Faculty of Computer Science

Nonlinear independent component analysis: A principled framework for unsupervised deep learning

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Währinger Strasse 29, 1090 Vienna

Unsupervised learning, in particular learning general nonlinear representations, is one of the deepest problems in machine learning. Estimating latent quantities in a generative model provides a principled framework, and has been successfully used in the linear case, e.g. with independent component analysis (ICA) and sparse coding. However, extending ICA to the nonlinear case has proven to be extremely difficult: A straight-forward extension is unidentifiable, i.e. it is not possible to recover those latent components that actually generated the data.

Here, we show that this problem can be solved by using additional information either in the form of temporal structure or an additional, auxiliary variable. We start by formulating two generative models in which the data is an arbitrary but invertible nonlinear transformation of time series (components) which are statistically independent of each other. Drawing from the theory of linear ICA, we formulate two distinct classes of temporal structure of the components which enable identification, i.e. recovery of the original independent components.

We show that in both cases, the actual learning can be performed by ordinary neural network training where only the input is defined in an unconventional manner, making software implementations. We further generalize the framework to the case where instead of temporal structure, an additional auxiliary variable is observed (e.g. audio in addition to video). Our methods are closely related to "self-supervised" methods heuristically proposed in computer vision, and also provide a theoretical foundation for such methods.

The talk is based on the following papers:

http://www.cs.helsinki.fi/u/ahyvarin/papers/NIPS16.pdf
http://www.cs.helsinki.fi/u/ahyvarin/papers/AISTATS17.pdf
https://arxiv.org/pdf/1805.08651