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POST-DOCTORAL FELLOWSHIP

Référence : **PDOC-DOTA-2017-04**

ONERA: Optics and Associated Techniques (DOTA)

Location: Palaiseau

Contact : Sidonie LEFEBVRE – sidonie.lefebvre@onera.fr- (+33)01 80 38 63 76

Title : Modelization of textured multispectral backgrounds in kernel space and robust bands selection for anomaly detection

Keywords : Multispectral, Hyperspectral, Kernel methods, Bands selection, Anomaly detection, Uncertainty

Context: For some years now, multispectral sensor devices are attracting growing interest, as they sample the incoming light from the scene in several, about 10 or less, infrared or visible wavelength bands. In order to optimize spectral bands for applications such as anomaly detection, one must properly describe the background texture and account for the dispersion induced by uncertainty on input data, such as meteorological conditions, and for targets variability. Anomaly detection algorithms aim at identifying areas or pixels of the image which significantly differs from the background. The anomalies can then be analyzed in a more thorough way, in order to assess if they really correspond to the targets of interest.

Description: The objective is twofold. First, we wish to extend Gaussian mixture models proposed for textured multispectral backgrounds in François Weber PhD (2014-2017) thanks to kernel methods, in order to measure the gain obtained by considering simultaneously spectral and spatial informations within an anomaly detection method. For this purpose, we will adapt Maximum Mean Discrepancy methods [1-2], widely used for two-sample hypothesis testing and change detection, to textured backgrounds. This will require proposing an estimation algorithm for Gaussian mixture models in a reproducing kernel Hilbert space. The input of these models for anomaly detection will then be evaluated on several multispectral datasets.

Second, starting from Florian Maire PhD results (DGA PhD prize 2016) obtained by considering simultaneously spectral and spatial variability of targets and background within an anomaly detection method [3], the candidate will have to propose new criteria for robust selection of optimal spectral bands. This issue is a key point for designing future multispectral sensor devices, but is still little explored in the literature. Bands selection algorithms have been more and more studied over the last decade, and can take into account the intended application (mostly classification) in the optimization step, but few methods consider merging highly correlated neighboring bands, and there is almost no concern in the literature about target and background variability.

A promising way will consist in adapting some measures used for robust optimization under uncertainty, such as quantiles, to anomaly detection criteria. One could also combine multiple optimization criteria, and take advantage of existing evolutionary algorithms for multidisciplinary design optimization. Bagging methods [4] could also enable to obtain more robust results.

Deliverables and expected outcomes:

New algorithms for anomaly detection on multispectral textured background + publication.

Bands selection optimization accounting for uncertainties + publication. Robust selection of optimal

spectral bands is a key point for designing future multispectral sensor devices.

Bibliography :

[1] W. Zaremba, A. Gretton, M. Blaschko, *B-tests : Low variance Kernel Two-Sample Tests,* Neural Information Processing Systems, Lake Tahoe, United States, 2013.

[2] S. Li, Y. Xie, H. Dai, L. Song, *M-Statistic for Kernel Change-Point Detection*, J. of Machine Learning Research 1, 1-48, 2016.

[3] F. Maire, S. Lefebvre, *Detecting aircraft in low-resolution multispectral images: specification of relevant IR wavelength bands*, J. of Selected Topics in Applied Earth Observations and Remote Sensing 8 (9), 4509-4523, 2015.

[4] J. Bi, K. P. Bennett, M. Embrechts, C. M. Breneman, M. Song, *Dimensionality reduction via sparse support vector machines*, Journal of Machine Learning Research, 3, 1229-1243, 2003.

External collaborations: E. Moulines and Zoltan Szabo from CMAP - Ecole Polytechnique

Duration: 12 months

Salary: about 25 k€ / year (net salary, medical insurance included)

CANDIDATE PROFILE

PhD in applied mathematics
Desirable skills :

- Statistics
- Modelization
- Optimization
- Demonstrated publication capabilities