

Curriculum Vitae: Morten Mørup

PERSONAL	Born 12 January 1978 Married to Erika Mørup
CONTACT INFORMATION	Home Slotsvænget 26 2800 Kgs. Lyngby Denmark <i>phone:</i> 27 29 29 75 <i>e-mail:</i> morten.morup@gmail.com <i>www:</i> www.mortenmorup.dk Work Cognitive Systems, DTU Informatics Richard Petersens Plads, bld. 321/118 2800 Kgs. Lyngby Denmark <i>phone:</i> 45 25 39 00 <i>fax:</i> 45 87 25 99 <i>www:</i> www.imm.dtu.dk/~mm
RESEARCH INTERESTS	Machine Learning, Unsupervised Learning, Multi-way/Tensor Decomposition Methods, Bayesian Inference, Neuro-imaging, Bio-informatics.
EDUCATION AND RESEARCH EXPERIENCE	Copenhagen University, Bio-physics and Mathematics: (Fall 1999 - Summer 2001) Washington State University, Exchange student following courses within Computational Neuroscience (Spring 2004) Technical University of Denmark Cand. Polyt. Applied Mathematics (February 2005) PhD Intelligent Signal Processing Group at DTU Informatics (September 2008) Dissertation title: Decomposition Methods for Unsupervised Learning. PostDoc Intelligent Signal Processing Group at DTU Informatics (Current Position) Project: PERCEPT: Perceptual Consciousness Explication and Testing (http://www.nest-percept.eu/) Stanford University Visiting Ph.D. Student at Department for Scientific Computing (Summer 2006 - Fall 2006) Host: Professor Gene H. Golub Berkeley University Visiting Ph.D. Student at Department of Mathematics (Fall 2007) Host: Morrey Assistant Professor Lek-Heng Lim
HONORS AND AWARDS	Best Thesis Award: Direktør Peter Gorm-Petersens Mindelegat 2008 (14.000 DKR) Elite Research Travel Scholarship 2007: Danish Ministry of Science (250.000 DKR) Travel Award: Organization for Human Brain Mapping 2005
TEACHING EXPERIENCE	Technical University of Denmark <i>Teacher</i> 02901: Advanced Digital Signal Processing (Summer 2008) <i>Assistant Teacher</i> 02405: Probability Theory (2005-2007)

Assistant Teacher 02409: Multivariate Statistics (2004-2005)

Assistant Teacher 02701: Introduction to Operations Research (2002-2003)

Have further given lectures or been assistant teacher in the following courses:

02451 Digital Signal Processing, 02457 Non-linear signal processing , 02459 Machine Learning for Signal Processing.

International Summer School in Biomedical Engineering

Teacher at the 1st International Summer School in Biomedical Engineering 2006 "Decomposition Methods for Multidimensional Data" in the session on Parallel Factor Analysis.

MEETINGS ORGANIZED

2009 European Workshop on Challenges in Modern Massive Data Sets Organizer (with L.-H. Lim, L.K. Hansen, G. Carlsson), Technical University of Denmark, Lyngby, Denmark, July 1-4, 2009. (<http://mmds.imm.dtu.dk>)

KEY PUBLICATIONS

F. Calamante , M. Mørup, L. K. Hansen, Defining a local arterial input function for perfusion MRI using independent component analysis. *Magnetic Resonance in Medicine*, Volume 52 Issue 4, Pages 789 - 797, 2004

This paper proposes the use of Independent Component Analysis to extract arterial input functions for perfusion MRI data. A software assisting medical doctors in the analysis was developed.

Citations: Google Scholar 55, ISI 44

M. Mørup, L. K. Hansen, C. S. Hermann, J. Parnas, S. M. Arnfred, Parallel Factor Analysis as an exploratory tool for wavelet transformed event-related EEG. *NeuroImage*, vol. 29(3), pp. 938-947, 2006

This paper proposes the use of multi-linear approaches for the analysis of wavelet transformed event related EEG data and demonstrate its success in correctly extracting the underlying neurological activation of a visual paradigm.

Citations: Google Scholar 45, ISI 32

M. Mørup, L.K. Hansen, S.M. Arnfred, ERPWAVELAB A toolbox for multi-channel analysis of time-frequency transformed event related potentials. *Journal of Neuroscience Methods*, vol. 161, pp. 361-368, 2007

This paper presents the open source toolbox ERPWAVELAB for time-frequency analysis of event related EEG and MEG data.

