Physics-Aware Deep Nonnegative Matrix Factorization

Chinellato Erik

Department of Mathematics, University of Padova

In this talk we present the Physics-Aware Deep Nonnegative Matrix Factorization (PAD-NMF), a neural network stemming from recent “deep-unfolding” techniques with the goal of creating more interpretable networks by unfolding the iterations of traditional algorithmic schemes, here the well-known Nonnegative Matrix Factorization (NMF) algorithm. In general, NMF can be applied to a variety of dictionary learning problems as well as signal detection tasks. It can be unfolded to exploit a neural training and made ”Physics-Aware” by embedding in the network’s architecture intrinsic properties of the expected output. Indeed, the two- factor iterative paradigm typical of NMF, once unfolded, allows great control on the way the quantities of interest are propagated through the network, e.g. sparsity, smoothness, etc. Its interpretability is then guaranteed by a nonnegativity- preserving back-propagation algorithm. Furthermore, the physics-awareness is introduced by three main aspects: discriminative initialization of the dictionary based on our prior knowledge of the physical system, enforcement of the time- correlation by projecting the forward- and back-propagated factors into a block- Hankel space, and a modified loss-function that shifts the focus away from Wiener filtering in favor of a more accurate separation of the mixture contents.

We will show some applications of PAD-NMF in the context of audio source separation and detection, where the signals to be recognized within general mixtures are transients from impulses applied to a mechanical system.