ERCIM "Alain Bensoussan" Fellowship Scientific Report

Fellow:	Giuseppe Scarpa
Visited Location :	INRIA, Sophia Antipolis (France)
Duration of Visit:	9 months (January 1st – September 30, 2006)

I - Scientific activity

The research activity of the Fellow supervised by Prof. Josiane Zerubia, INRIA, Sophia Antipolis, during the tenure of the second part of his fellowship has been focused on the further development and testing of a novel method for texture image segmentation (see related publication [1]) previously introduced by the Fellow in collaboration with the Institute of Information Theory and Automation of the Czech Academy of Sciences, Prague, during the first part of his activity supervised by Prof. Michal Haindl.

According to the proposed method, the image to be segmented is first discretized and then a hierarchical finite-state region-based model is automatically coupled with the data by means of a sequential optimization scheme, namely the Texture Fragmentation and Reconstruction (TFR) algorithm. The TFR algorithm allows to model both intra- and inter-texture interactions, and eventually addresses the segmentation task in a completely unsupervised manner. Moreover, it provides a hierarchical output, as the user may decide the scale at which the segmentation has to be given.

The TFR is basically composed of two steps. The former focuses on the estimation of the states at the finest level of the hierarchy, and is associated with an image fragmentation, or over-segmentation. The latter deals with the reconstruction of the hierarchy representing the textural interaction at different scales.

With respect to the original method, the novel version has been modified in both the optimization schedule and the criterion for identifying the model hierarchy. As for optimization we mean the separation of the states of the model at the finest level, we have improved it by replacing a simple *k*-means clustering with an iterative solution. On the other hand the hierarchal dependencies among the states are now revealed by means of a new metric, i.e. a *region gain*, more reliable w.r.t. the previous one, which aims at controlling the region (state) merging process.

Experimental tests were extended to remote-sensing data portraiting forest areas with different species of trees. According to these tests the new version clearly outperform the previous. The details of the modified version, as well as the comparative results, will appear in [2,3].

II- Publication(s) during your fellowship

[1] G.Scarpa, M.Haindl, "Unsupervised Texture Segmentation by Spectral-Spatial-Independent Clustering," In proceedings of *18th International Conference on Pattern Recognition* (ICPR'06), Hong Kong (China), August 20-24, 2006.

[2] G.Scarpa, M.Haindl, J.Zerubia, "Hierarchical Finite-State Model for Texture Segmentation with application to Forests Classification" to be submitted as INRIA Research Report.

[3] G.Scarpa, M.Haindl, J.Zerubia, "Hierarchical Finite-State Model for Texture Segmentation" to be submitted to IEEE ICASSP'07.

Abstract of [1]:

A novel color texture unsupervised segmentation algorithm is presented which processes independently the spectral and spatial information. The algorithm is composed of two parts. The former provides an over-segmentation of the image, such that basic components for each of the textures which are present are extracted. The latter is a region growing algorithm which reduces drastically the number of regions, and provides a region-hierarchical texture clustering. The over-segmentation is achieved by means of a color-based clustering (CBC) followed by a spatial-based clustering (SBC). The SBC, as well as the subsequent growing algorithm, make use of a characterization of the regions based on shape and context. Experimental results are very promising in case of textures which are quite regular.

Abstract of [2]:

In this work we present a new model for texture representation which is particularly suited for image analysis and segmentation. Any image is first discretized and then a hierarchical finite-state region-based model is automatically coupled with the data by means of a sequential optimization scheme, namely the Texture Fragmentation and Reconstruction (TFR) algorithm. The TFR algorithm allows to model both intra- and inter-texture interactions, and eventually addresses the segmentation task in a completely unsupervised manner. Moreover, it provides a hierarchical output, as the user may decide the scale at which the segmentation has to be given. Tests were carried out on both natural texture mosaics provided by the Prague Texture Segmentation Datagenerator Benchmark and remote-sensing data of forest areas.

Abstract of [3]:

A novel model for unsupervised segmentation of texture images is presented. The image to be segmented is first discretized and then a hierarchical finite-state region-based model is automatically coupled with the data by means of a sequential optimization scheme, namely the Texture Fragmentation and Reconstruction (TFR) algorithm. The TFR algorithm allows to model both intra- and inter-texture interactions, and eventually addresses the segmentation task in a completely unsupervised manner. Moreover, it provides a hierarchical output, as the user may decide the scale at which the segmentation has to be given.

The TFR is basically composed of two steps. The former focuses on the estimation of the states at the finest level of the hierarchy, and is associated with an image fragmentation, or over-segmentation. The latter deals with the reconstruction of the hierarchy representing the textural interaction at different scales.

III -Attended Seminars, Workshops, and Conferences

Attended seminars:

- INRIA/ARIANA seminar: "A Markovian Approach on Foreground-Background-Shadow Segmentation of Video Images" by Csaba Benedek at INRIA Sophia Antipolis, February 6, 2006.
- INRIA/ARIANA seminar: "Prior-based Segmentation by Projective Registration and Level Sets" by Tammy Riklin-Raviv, Sophia Antipolis, February 20, 2006.
- INRIA/ARIANA seminar: "On example based segmentation with wavelet features" by Claire Gallagher, Sophia Antipolis, March 13, 2006.
- INRIA/ARIANA seminar: "Bayesian Denoising in Oriented and Non-Oriented Multi-Scale Pyramids" by Jalal Fadili, Sophia Antipolis, April 3, 2006.
- INRIA/ARIANA seminar: "Statistical Analysis of Shapes of 2D Curves, 3D Curves, and Facial Surfaces" by Anuj Srivastava, Sophia Antipolis, May 22, 2006.
- INRIA/ARIANA seminar: "Compressive Sampling" by Robert-D. Nowak, Sophia Antipolis, May 29, 2006.
- INRIA/ARIANA seminar: "Hybrid Imaging" by Yoav Schechner, Sophia Antipolis, June 16, 2006.
- INRIA/ARIANA seminar: "Region-based extraction and analysis of visual object information" by Ferran Marques, Sophia Antipolis, June 19, 2006.

Talks or seminars given:

- INRIA/ARIANA seminar: "Finite states modeling for unsupervised texture segmentation", Sophia Antipolis, February 20, 2006.
- ARIANA brainstorming, talk: "Unsupervised texture segmentation through TFR algorithm", Sospel (F), June 13-15, 2006.

Attended conferences:

- *18th International Conference on Pattern Recognition* (ICPR), August 20-24, 2006, Hong Kong (China), where he presented [1].