Citations: Google Scholar 10 , ISI 6

M. Mørup, L.K. Hansen, S.M. Arnfred, L.-H. Lim, K.M. Madsen, Shift Invariant Multilinear Decomposition of Neuroimaging Data. *NeuroImage* vol. 42(4), pp.1439-50, 2008

This paper proposes a framework to model the inevitable delay variability in neuroscience data. On fMRI and EEG data it is demonstrated how the proposed approach effectively extracts the underlying neural activity despite SNR's less than -10dB. The algorithm is publicly available.

M. Mørup, L. K. Hansen, S. M. Arnfred, Algorithms for Sparse Nonnegative Tucker Decomposition. *Neural Computation*, vol. 20 no. 8, pp. 2112-2131, 2008

We demonstrate how tensor decomposition based on the Tucker model incorporating sparseness can be used to turn of excess components and alleviate model ambiguities. Results on a range of life-science data from chemometrics and neuroscience demonstrate the success of the approach. The algorithm is publicly available.

M. Mørup, L.K.Hansen, An Exact Relaxation of Clustering. Submitted to *Journal of Machine Learning Research*, 2009

This paper presents the surprising result that clustering problems that traditionally have been considered non-continuous combinatorial search problems can be posed as continuous optimization problems over the simplex. The paper demonstrate how this exact relaxation outperforms existing

combinatorial search algorithms and is able to efficiently extract communities in social networks as well as perform clustering in image databases. The algorithms are publicly available.

FULL LIST OF
PUBLICATION

Journal Publications

- I. Griskova, M. Mørup, Josef Parnas, Osvaldas Ruksenas, Sidse M. Arnfred, Two discrete components of the 20 Hz steady-state response are distinguished through the modulation of activation level. *Clinical Neurophysiology*, in press, 2009
- M. Mørup, L.K. Hansen, Automatic Relevance Determination for multi-way models, *Journal of Chemometrics*, in press, 2009
- M. Mørup, L.K. Hansen, S.M. Arnfred, L.-H. Lim, K.M. Madsen, Shift Invariant Multilinear Decomposition of Neuroimaging Data. *NeuroImage* vol. 42(4), pp.1439-50, 2008
- M. Mørup, L. K. Hansen, S. M. Arnfred, Algorithms for Sparse Nonnegative Tucker Decomposition. *Neural Computation*, vol. 20 no. 8, pp. 2112-2131, 2008
- I. Griskova, M. Mørup, J. Parnas, O. Ruksenas, O., S.M. Arnfred, The amplitude and phase precision of 40 Hz auditory steady-state response depend on the level of arousal. *Experimental Brain Research*, vol. 183(1), pp. 133-138, 2007
- M. Mørup, L.K. Hansen, S.M. Arnfred, ERPWAVELAB A toolbox for multi-channel analysis of time-frequency transformed event related potentials. *Journal of Neuroscience Methods*, vol. 161, pp. 361-368, 2007
- S.M. Arnfred, L.K. Hansen, L. K., J. Parnas, M. Mørup, Proprioceptive Evoked Gamma Oscillations. *Brain Research*, vol. 1147, pp. 167-174, 2007
- M. Mørup, L. K. Hansen, C. S. Hermann, J. Parnas, S. M. Arnfred, Parallel Factor Analysis as an exploratory tool for wavelet transformed event-related EEG. *NeuroImage*, vol. 29(3), pp. 938-947, 2006
- F. Calamante , M. Mørup, L. K. Hansen, Defining a local arterial input function for perfusion MRI using independent component analysis. *Magnetic Resonance in Medicine*, Volume 52 Issue 4, Pages 789 - 797, 2004

Conference Proceedings

- C. Stahlhut, M. Mørup, O. Winther, L. K. Hansen, Hierarchical Bayesian Model for simultaneous EEG Source and Forward Model Reconstruction (SOFOMORE). Accepted for publication *Machine Learning for Signal Processing*, 2009 IEEE Workshop on
- M. Mørup, L.K.Hansen, Tuning Pruning in Sparse Non-negative Matrix Factorization. Accepted, *European Signal Processing Conference (EUSIPCO-2009)*
- C. Stahlhut, M. Mørup, O. Winther, L. K. Hansen, SOFOMORE: Combined EEG Source and Forward Model Reconstruction. Accepted for publication *2009 IEEE International Symposium on Biomedical Imaging*
- V. Potluru, S. Plis, M. Mørup, V. Calhoun, T. Lane, Efficient Multiplicative updates for Support Vector Machines. *SIAM International Conference on Data Mining (SDM09)*
- M. Mørup, L.K. Hansen, Sparse Coding and Automatic Relevance Determination for Multi-way models. *Signal Processing with Adaptive Sparse Structured Representations (Spars09)*
- P. M. Rasmussen, M. Mørup, L. K. Hansen, S. M. Arnfred, Model Order Estimation for Independent Component Analysis of Epoched EEG Signals. *Biosignals 2008, International Conference on Bio-inspired Systems and Signal Processing.*, 2008

