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## CS-Colloquium

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

mit Univ.-Prof. Aapo Hyvärinen (University of Helsinki, Finland)

**Wann?** 19. Juni, ab 15:00 Uhr  
**Wo?** Hörsaal 3 (HS3), Fakultät für Informatik  
Währinger Straße 29  
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### Abstract

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>

## **Bio**

Aapo Hyvarinen studied undergraduate mathematics at the universities of Helsinki (Finland), Vienna (Austria), and Paris (France), and obtained a Ph.D. degree in Information Science at the Helsinki University of Technology in 1997. After post-doctoral work at the Helsinki University of Technology, he moved to the University of Helsinki in 2003, where he was appointed Professor in 2008, at the Department of Computer Science. From 2016 to 2019, he was Professor at the Gatsby Computational Neuroscience Unit, University College London, UK. Aapo Hyvarinen is the main author of the books "Independent Component Analysis" (2001) and "Natural Image Statistics" (2009), and author or coauthor of more than 200 scientific articles. He is Action Editor at the Journal of Machine Learning Research and Neural Computation and Editorial Board Member in Foundations and Trends in Machine Learning. He has served as Contributing Faculty Member of Faculty of 1000 Prime. Google Scholar gives him approximately 40,000 citations. His current work concentrates on unsupervised machine learning and its applications to neuroscience.