Analysis and prediction of wavelet & filter-bank frames performance for machine learning/scattering networks (Internship, Spring/Summer 2018, IFPEN)

1 Internship description

1.1 Main topics

Sparse-domain data (signal/image) processing for classification and learning: basis/frame influence and selection in designing and training *scattering networks* with experimental data (geosciences, chemistry)

1.2 Keywords

Energy — Experimental data — Clustering — Scattering networks — Machine learning — Deep learning

1.3 Research context

IFP Energies nouvelles (IFPEN) is a major research and training player in the fields of energy, transport, and environment. From research to industry, technological innovation is central to all its activities, structured around three strategic priorities: sustainable mobility, new energies, and responsible oil and gas. As part of the public-interest mission with which it has been tasked by the public authorities, IFPEN focuses on: (a) providing solutions to take up the challenges facing society in terms of energy and the climate, promoting the transition towards sustainable mobility and the emergence of a more diversified energy mix; (b) creating wealth and jobs by supporting French and European economic activity, and the competitiveness of related industrial sectors.

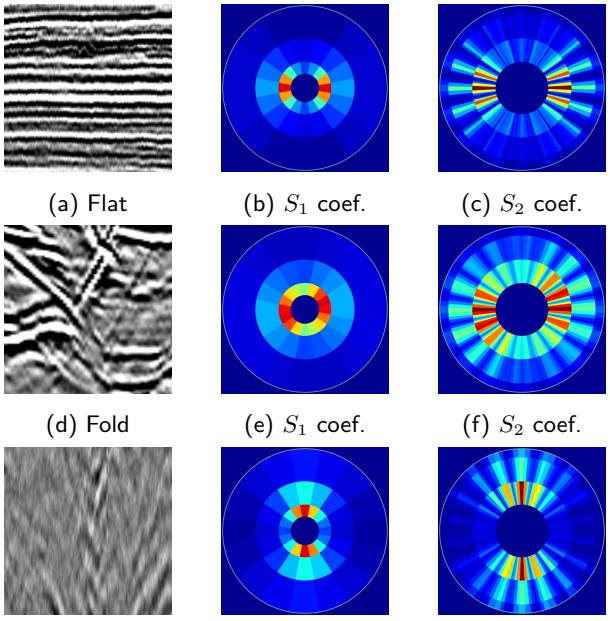
1.4 General presentation

We wish to study large datasets of experimental data (e.g. physico-chemical spectral signals, microscopy or geophysical subsurface images) toward clustering, classification and learning. When data satisfy regularity properties, they often admit sparse or compressible representations in a judicious transformed domain: a few transformed coefficients provide accurate data approximation. Such representations, like multiscale or wavelet transforms, are beneficial to subsequent processing, and they form the core of novel data processing methodologies, such as *Scattering networks/transforms (SN, or ScatNets)* [Mal12, BM13, Mal16] or *Functional Data Analysis (FDA)* [RS05, RHG09].

Due to the variety of such transforms [JDCP11, AAG14], without prior knowledge, it is not evident to find the most suitable representation for a given set of data. The aim of this subject is to investigate potential relations between transform properties and data compressibility on the one hand, and classification/clustering performance on the other hand, especially with respect to the robustness to shifts/translations or noise in data features, with matters in experimental applications.

1.5 Objective of the internship

Rooting on a recent work [BCD18], the first objective is to develop a framework to allow the use of different sparsifying transformations (bases or frames of wavelets and multiscale transformations, Fig. 1 and 2) at the input of reference SN [Mal16] algorithms. This will permit to evaluate the latter on a variety of experimental datasets, with the aim of choosing the most appropriate, both in terms of performance and usability, since the redundancy in transformations may hinder their application to large datasets. A particular interest could be laid on complex-like transformations, that may improve either the sparsification or "invariance properties" [BM13, BG17] in the transformed data. Their importance has been underlined recently for deep convolutional networks [TBC+16, TBS+17].



(a) Flat (b) S_1 coef. (c) S_2 coef.

(d) Fold (e) S_1 coef. (f) S_2 coef.

(g) Low int. (h) S_1 coef. (i) S_2 coef.

Figure 1: Left: exemplars for each class. Center/right: multi-level, angular sector representation of a two-level scattering transform.

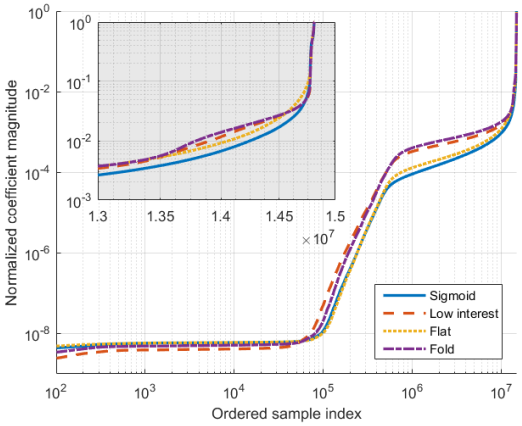


Figure 2: Compressibility of ordered scattering transform feature vectors from Fig. 1 in log-log-scale.

Then, starting from real data, the trainee will develop realistic models reproducing the expected behaviors in the data, for instance related to shifts or noise.

Finally, the relative clustering/classification performances will be assessed with respect to different transformation choices [DBMdH17], and their impact on both realistic models and real data. A particular interest could be laid on either transform properties (redundancy, frame bounds, asymptotic properties) or the resulting data multiscale statistics [Wal17, DBMdH17, CL17].

2 General information

2.1 Duration

5 months. Potential for a PhD thesis starting Sep./Oct. 2018: *Data characterization and classification with invariant multiscale features*. PhD advisor: Jean-Christophe Pesquet, Digital Vision Center, CentraleSupélec, INRIA team GALEN.

2.2 Expected ability of the student

Second/third year engineering school and/or master of science with strong skills and curiosity in signal/image processing, statistics, machine learning, applied mathematics. Applicants should provide a resume and a motivation letter emphasizing prior knowledge related to the subject (esp. learning and sparsifying transforms).

2.3 Contact

- Team: Laurent Duval, Jean Charléty, Aurélie Pirayre (first.last@ifpen.fr, without accents)
- City/country: Rueil-Malmaison (Paris suburbs), France

2.4 Information updates

`http://www.laurent-duval.eu/lcd-2018-intern-transform-classification.html`

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