M. Mørup, L. H. Clemmensen, Multiplicative updates for the LASSO. Machine Learning for Signal Processing, 2007 IEEE Workshop on, pp. 33-38, 2007

M. Mørup, K. H. Madsen, L. K. Hansen, Shifted Non-negative Matrix Factorization. Machine Learning for Signal Processing, 2007 IEEE Workshop on, pp. 139-144, 2007

M. Mørup, K. H. Madsen, L. K. Hansen, Shifted Independent Component Analysis. Independent Component Analysis and Signal Separation, Lecture Notes in Computer Science 4666, pp. 89-96, 2007

M. N. Schmidt, M. Mørup, Nonnegative Matrix Factor 2-D Deconvolution for Blind Single Channel Source Separation. Independent Component Analysis and Blind Signal Separation 3889 pp. 700-707, 2006

Editorials

A. Cichocki, M. Mørup, P. Smaragdis, W. Wang, and R. Zdunek, Editorial. Advances in Non-negative Matrix and Tensor Factorization, Computational Intelligence and Neuroscience, 2008

Technical Reports

M. Mørup, M. N. Schmidt, L. K. Hansen, Shift Invariant Sparse Coding of Image and Music Data. Technical report no: IMM2008-04659, 2008

M. Mørup, L. K. Hansen, J. Parnas, S. M. Arnfred, Decomposing the time-frequency representation of EEG using non-negative matrix and multi-way factorization. Technical report no: IMM2006-04144, 2006

M. N. Schmidt, M. Mørup, Sparse Non-negative Matrix Factor 2-D Deconvolution for Automatic Transcription of Polyphonic Music. Technical report no: IMM2006-04100, 2006

Submitted Work

M. Mørup, L.K.Hansen, An Exact Relaxation of Clustering. Submitted to Journal of Machine Learning Research, 2009

Selected Software

www.erpwavelab.org: Open source toolbox for analysis and visualization of wavelet transformed event related electroencephalograph (EEG) and magneto-encephalography (MEG) data. (As of 23rd September 2008 downloaded by more than 200 different institutions).

ARDTUCKER and ARD-SC: Algorithms to perform model order estimation for the Tucker and CP model based on Automatic Relevance Determination including sparse coding as a special case.

ShiftCP: Algorithm to estimate the CandComp/PARAFAC model with delay variability across one mode.

sr-clustering: Software based on simplicial relaxation to clustering that recover the assignment problem upon convergence. Can solve k-means, pairwise clustering and community detection in networks based on Modularity and Hamiltonian optimization.

SELECTED INVITED TALKS Bayesian and Non-linear Multi-way analysis, Three-way methods In Chemistry And Psychology, TRICAP 2009, Nuria, Spain, June 2006

The wonders of the L1-norm, Seminar at Informatics and Mathematical Modelling, Seminar at DTU Informatics, April 2008

Decomposing data under invariance constraints, Image Analysis, Computer Graphics and Geoinfor-

matics 9th Annual Workshop, DTU, December 2007

Shift Invariant Data Decomposition, Seminar at Lawrence Livermore Lab, Berkeley, USA, November 2007

Sparseness constraints and non-negative tensor factorization, Session on: Tensor decompositions and their application ICIAM, ETH Zurich, Switzerland, July 2007

Non-negative tensor decomposition, seminar at Scientific Computing, Stanford, USA, October 2006 and Sandia National Lab, Livermore, USA August 2006

An introduction to ERPWAVELAB, Columbia University, October 2006

Extensions of non-negative matrix factorization to higher order data, Three-way methods In Chemistry And Psychology, TRICAP 2006, Crete, Greece, June 2006

REVIEWING
EXPERIENCE

Statistics in Medicine, ISCAS 2007, Computational Intelligence and Neuroscience, EURASIP JASP, IEEE Transactions on Biomedical Engineering, Journal of Neuroscience Methods, EUSIPCO 2008, Computer Physics Communication, Signal Processing, Journal of Chemometrics, EUSIPCO 2009, Neural Processing Letters, Data Mining and Knowledge Discovery.