SPARSE

Reconciling sparsity and parametric models: sparse representations in continuous dictionaries

INRIA Rennes
ENSTA Bretagne
IMT Atlantique
IRMAR UR1

Main Goals

The project aimed at exploring the full potential of the new paradigm of sparse representations in *continuous* dictionaries.

This research topic is one of the latest developments in the theory of compressed sensing and promises to provide new theoretical and algorithmic answers to the field of data processing and acquisition.

The project was composed of a methodology part and an application part:

- The *methodology part* was dedicated to the derivation of new algorithmic and theoretical results at the frontier of the current knowledge.
- In the *applicative part*, we elaborated on the theoretical results to illustrate the strong potential and relevance of the proposed approaches in different applicative domains.

Consortium

The consortium of the project was made up of five partners and four research institutes:

- **Cédric Herzet (INRIA Rennes)**: He was the project's PI. He worked on the methodological/theoretical aspects.
- **Rémi Gribonval (INRIA Rennes)**: He worked on some theoretical aspects of the project.
- **Angélique Drémeau (Ensta Bretagne)**: She worked on some algorithmic aspects of the sparse representation problem.
- **Pierre Tandéo (IMT Atlantique)**: He worked the analysis of sea wave fields
- **Valérie Monbet (IRMAR UR1)**: She worked on to the diagnosis of non-alcoholic steatosis.

Result 1: recovery guarantees for OMP

Problem: identification of conditions under which a given heuristic procedure can solve the ideal sparse representation problem.

Result: we provided necessary and sufficient conditions of success for a well-known algorithm, ``Orthogonal Matching Pursuit'' (OMP), in some particular types of continuous dictionaries.

This work has led to two communications in international conferences [1, 2] and the submission of one journal paper [3]

Result 2: recovery guarantees for OMP

Problem: continuous dictionaries involve (by definition) an infinite uncountable number of elements, the question naturally arises of the complexity required to exploit them. In particular, algorithmic solutions that efficiently handle this type of dictionary are needed to validate the practical interest of the continuous approach.

Result A: We propose a new methodology to implement ``screening'' techniques in the context of continuous dictionaries. Our procedure is able to identify regions of atoms not participating to the sparse decomposition with a polynomial complexity.

Result B: We propose a novel procedure to address efficiently the so-called « *atom selection* » problem which appears in the implementation of several standard sparse-representation procedures.

These works have led to one journal publication in the IEEE transactions on Signal Processing [4] and a communication in an internal conference [5].

Result 3: wavefield analysis and non-alcoholic steatosis diagnosis

The concept of continuous dictionaries, considered in this project, perfectly fit the physical/biological models encountered in many applications. We focussed on the resolution of some practical problems via the use of sparse-representation tools:

- Wavefield analysis: the goal is to provide information about the origin and nature of the wave field observed in some particular region of the globe.
- Diagnosis of non-alcoholic steatosis: the goal is to be able to exploit spectrometry measurements, thanks to the use of sparse representation algorithms.

Publications of the project

[1] C. Elvira, R. Gribonval, C. Soussen, and C. Herzet, "OMP and continuous dictionaries: is k-step recovery possible?," in IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), Brighton, United Kingdom, May 2019

[2] C. Elvira, R. Gribonval, C. Herzet, and C. Soussen, "Uniform k-step recovery with CMF dictionaries," in SPARS 2019 - Signal Processing with Adaptive Sparse Structured Representations, Toulouse, France, July 2019.

[3] C. Elvira, R. Gribonval, C. Soussen, and C. Herzet, "When does OMP achieve support recovery with continuous dictionaries?," 2019.

[4] C. Herzet, C. Dorffer, and A. Drémeau, "Gather and conquer: Region-based strategies to accelerate safe screening tests," IEEE Transactions on Signal Processing, vol. 67, no. 12, pp. 3300–3315, 2019.

[5] C. Dorffer, C. Herzet, and A. Drémeau, "Region-based relaxations to accelerate greedy approaches," in 27th European Signal Processing Conference, EUSIPCO, 2019.