Inverse problems in signal and image processing" in Porquerolles, France. She gave a talk at Sup'Com Tunis students in June and presented a paper at the conference PCV'10, Paris, in September.

- Laure Blanc-Féraud gave a lesson at the summer school on ‘Inverse Problems in Signal and Image Processing’ in Porquerolles, France, and attended summer school on "Apprentissage pour le TSI" in Peyresq. She attended the IEEE ICASSP’10 where she presented a poster and chaired a session. She gave an invited talk at the colloque STATIM on "Restauration de problèmes inverses et estimation d’hyperparamètres". She presented a poster at "Grand colloque STIC" of ANR in january, and organized the end meeting of ANR DETECFINE. She organized regularly meetings for Gyrovision FUI with ATE, and attended meetings with I3S, CNES and TAS for M. Carlavan PhD thesis supervision. She attended meetings of ANR DIAMOND in Sophia Antipolis, Mulhouse and Paris.
- Xavier Descombes visited the Dobrushin Laboratory (IITP, Russian Academy of Science) for two weeks in July. He was an invited speaker in the Workshop on ‘Stochastic approaches for image processing’ at CIRM in Luminy in May and gave an invited talk at GdR Isis in May. He organised several meetings for the Associated Team ODESSA and participated in ANR Micro-Réseaux project meetings. He regularly took part in meetings with Galderma.
- Aymen El Ghoul gave seminars at the ADSTIC meeting at I3S, and at the SHAPE working group meeting, both in Sophia Antipolis, in April and May respectively. He presented a paper at the conference PCV/ISPRS’10 in Paris, France, in September.
- Ahmed Gamal-Eldin presented the Ariana team in the “Euro-Mediterranean Innovation Marketplace 2010“ at Cairo in Egypt, where France was guest of honor. In May, Ahmed Gamal-Eldin has presented his masters work about fuzzy segmentation at ISSPA conference in Malaysia. He presented his PhD work at SITIS Conference again in Malaysia in December.
- Ian Jermyn gave a seminar in the Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, Urbana, USA, in April. He gave invited talks in the Fifth Solar Image Processing Workshop, Les Diablerets, Switzerland and the International Workshop on Shape Perception in Human and Computer Vision, in conjunction with the European Conference on Computer Vision, Heraklion, Crete, Greece, both in September.
- Vladimir Krylov gave a talk at the ORFEO Methodology meeting at CNES, Paris in January. He presented a paper at the conference 30th International Workshop on Bayesian Inference and Maximum Entropy Methods in Science and Engineering (MaxEnt), Chamonix, France in July.
- Florent Lafarge gave seminars at the Institute for Computer Graphics and Vision , University of Technology , Graz, Austria, at the "journée GDR ISIS modélisation mathématique des textures", Paris, France and at the "journée envol recherche de la Fondation d’Entreprise EADS", Paris, France. He gave an oral presentation at CVPR’10, San Francisco, US.
- Sylvain Prigent presented a paper at the conference Whispers’10 in Reykjavik (Iceland) in June, and presented a paper at the conference ICIP’10 in Hong Kong (China) in September.
- Josiane Zerubia gave talks at CS, Noveltis and Vega Technologies in Toulouse in January, and participated in the CNES ‘Research and Technology Day’ in Labege and she also visited Telecom Paris-Tech, in Paris. In February, she visited Astrium/EADS and Sanofi Aventis, in Toulouse. In March, she visited again Telecom-ParisTech, attended the annual Editorial Board meeting of SFPT at CNES in Paris, and participated in the IGN ‘Research Days’ in Saint Mandé, and went to Tunisia where she was part of two Masters Commitees at ENSI-Tunis. She gave a plenary talk at PHARES 2010 [http://www.arts-pi.org.tn/phares2010.php] and presented activities of INRIA to a large audience composed of Professors and PhD students of SupCom Tunis and ENSI-Tunis. In April, she was part of a meeting at Sophia Antipolis about the ISA/DIBE collaboration. In May, she attended the French Defence Agency (DGA) ‘Research and Innovation Day’ in Paris and participated to the CERT annual meeting at the French Space Agency (CNES) in Toulouse. In June, she gave a talk at Magellium and attended the general assembly of SFPT, both in Toulouse. She participated to the international Toulouse Space Show and attended the ‘UpMed Day’, finally she attended meetings at Astrium/EADS and Sanofi Aventis both in Toulouse, she organized two INRIA/ISA/DIBE meetings at Sophia-Antipolis and in Savona, she attended a Biorezo meeting

