2024 MSc research internship proposal

Title:
Fast joint demosaicing and unmixing approaches for multispectral "snapshot" images. Application to video sequences shot on a drone.

Keywords:
Demosaicing; Unmixing; Snapshot multispectral camera; videos; environmental observation.

Description:
This internship is part of work developed at LISIC around on-board multispectral imaging. A multispectral image consists of a data cube in which two axes describe the spatial variations of a scene while the third axis describes its spectral content. This type of imagery has become extremely classic in satellite observation (of the earth or space). More recently, compact imagers have enabled deployments in a multitude of configurations, including drone data acquisition. Among existing technologies, some miniaturized imagers using Fabry-Perot filters operate like traditional cameras and allow instantaneous acquisition of images or even videos [1]. In practice however, for each spatial pixel of the cube theoretically observed, only one wavelength of interest is acquired (see Fig. 1). Restoring this cube from the raw sensor image is called "demosaicing" and many techniques have been proposed, for example [2–6]. However, the authors in [5] have shown that sequential processing—i.e., post-processing such as classification after a demosaicing step (whatever the tested demosaicing method)—was not efficient.

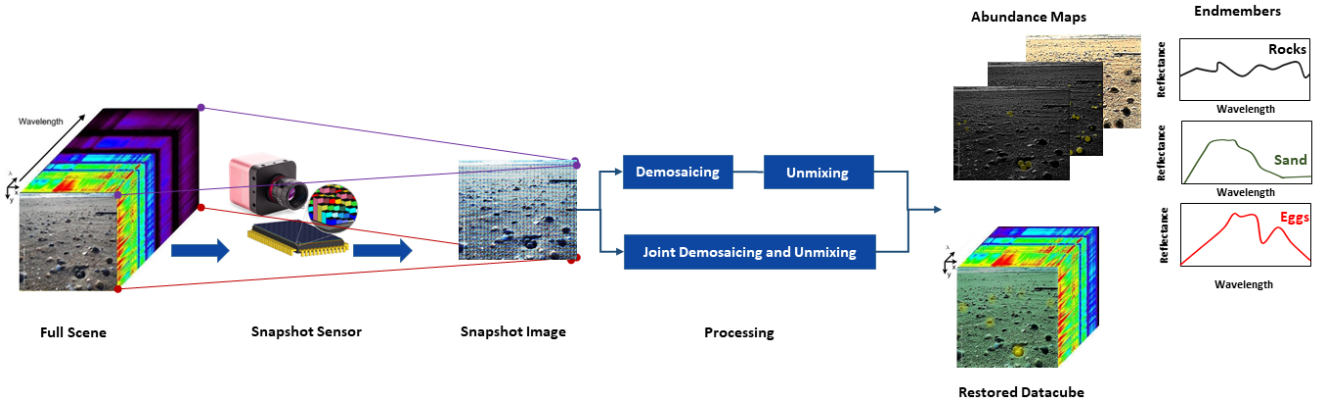

Figure 1: Acquisition and processing pipeline of a snapshot multispectral image. In order to restaure the datacube and to extract both the final endmembers and the abundance maps, such an image can be processed either in a 2-stage framework or in a joint unmixing and demosaicing strategy.

We thus proposed to carry out post-processing directly from the raw images. More specifically, we seek to estimate the spectral signatures of the materials present on the scene—aka endmembers—as well as their spatial distribution maps (or abundances). This task is called "unmixing" and our proposed strategies allow to jointly demosaice and unmix the raw images [7, 8]. Our approaches provide much better unmixing quality than the sequential strategy while allowing the same demosaicing performance as SotA techniques.

However, the methods proposed in [7, 8] are not well-suited to process large data volumes, and in particular to process videos. The goal of this internship will consist of proposing fast extensions of [7, 8] and of testing them on video sequences acquired on drones, with applications in environmental observation.

Supervisors:
The internship will take place in the new antenna of LISIC which is located in Longuenesse and currently dedicated

to hyperspectral imaging. This antenna currently has 6 permanent researchers, 1 research engineer and 4 Ph.D. students. The intern will be primarily supervised by Kinan Abbas, Matthieu Puigt and Gilles Roussel.

Moreover, the internship will be done in collaboration with the MIS laboratory, located in Amiens, and the joint CNRS-AIST JRL laoratory, located in Japan. As a consequence, the recruited intern will also be supervised by Guillaume Caron.

LISIC is located in the heart of the Regional Natural Park of "Caps et Marais d'Opale", close to Lille, England, Belgium, and Northern Europe (Amsterdam is only 4 h drive from Longuenesse).

Applications:
Pursuing scientific studies in the field of data sciences (signal and image processing, computer science with a focus in artificial intelligence / machine learning, applied mathematics), you are curious and very comfortable in programming (Matlab, Python). You read and speak fluent English with ease. Although not compulsory, a first experience in data factorization—e.g., matrix or tensor decomposition, blind source separation, dictionary learning—will be appreciated.

To apply, please send an e-mail to `{kinan.abbas, matthieu.puigt, gilles.roussel} [at] univ-littoral.fr` while attaching the documents that can support your application:

- your resume;
- a cover letter;
- your transcripts for the last year of B.Sc, the first year of M.Sc, and the last year of M.Sc (if the latter is available);
- two reference letters or the names and means of contact of two academic advisers.

References

[1] Bert Geelen, Carolina Blanch, Pilar Gonzalez, Nicolaas Tack, and Andy Lambrechts. A tiny VIS-NIR snapshot multispectral camera. In *Advanced Fabrication Technologies for Micro/Nano Optics and Photonics VIII*, volume 9374, page 937414. International Society for Optics and Photonics, 2015.

[2] Johannes Brauers and Til Aach. A color filter array based multispectral camera. In German Color Group, editor, *12. Workshop Farbbildverarbeitung*, Ilmenau, October 5-6 2006.

[3] Junya Mizutani, Shusaku Simizugaoka Ogawa, Kazuma Shinoda, Madoka Hasegawa, and Shigeo Kato. Multispectral demosaicking algorithm based on inter-channel correlation. In *Proc. IEEE VCIP'14*, pages 474–477, 2014.

[4] Sofiane Mihoubi, Olivier Losson, Benjamin Mathon, and Ludovic Macaire. Multispectral demosaicing using pseudo-panchromatic image. *IEEE Trans. Comput. Imaging*, 3(4):982–995, December 2017.

[5] Grigorios Tsagkatakis, Maarten Bloemen, Bert Geelen, Murali Jayapala, and Panagiotis Tsakalides. Graph and rank regularized matrix recovery for snapshot spectral image demosaicing. *IEEE Trans. Comput. Imaging*, 5(2):301–316, June 2019.

[6] K. Dijkstra, J. van de Loosdrecht, L. R. B. Schomaker, and M. A. Wiering. Hyperspectral demosaicking and crosstalk correction using deep learning. *Machine Vision and Applications*, 30(1):1–21, July 2018.

[7] Kinan Abbas, Matthieu Puigt, Gilles Delmaire, and Gilles Roussel. Locally-rank-one joint unmixing and demosaicing methods for snapshot spectral images. part I: a matrix-completion framework. article soumis en cours de révision, 2024.

[8] Kinan Abbas, Matthieu Puigt, Gilles Delmaire, and Gilles Roussel. Locally-rank-one joint unmixing and demosaicing methods for snapshot spectral images. part II: a filtering-based framework. article soumis en cours de révision, 2024.