Post Doc position in Digital sciences

Tensor tools for multimodal data fusion and signal processing (12 months)

Research unit: I3S (Laboratoire d'Informatique, Signaux et Systèmes de Sophia Antipolis) / Mixed research unit Université Côte d'Azur, National Centre for Scientific Research (CNRS) and INRIA

Project summary:

Goals and methodology: In an increasingly digitized and interconnected world, the volume of multidimensional, multimodal, heterogeneous and often incomplete data to be processed keeps growing at an unprecedented rate. In this context, today tensors play a central role in many fields of application, particularly in signal processing and machine learning, for the representation, compression, analysis, fusion and classification of data.

Data tensors can be constructed by arranging multidimensional observed signals or information to be processed in arrays with more than two dimensions. Tensors can also contain the received signals in wireless communication systems designed using tensor-based approaches. Theses tensors are decomposed in terms of factors which highlight the underlying structure of the data by revealing hidden relationships between observed physical variables. In the case of communication systems, the factors are directly linked to the parameters of the system to be estimated, namely the communication channels and the transmitted information symbols.

In Data Science, data fusion is a fundamental problem. Indeed, in the era of big data and digital information, the processing of ever-increasing volumes of data in the form of signals, images and videos requires the use of data fusion techniques to optimally combine the different modalities with the aims of compression, analysis, and classification, based on new tensor models, with specific algorithms. Moreover, when information is missing in data tensors, i.e., only a part of the entries are known due to defective sensors and/or communication links, tensor completion methods are very useful to retrieve missing data.

Over the past two decades, teams from the I3S laboratory have conducted research works on the study of new tensor models and new multilinear algebra tools, with applications in signal processing, particularly for wireless communication systems and biomedical signals processing. These works were largely carried out in collaboration with several teams from French laboratories (GIPSA/Grenoble, CRIStAL/Lille, and CRAN/Nancy), and Brazilian universities (UFC/Fortaleza, UNICAMP/Campinas, and UFSC/Florianopolis) [FAV21, MIR20].

The present project pursues three main **objectives**:
1. To make advances in the fundamental theory of deep learning, tensor decompositions / networks, including tensor trains and coupled tensor models, and tensor completion, with specific algorithms for parameter estimation of large-scale incomplete data tensors in the context of multimodal data fusion. The focus will be on new neural networks composed of multiple layers, each layer built up of a tensor factorization, resulting in tensor-based multilayer architectures.

2. To tackle current challenging biomedical problems requiring advanced methods for physiological data analysis, particularly the multimodal characterization of multi-electrode records for patient-tailored treatment of cardiac arrhythmia [MOR20, OLI19, OLI22].

3. To design new cooperative (multi-relay) massive MIMO millimeter-wave cellular systems [ZNI20a, ZNI20b], which open new challenges for mobile communications, including reconfigurable intelligent surfaces (RIS) and massive MIMO reconfigurable antennas.

This postdoctoral fellowship will take place in the context of a Senior Chair of the Interdisciplinary Institute for Artificial Intelligence (3IA) Côte d'Azur.

Candidate profile:

Prospective candidates must hold a PhD and attest good knowledge of tensorial tools and skills in biomedical signal processing and/or wireless communication systems.

Supervision and host laboratory:

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