A tensor-based framework for blind identification of linear MIMO FIR systems

Frederik Van Eeghem [⋆ † ‡]
Frederik.VanEeghem@kuleuven.be

Otto Debals [⋆ † ‡]
Otto.Debals@kuleuven.be

Lieven De Lathauwer [⋆ † ‡]
Lieven.DeLathauwer@kuleuven-kulak.be

[⋆] Department of Electrical Engineering (ESAT), STADIUS Center for Dynamical Systems, Signal Processing and Data Analytics, KU Leuven. Kasteelpark Arenberg 10, 3001 Leuven, Belgium.
[†] Group Science, Engineering and Technology, KU Leuven Kulak.
Etienne Sabbelaan 53, 8500 Kortrijk, Belgium.
[‡] iMinds Medical IT, KU Leuven.
Kasteelpark Arenberg 10, 3001 Leuven, Belgium.

1 Blind system identification

Contrary to classical identification, blind system identification (BSI) attempts to estimate a system using output measurements only. This is especially useful when the input data are expensive or impossible to measure, as is the case in several medical applications, wireless communications, and the processing of seismographic data [1]. However, it is not possible to blindly identify systems without making some extra assumptions. Here, the inputs are assumed to be statistically independent, which is done often and has proven to be a good approximation in several applications [2]. This assumption bridges the gap between BSI and independent component analysis (ICA).

In its most basic form, ICA tries to estimate signals from an instantaneous mixture. The convolutive extension of ICA strongly resembles the blind identification of linear FIR systems, which are characterized by a convolution. The only difference in both approaches lies in the goal: BSI tries to identify the system itself, whereas ICA is mainly interested in estimating the input signals.

2 A tensor-based framework

Datasets are frequently surfacing as multi-way arrays, making tensors a natural tool for data representation. As a higher-dimensional generalization of vectors and matrices, tensors possess favorable properties lacking in their lower-dimensional counterparts. One of the key properties is the uniqueness under mild conditions of several decompositions, motivating why tensors have been increasingly studied during the past decades [3].

Tensor methods for instantaneous ICA have already been well established and mostly make use of second- and higher-order statistics [2]. Here, the focus lies on expanding these tensor-based methods to blind MIMO FIR identification and convolutive ICA, which has only been studied little so far [4, 5]. A tensorial framework is developed which allows to blindly identify linear FIR systems with either i.i.d. or temporally coherent inputs, assumed mutually independent. The framework not only comprises existing methods but has new variants as well. By relating each method to a tensor decomposition, we can tap into the theory developed for the latter. This allows us to formulate uniqueness conditions. Moreover, the performance of several methods is improved by fusing both second- and higher-order statistics in coupled decompositions.

References

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