Optimal transport for change detection between heterogeneous images

– M.Sc. proposal in machine learning and signal/image processing –

Elsa CAZELLES[1], Nicolas DOBIGEON[1], Marie CHABERT[1]

[1]Institut de recherche en informatique de Toulouse (IRIT)

Abstract

This internship will consist in developing methods for detecting changes between heterogeneous images within a probabilistic framework, by defining a loss with respect to the sliced Wasserstein distance [1]. By catering change detection as a fusion problem, this internship aims at proposing a new method for learning changes between two images, one multispectral and the other hyperspectral. Another avenue that will be explored for dealing with heterogeneous images is the use of the Gromov Wasserstein distance, which directly compares pairs of pixels extracted from the two images. The main expectations of this project are the development of a methodology and of open access algorithms for the detection of changes between images of different resolutions. These tools will be applied to real images, in particular in remote sensing for Earth observation, as a follow-up to the work of the thesis [2].

Keywords

Machine learning, Signal and image processing, Optimal transport, Change detection.

Detailed description

A ubiquituous task encountered in image processing and analysis consists in detecting changes between two optical images. When acquired by the same sensor, these images share the same spatial and spectral resolutions ; identifying these changes is straightforward by pixelwise comparisons. However, when considering images acquired through sensors of different spatial and/or spectral resolutions, change detection becomes considerably more complicated ; examples include emergency situations and one-off missions. The usual approach is to independently apply a transformation to each image to reach a pair of images of the same lower spatial and/or spectral resolutions. However, this pre-processing step discards part of the information shared by the two images. Recently, Ferraris *et al.* proposed to formulate the change detection problem as a robust image fusion problem by inferring two latent images of the same resolutions [2]. A key ingredient to regularize the underlying inverse problem is to impose a spatial sparsity to the changes between the two inferred latent images.

Subsequently, the first aim of this internship will be to generalize the sliced Wasserstein (SW) based formulation of the fusion problem, already studied, to a change detection problem between a hyperspectral image and a multispectral image. The second objective will be to explore the use of Gromov Wasserstein distance [3] in a change detection problem by identifying the pixel pairs that vary the most when transported from one image to the other. A large part of this internship will be dedicated to the proposal of efficient algorithms and to the development of a toolbox to solve these image processing problems, and finally to the application to real data.

Scientific environment & Period

The M.Sc. student will be co-advised by the following researchers within the SC group at IRIT laboratory (UMR CNRS 5505, Toulouse) :

— Elsa Cazelles, CNRS researcher,
— Nicolas Dobigeon, Professor and AI Research Chair at the Artificial and Natural Intelligence Toulouse Institute (ANITI),
— Marie Chabert, Professor.

This internship shall take place in 2023. The precise starting and ending dates can be adjusted according to the availability of the selected candidate.

Candidate profile & requirements

Master or Engineering school students with major in applied mathematics, computer science or electrical engineering.

The knowledge needed for this work includes a strong background in **signal & image processing**, **applied mathematics** (probability & statistics, optimization, etc.) and/or **machine learning**. Good scientific programming skills (e.g., Python or Matlab) and good communication skills in English, both written and oral are also expected.

Contact & application procedure

Applicants are also invited to send (as pdf files)
— a detailed curriculum,
— official transcripts from each institution you have attended (in French or English).
to the co-advisors
— Elsa Cazelles, elsa.cazelles@irit.fr
— Nicolas Dobigeon, nicolas.dobigeon@irit.fr
— Marie Chabert, marie.chabert@toulouse-inp.fr
You will be contacted if your profile meets the expectations. Review of applications will be closed when the position is filled.

References

[1] N. Bonneel, J. Rabin, G. Peyré and H. Pfister (2015). Sliced and radon Wasserstein barycenters of measures. *Journal of Mathematical Imaging and Vision*, 51(1), 22-45 (2015).

[2] V. Ferraris, N. Dobigeon, M. Chabert. Robust fusion algorithms for unsupervised change detection between multi-band optical images - A comprehensive case study. *Information Fusion*, vol.64, p.293-317 (2020).

[3] F. Mémoli. The Gromov–Wasserstein distance : A brief overview. *Axioms*, 3(3), 335-341 (2014).