PROPOSITION DE SUJET DE THESE

Intitulé : Machine Learning for Classification of Big Remote Sensing Data

Référence : **TIS-DTIM-2015-24**
(à rappeler dans toute correspondance - to be quoted in all correspondence)

Laboratoire d'accueil à l'ONERA :
Branche : Traitement de l'Information et Systèmes | Lieu (centre ONERA) : Palaiseau

Département : Traitement de l'Information et Modélisation

Unité : Perception Sémantique et Raisonnement | Tél. 01 80 38 65 73

Responsable ONERA : Bertrand Le Saux | Email: bertrand.le_saux@onera.fr

Directeur de thèse extérieur envisagé: Sébastien Lefèvre
Adresse : Université de Bretagne Sud / Irisa, Campus de Tohannic, 56000 Vannes:
Tél. 02 97 01 72 66 : Email : sebastien.lefevre@irisa.fr

Keywords *: Big Data; Remote Sensing; Earth Observation; Machine-learning; Neural Networks; Structured prediction;*

1 Context, goals and applications

Thanks to high resolution imaging systems and multiplication of data sources, earth observation (EO) with satellite or aerial images has entered the age of big data. This allows the development of new applications (EO data mining, large-scale land-use classification, etc.) and the use of tools from information retrieval, statistical learning and computer vision that were not possible before due to the lack of data.

This project is about designing an efficient classification scheme that can benefit from very high resolution and large datasets (if possible labelled) for creating thematic maps. Targeted applications include geology and vegetation for industrial purposes.

2 Methodology

The PhD thesis objective will be to develop new statistical tools for classification of aerial and satellite image. Beyond state-of-art approaches that combine a local spatial characterization of the image content and supervised learning (such as [1,2,3,4]), Machine learning approaches which take benefit from large labeled datasets for training classifiers such that structural and latent SVMs [5] or Deep Neural Networks [6] will be particularly investigated. The main issues are:

Problem #1: Structured prediction, or how to incorporate knowledge about the underlying spatial and contextual structure of classes of patterns as hidden variables? Graphical models such as Conditional Random Fields can be used to model the spatial relationships of various locations of the images. This could be combined in a multi-scale and hierarchical framework for context learning, following successful adaptation of kernel methods to such a framework [7]. A practical issue is to determine which contextual information is helpful, and this require a mix of expert knowledge and real-case testing. Representing images at multiple scales through partition trees will allow to overcome the limitations raised by using a context of fixed spatial extent. Indeed, the binary partition tree has recently been shown to be an appropriate data structure to support the efficient usage of graphical models [8].

Problem #2: Data fusion from various sensors, or how to merge heterogeneous data into the learning process? Indeed, beyond optical sensors, data from SAR, hyperspectral and Lidar sensors will be used when available. The designed architecture would thus have to be make the best of available but heterogeneous data (e.g., vector measurements, 3D information).

Problem #3: Physical plausibility of the analysis, or how to include prior physical knowledge in the classifier? While the majority of approaches from computer vision and machine learning are easily transfered to optical images, the peculiarities of sensors that capture other wavelengths (e.g. backscatter in SAR, specific responses of some hyperspectral bands to a given material) have to be taken into account. This requires to imagine new ways to mix prior knowledge and information learnt or estimated from the data. To illustrate, this has recently led to a new way to compare pixels and design non-linear operators based on spectral end-members [9].

Problem #4: Scalability, or how to make the proposed solutions tractable in presence of Big Remote Sensing Data? While advanced machine learning schemes based on statistical approaches have been proven to provide accurate and robust classification results, they are also often prone to bring a high computational cost. Such a drawback could be probihitive when assessing big data. Thus, a specific attention will be paid to the efficiency of the algorithms, e.g. in mixing efficient deterministic steps and robust probabilistic ones.

Publication in the highest impact conferences and journals in computer vision, statistical machine learning, and remote sensing is expected.

3 Bibliography

[1] Fauvel, M., Chanussot, J., Benediktsson, J.-A., "A Spatial-spectral Kernel-based approach for the Classification of Remote Sensing Images", Pattern Recognition 2012

[2] Le Saux, B., "Interactive design of object classifiers in Remote Sensing", Int. Conf. on Pattern Recognition 2014

[3] Randrianarivo, H., Le Saux, B., Ferecatu, M., "Man-made Structure Detection with Deformable Part-Models", Int. Geoscience and Remote Sensing Symp. 2013

[4] Lefèvre, S., Chapel, L., Merciol, F., "Hyperspectral image classification from multiscale description with constrained connectivity and metric learning", Workshop on Hyperspectral Image ans Signal Processing: Evolution in Remote Sensing (WHISPERS), 2014

[5] Yu, C.-N., Joachims, T., "Learning Structural SVMs with Latent Variables", Int. Conf. on Machine Learning 2009

[6] Mnih, V., Hinton, G., "Learning to Detect Roads in High-Resolution Aerial Images", Eur. Conf. On Computer Vision 2010

[7] Cui, Y., Chapel, L., Lefèvre, S., "A subpath kernel for learning hierarchical image representations", Int. Workshop on Graph-based Representations in Pattern Recognition (GbR), 2015

[8] Al-Dujaili, A., Merciol, F., Lefèvre, S., "GraphBPT: An efficient hierarchical data structure for image representation and probabilistic inference", Int. Symp. on Mathematical Morphology (ISMM), 2015

[9] Aptoula, E., Courty, N., Lefèvre, S., "An end-member based ordering relation for the morphological description of hyperspectral images", Int. Conf. on Image Processing, 2014

4 Applicant Profile

What do we expect?

Applicants should hold an exceptionally strong academic record with an excellent degree (M.Sc., M.Eng. or equivalent) in Computer Science, Mathematics, or a related field (e.g. Electrical Engineering). Strong mathematical skills and a background in machine learning, computer vision and programming is required.

Besides, applicants should be highly organized to meet deadlines with internal partners.

How to apply?

For further inquiries about the project, please contact: Bertrand Le Saux (bertrand.le_saux@onera.fr) and Sébastien Lefèvre (sebastien.lefevre@irisa.fr"sebastien.lefevre@irisa.fr)

Application should comprise a letter outlining the academic education and past research, motivation for this position and specific experience (max. 2 pages), CV and transcripts as well as contact details of 2-3 referees.

Collaborations extérieures : The position is located in Palaiseau, France (near Paris) but will require business trips to Vannes (South Brittany) to meet the PhD advisor and to south of France to meet the partners of the project.

PROFIL DU CANDIDAT

Formation :

Excellent degree (M.Sc., M. Eng. or equivalent) in Computer Science, Mathematics, or a related field (e.g. Electrical Engineering).

Spécificités souhaitées :

Strong mathematical skills and a background in machine learning, computer vision and programming.