

# ERCIM “Alain Bensoussan” Fellowship Scientific Report

Fellow: Raffaele GAETANO

Visited Location : INRIA, Sophia Antipolis – Project ARIANA

Duration of Visit: 9 months (01/04/2009 – 31/12/2009)

## I - Scientific activity

The ideas for the work introduced here arise from a former image modeling framework based on the *Hierarchical Multiple Markov Chain* model (H-MMC), and its related unsupervised algorithm for hierarchical texture-based segmentation named *Texture Fragmentation and Reconstruction* (TFR). The TFR algorithm points at the detection of the different textures of an image using a fragmentation and reconstruction approach: in earlier stages, the image is over-segmented to provide a set of elementary regions, whose connected components are featured using spectral and contextual information and clustered to form basic texture patterns. Later on, the resulting regions are sequentially merged, according to a suitable metric, to compose texture patterns at higher scales and contextually retrieve the underlying hierarchical image structure.

The TFR algorithm mainly uses spectral features to provide fine segmentation and to describe interactions among image regions. In many real world applications, where the sole observation of spectral properties can strongly limit the completeness of scene description, the TFR algorithm shows its major drawbacks: it is the case of satellite/aerial images with a significant presence of human made structures (buildings, roads, fields, etc.). Based on this observation, a new study has begun to include geometrical features in the TFR framework, while keeping low the complexity of the overall technique. The key idea is to provide a geometrical characterization of image elements by means of regular elementary shapes such as curves, rectangles or ellipses. To this end, we resorted to a simplified marked point process framework that applies on segmentation maps instead of dealing directly with image data.

This choice holds for two reasons: first, working on hierarchical maps increases the possibility that regular structures present in the image emerge at some scale, making it possible to detect them avoiding the use of complex data-driven models; moreover, the application of marked point processes to segmentation maps turns out to be efficient and powerful, since it allows the definition of simple energy functions and can benefit from the use of morphological tools.

In this first stage of the work, a fast algorithm for feature extraction based on elementary shapes has been developed: starting from a segmentation map, each connected component is independently analyzed to fit with an elementary shape, by applying a marked point process that uses a simple data likelihood function, weighting the trade-off between the inner uniformity and the outer diversity of labels. To limit the complexity of the process, a prior morphological analysis is performed on the initial map: skeleton of the connected components are extracted, and used to estimate the leading dimensions and orientation of the reference shape. Its center is also estimated by computing an approximation of the geodesic center of the original shape. All this information is then used to reduce the range in which the marks can be defined, finally speeding up the process.

Integration into the TFR algorithm has been only roughly tested on some benchmark data. This task will be completed in the second part of the fellowship, along with the application of the resulting algorithm to remote sensing data for hierarchical land cover classification.

## **II- Publication(s) during your fellowship**

The fellow is currently working on three joint publications for with the first hosting institute:

- A conference paper (*submission expected in February/March 2010*)
- A journal paper
- An internal INRIA research report

## **III -Attended Seminars, Workshops, and Conferences**

During its stay at INRIA, the fellow took part as a speaker into the joint “Journée Pole SIS” (Signaux – Images – Systèmes), organized by the I3S laboratory, as representative of the research activity for project ARIANA (INRIA).

The fellow also attended several INRIA seminaries given by researchers and professors of international level.

- « Non-Stationary Image Formation: A State-Space Approach.. Astrophysical Applications » by *Farzad Kalamabadi (University of Illinois, USA)*
- « Bayesian Search for Shapes in Cluttered Image Primitives » by *Anuj Srivastava (Florida State Univ., USA)*
- « The SURE-LET Methodology --- A Prior-Free Approach to Image Denoising » by *Thierry Blu (Chinese Univ. of Hong Kong)*
- « View Invariance and Its Role in Human Pose and Action Recognition » by *Hassan Foroosh (Univ. of Central Florida, USA)*
- « Mean-shift for shape inference » by *Rozenn Dahyot (Trinity College, Dublin, Ireland)*
- « A New Method of Approximate Bayesian Inference on Diffusion Process Parameters » by *Simon Wilson (Trinity College, Dublin, Ireland)*
- « Unsupervised change-detection methods for single-channel and multichannel SAR images » by *Gabriele Moser (Univ. of Genova, Italy)*
- « Internet-inspired 3-dimensional modeling of the human habitat » by *Franz Leberl (Graz Univ. of Technology, Austria)*
- « On the notion of prediction error for image and video compression » by *Philippe Salembier (Univ. Politecnica de Catalunya, Spain)*

He finally gave several demos for international invited professors and researcher.

## **IV – Research Exchange Programme (12 month scheme)**

Not applicable.