organized by the ‘Pôle EurobioMed’. In September, she attended the ‘Space and Law’ Day at Hotel de Région in Toulouse and presented the work of Ariana research team at Rochwell-Collins in Blagnac. She attended the ICIP’ 10 conference in Hong Kong to present a poster and participated to the IVMSP TC and ICIP to ICIP meetings. She also visited 3 Departments (Math, Elec.Eng, and Space Eng.) at the Chinese University of Hong Kong and gave an invited talk at the Department of Mathematics. In October, she participated to the ’Astrium/EADS/INRIA Day’ in Paris and to INRIA evaluation meeting where she presented the work of Ariana during the first day. In November, she organized the visit of Dr. Nigoux and research engineers of IPleanware [http://www.ipleanware.com/] at INRIA Sophia Antipolis Meditérannée and presented the work of Ariana. In December, she visited E3I2 Laboratory at ENSIETA in Brest, attended the ‘ORFEO Days’ at CNES in Paris, and participated to a meeting with IGN. 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.

9.2. Refereeing

- Laure Blanc-Féraud is Associate Editor of the “revue Traitement du Signal”. She also reviews papers for IEEE Trans. on Signal Processing and Applied Optics, Traitement du Signal and for the conferences IEEE ICIP, ICASSP, and ISBI as member of the IEEE BISP TC. She was a member of AERES visiting comitee of LIRIS laboratory, and member of a selection committee in Strasbourg University. She reviews proposals for the ANR Programme Blanc, and PEPS projects for CNRS. She was a reviewer for one HdR thesis and four PhD theses, and president of one PhD committee.
- Xavier Descombes was a regular reviewer for IEEE TIP, IEEE TPAMI, IEEE TGARS, Traitement du Signal and IJRS. He was a reviewer for the CIBLE programme of Région Rhones Alpes. He was reviewer of two PhD thesis and one HdR.
- Ian Jermyn was a reviewer for the journal IEEE TPAMI and for the conference ECCV’10.
- F. Lafarge was a referee for Springer Eds., IEEE TPAMI, IEEE TIP, IEEE TSP, JPRS, PERS, IEEE CVPR, IEEE ICIP, ACIVS, GEOBIA. He reviewed proposals for the Czech Science Foundation.
- Josiane Zerubia was president of one PhD committee, and a committee member for two more. She was a regular reviewer for IEEE TGRS, GRS Letters, and SFPT (Revue Française de Photogrammétrie et de Télédétection). She was a reviewer or a program committee member for ICASSP’10, ISBI’10 and ICIP’10, as member of the IEEE BISPTC and IEEE IVMSP TC, and for SPIE-ISPRS’10 (‘Image and Signal Processing for Remote Sensing’), ISPRS PCV’10, GEOBIA’10, ICPR’10. Finally, she was part of the CR2 and CR1 selection comittee at INRIA Sophia-Antipolis Méditerrannée.

9.3. Organization

- Laure Blanc-Féraud is a member of the IEEE Biological Image and Signal Processing Technical Committee. She is the ‘directrice adjointe’ of the GdR ISIS. She is member of thematic consultation group of the Ministery of Research and Teaching (MESR) for "Math-Stic". She is a permanent member of the Organizing Committee of the Gretsi Peyresq annual Summer School in TSI. She is Associate Editor of the journal ‘Traitement du Signal’ (Hermès). She is member of the steering committee of GdR "Mathématiques des Systèmes Perceptifs et Cognitifs" (MSPC). She is part of the CNECA 3 (equivalent of CNU for agricultural ministry). She is part of the Administrative Council of Gretsi. She is a member of the board of INRIA-SAM "Comité des projets".
- Xavier Descombes is a member of the scientific committee of the ‘Pôle de compétitivité Optitec’, and a member of the strategic committee of PopSud. He is computer systems coordinator for the Ariana project. He is PI of the Associated Team ODESSA.

