Ph.D. Thesis Opening

Title: Joint Hyperspectral Video Demosaicing and Demixing
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Team: SPeciFI

I. Ph.D. Thesis Description

During the last decades, infrared/visible imaging and then multispectral (MS) imaging allowed great breakthoughts, e.g., in industrial or environmental engineering. The more recent development of hyperspectral (HS) cameras–observing the same image at several hundreds or even thousands of wavelengths–makes possible to imagine new observation systems for which novel data processing techniques–at the frontier between image processing and machine learning–must be proposed.

In the context of this Ph.D. thesis, we are particularly interested in HS videos. They provide time sequences of HS data cubes (big data). However, for the sake of miniaturization and of maintaining hardware costs, these cameras do not necessarily acquire all the information they are supposed to sense. Post-processing called "demosaicing" is then necessary to reconstruct the data cube observed at each time instant. Moreover, in each pixel of each image of the HS video, the observed spectrum can be considered as a mixture of pure spectra of materials present in the pixel. Within the framework of this Ph.D. thesis, we wish to estimate such spectral, from partially observed video sequences, to perform HS video demosaicing.

From an application point of view, we are interested in monitoring natural, human, or industrial activities

Keywords: hyperspectral videos, hyperspectral data cubes, demosaicing, demixing, low-rank approximations, non-negative matrix (co-)factorization, big data, marine monitoring, industrial monitoring, human monitoring, environment.

II. Related Bibliography

[1] Tsagkatakis, G., Bloemen, M., Geelen, B., Jayapala, M., & Tsakalides, P. (2018). Graph and Rank Regularized Matrix Recovery for Snapshot Spectral Image Demosaicing. IEEE Transactions onComputational Imaging, 5(2), 301-316.

[2] Tochon, G., Pauwels, D., Dalla Mura, M., & Chanussot, J. (2016, August). Unmixing-based gas plumet racking in LWIR hyperspectral video sequences. In 2016 8th Workshop on Hyperspectral Image andSignal Processing: Evolution in Remote Sensing (WHISPERS) (pp. 1-5). IEEE.

[3] Bioucas-Dias, J. M., Plaza, A., Dobigeon, N., Parente, M., Du, Q., Gader, P., & Chanussot, J. (2012). Hyperspectral unmixing overview: Geometrical, statistical, and sparse regression-based

approaches. IEEE journal of selected topics in applied earth observations and remote sensing, 5(2), 354-379.

[4] Ma, W. K., Bioucas-Dias, J. M., Chan, T. H., Gillis, N., Gader, P., Plaza, A. J., ... & Chi, C. Y. (2014). A signal processing perspective on hyperspectral unmixing: Insights from remote sensing. IEEE Signal ProcessingMagazine, 31(1), 67-81.

III. Team publications linked with the subject

- **F. Yahaya**, **M. Puigt**, **G. Delmaire**, **G. Roussel**, How to apply random projections to nonnegative matrix factorization with missing entries?, in Proc. EUSIPCO, A Coruña, Spain, September 2-6, 2019.
- **C. Dorffer**, **M. Puigt**, **G. Delmaire**, **G. Roussel**, Informed Nonnegative Matrix Factorization Methods for Mobile Sensor Network Calibration, IEEE Transactions on Signal and Information Processing over Networks, Volume 4, Issue 4, pp. 667-682, December 2018. IF: 3.153
- **G. Delmaire**, M. Omdivar, **M. Puigt**, F. Ledoux, **A. Limem**, **G. Roussel**, D. Courcot, Informed WeightedNon-negative Matrix Factorization Using αβ-Divergence Applied to Source Apportionment, Entropy,Volume 21, Issue 3, Article number 253, special issue on "Information Theory Applications in Signal Processing", March 2019. IF: 2.419
- **C. Dorffer**, **M. Puigt**, **G. Delmaire**, **G. Roussel**, Fast nonnegative matrix factorization and completion using Nesterov iterations, in Proc. of LVA/ICA'17, Springer International Publishing AG, vol. LNCS 10179,pp. 26-35, Grenoble, France, February 21-24, 2017.
- **A. Limem**, **G. Delmaire**, **M. Puigt**, **G. Roussel**, D. Courcot, Non-negative matrix factorization underequality constraints–a study of industrial source identification, Applied Numerical Mathematics (APNUM), Volume 85, pp. 1-15, November 2014. IF: 1.678

IV. Host Institution and Place of Work

The successful candidate will be employed by the Université du Littoral Côte d'Opale (ULCO, https://www.univ-littoral.fr). ULCO is a human-scaled university whose priority research policies are (i) Environment and Sustainable Development and (ii) Marine Environment. The successful candidate will be hosted in the LISIC laboratory, which is the ULCO Computer & Information Science Lab (and the second largest ULCO lab). In particular, he will join the SPeciFI team of LISIC, which develops novel signal processing methods for industrial, natural and environmental monitoring.

In the framework of the Ph.D. thesis, the selected candidate will integrate a novel research environment, in Saint-Omer, dedicated to HS or MS imaging. In particular, he will work within a group of 3 permanent researchers, 1 post-doc researcher, and 2 Ph.D. students working on matrix factorization and/or HS imaging. He will have the possibility to apply the methods proposed within the Ph.D. thesis to several real problems, in collaboration with other ULCO research labs. Lastly, he will get access to several computing facilities (PC, access to the ULCO computing servers, and other services).

The LISIC is located by the Regional Nature Park of Opal Coast and Marshes (http://www.parc-opale.fr/), a touristic area wich comprises varied landscapes (bays, dunes, marshes, rock and fine sand beaches) and which is famous for its outdoor activities (e.g., trekking, biking, windsurfing,

kitesurfing, horsing, triathlon, etc https://en.wikipedia.org/wiki/C%C3%B4te_d%27Opale) and its proximity with Great Britain, Belgium and Lille (the sixth largest French Metropole).

V. Candidate Profile and Application

Prospective applicants should hold a Master degree in Signal/Image Processing, in Machine Learning, in Applied Mathematics or in any related discipline. Applications from candidates with a good background in (non-negative) matrix/tensor factorization, deep learning, optimization, with excellent programming skilles (e.g., in Matlab, Python, C and/or C++) are particularly encouraged.

Applicants are expected to show good communications skills, both written and oral. In particular, speaking fluently in French or English is required. Writing in English is mandatory.

Candidates are requested to **send a resume**, **transcripts** from their last year of Bachelor to their last year of Master (if available), as well as **two reference letters** (**or contact details of two referees**).

Applications should be sent to:

- Prof. Gilles ROUSSEL (gilles.roussel [at] univ-littoral.fr)

- Assoc. Prof. Matthieu PUIGT (matthieu.puigt [at] univ-littoral.fr)

Shortlisted candidates will be invited to a **remote** or a **face-to-face interview**.