- Ian Jermyn was a member of the Programme Committee for the IEEE Computer Society Workshop on Perceptual Organization in Computer Vision. He is a member of the Doctoral Oversight Committee at INRIA Sophia Antipolis, and of the International Relations Working Group of the Scientific and Technological Orientation Council of INRIA. He is co-computer systems coordinator for the Ariana project.
- Josiane Zerubia is an IEEE Fellow. She is publicity chair of IEEE ICIP'11 in Brussels [http://www.icip2011.org/] 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 is 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 Defis DIAMOND, co-PI (with P. Couteron of IRD) of an AAP INRA/INRIA project, and PI of an INRIA/DIBE/ISA project. She is also principal investigator for eight of the industrial contracts and grants of the Ariana EPI. She is a member of the ORFEO group (CNES). She is a consultant for Sanofi-Aventis Research and Development in Toulouse.

9.4. Teaching

- Laure Blanc- Féraud is director of the "module de traitement numérique des images" of Master 2 at Poly'Tech Nice-Sophia Antipolis (UNS) and gave 17h. She also taught in the Biocomp Masters programme at Poly'Tech Nice-Sophia Antipolis (UNS) (12h) and in IMEA Master 1 in Valrose (20h).
- Mikael Carlavan was teaching assistant for 'Traitement Numérique du Signal' (18h) at Poly'Tech Nice-Sophia Antipolis.
- Giovanni Gherdovich was teaching assistant for 'Image/Compression Project' (20h) and 'Introduction to Programming' (44h) 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.
- Ian Jermyn taught 'Image analysis' (10h) at Poly'Tech Nice-Sophia, and 'Filtering and segmentation of space imagery' (7.5h ETD) at ISAE/SUPAERO.
- Florent Lafarge taught 'Image analysis' (9h) at Poly'Tech Nice-Sophia, and 'Image processing' and 'Advanced techniques in space imagery' (7.5h) at ISAE/SUPAERO.
- 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).
- Jia ZHOU taught mathematics (60h) at IUT Montpellier.

9.5. PhDs

9.5.1. In progress

1. Yannick Verdié: 'Urban scene reconstruction from 3D point clouds', 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. Athanasis Georgantas: 'Global reconstruction of urban scenes', EDITE, Telecom Paris-Tech. Defence expected in 2012.
4. Sylvain Prigent:'The contribution of multi and hyperspectral imaging to skin pigmentation evaluation', University of Nice-Sophia Antipolis. Defence expected in 2012.
5. 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 2012.
6. Jia Zhou: 'The contribution of object recognition from forest canopy images to the construction of an allometric theory of the structure of trees and of natural, heterogeneous forests', University of Montpellier 2. Defence expected in 2012.
7. Ahmed Gamal-Eldin: 'Marked point processes models of 3D objects: an application to the counting of King Penguins, University of Nice-Sophia Antipolis. Defence expected in 2011.

9.5.2. Defended in 2010

1. Aymen El Ghoul: 'Phase fields for the extraction of networks from remote sensing images', University of Nice-Sophia Antipolis. Defence expected in September 2010.

9.6. Prizes

- Ahmed Gamal Eldin received in December the Best Paper Award at SITIS'10 Conference in Kuala Lumpur, Maleysia. (http://www2.u-bourgogne.fr/SITIS/10/Guidelines.html)
- Gregoire Kerr received in November the prize of the city of Toulouse for the best ISAE-SUPAERO Master Internship for his research work conducted at INRIA (EPI Ariana) in collaboration with Florida State University (Professor A. Srivastava).

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[2] D. GRAZIANI, G. AUBERT, L. BLANC-FÉRAUD. *A formal Gamma-convergence approach for the detection of points in 2-D biological images*, in "Siam Journal of Imaging Science", September 2010, vol. 3, n^{o} 3, p. 578–594.

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