CV: Maximillian Vording

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EDUCATION

TECHN. UNIV. OF DENMARK
MSc in Mathematical Modelling and Computation
Focus area: Cognitive Science // Machine Learning and Signal Processing
Feb 2015-Jun 2017 | Lyngby, DK
Cum. GPA: 3.94 (US), 10.76 (DK) // Thesis: 12 (DK), A+ (US)

UNIVERSITY OF COPENHAGEN
BSc in Physics
Focus area: Biophysics // Complex Systems
Aug 2011-Dec 2014 | Copenhagen, DK
Grade Avg.: 9.35 (DK) // Thesis: 12 (DK), A+ (US)

SKILLS

PROGRAMMING
`Matlab` • LaTeX • `Python` (`NumPy`, `SciPy`, `Lasagne`, `TensorFlow`, `PyTorch`) • `Java` • `R` • `C` and `C++` (`OpenMP`, `CUDA`) • `MySQL`

EXPERIENCE

TEACHING ASSISTANT | NFYA06018U: Intro to Programming
Sep 2014 - Dec 2014 | UCPH, Copenhagen, DK
- `Matlab` programming - visualize data and simulations through GUI.
- Planning and implementation of exam project in Active Matter simulation

TEACHING ASSISTANT | 02456: Deep Learning
Aug-Dec 2017 | DTU Lyngby, DK
- Guide through and develop exercises on VAE. Supervised 3 projects on SegNet.

PRIVATE TEACHING | Mathematics, Physics and Programming
2012-2017 | Copenhagen, DK
- Teaching students individually on all educational levels

COURSEWORK

(`Matlab` and/or `Python` was used in most courses.)

PHD
Bayesian Data Analysis [DK]
Adv. Topics in Machine Learning [DK]
Summer School on Graphical Models [DK]
MLSS 2019 [ZA]
Bayesian Reading Group [DK]

MASTER
Advanced Machine Learning (`Python`)
High Performance Computing (`C++`)
Cognitive Science and Modelling
Computational Tools for Big Data (`Python`)
Auditory Signal Processing and Perception
Audio Information Processing Systems
Non-Linear Signal Processing
Constrained Optimization
Time Series Analysis (`R`)
Innovation and Product Development
Deep Learning (`Python`, `TensorFlow`)

BACHELOR
Dynamical and Complex systems
Molecular biology (`Python`)
Object oriented programming (`JAVA`)
Quantum Mechanics
Mathematical Methods in Physics, Calculus and Linear Algebra
Electrodynamics and -magnetism
Thermodynamics
Statistical and Experimental Methods
Intro to Programming for Physicists

RESEARCH

DTU COMPUTE: SECTION FOR COGNITIVE SYSTEMS

Advanced Machine Learning Exam Project
Mar 2016 - May 2016 | DTU Lyngby, DK
Super-resolution using Variational Auto-encoders
Supervisor: Ole Winther (PhD. Professor)
- Using Neural Networks in `Python` with `Theano`, `Lasagne` and `Parmesan`
- Creating and presenting a scientific poster and article

Deep Learning Exam Project
Sep 2016 - Dec 2016 | DTU Lyngby, DK
Music generation using recurrent neural networks
Supervisor: Ole Winther (PhD. Professor)
- Using Recurrent Neural Networks (GRU) in `Python` with `Theano` and `Lasagne`.

Master's thesis: Deep learning for single-cell transcript counts
Sep 2016 - Jun 2017 | DTU Lyngby, DK
Gaussian mixture variational auto-encoder
Supervisor: Ole Winther (PhD. Professor), Tune Pers (PhD. Professor)
- Developed variational inference library in `TensorFlow`.
- Handle over-dispersion and sparsity w. zero-inflated count distributions in deep generative model.

PAPERS

Jan 2019 | bioRxiv 318295
scVAE: Variational auto-encoders for single-cell gene expression data
CH Grønbech, MF Vording, PN Timshel, CK Sønderby, TH Pers, O Winther

RESEARCH PROFILE

Here I present you with the research activities I have been running during my Masters and onward in my PhD.
The reports and repositories from my last 3 research projects can be found here:

1. Super-resolution Using Variational Auto-encoding - GitHub
2. Music Generation Using Recurrent Neural Networks - GitHub

- In a course on Deep Learning with Prof. Ole Winther we implemented a GRU-network for music generation by next-step prediction. To enhance the generalization performance of the model and enable generation of new notes from the initial sequence, we were feeding the previous output as the next input.

3. Master's thesis - GitHub

, where we developed a Gaussian mixture variational auto-encoder for modeling single-cell gene expression counts with supervisor, Ole Winther, at The Technical University of Denmark and the biological research group, Pers Lab, at Novo Nordisk Foundation Center for Basic Metabolic Research. During my MSc I've been developing unsupervised and semi-supervised generative models for learning the complex inter-dependencies between distributions of high-dimensional sparse gene expression counts through the low-dimensional representation in auto-encoders. I am expanding the VAE framework from [1] Kingma and Welling to include Gaussian Mixture priors [2, 3, 4], time-dependence in latent space like Chung et al. [7] and likelihood distributions for counts like zero-inflated Poisson and Negative binomial. We can model single-cell transcripts from the Drop-Seq experiment in [9] Macosko et al. and **10x-Genomics**.
By modeling the data generating process in a latent representation, we can acquire clustering of data points and thereby use density and uncertainty sampling for to query for labels on the most representative cluster members and thereby save time in screening of new cell types. We have implemented our scVAE model **Github**
In August 2017 I started my PhD project in Active Deep Learning for Nano-sensor systems at DTU Compute, Section for Cognitive Systems and IDUN center of excellence. Together with my supervisors Professor Jan Larsen, Associate Professor Mikkel N. Schmidt and Senior Researcher Tommy Sonne Alstrøm, I have planned the research in two parts. The first part of research is methodological and will be leveraging the state-of-the-art active learning techniques build in frameworks of Bayesian neural networks and generative models, where model prediction uncertainties and distances in latent space are decision criteria. The second part of the research will be applying the achieved methods and my knowledge in data processing, physics and biology in a users-in-the-loop framework for nano-sensor, drug development and optimal experimental design in close cooperation with the projects at IDUN.
I see no boundaries between the different academic topics of research, when it comes to reaching new scientific findings and technological achievements, which is why I studied a bachelor in Biophysics at the University of Copenhagen to understand the nature of networks behind intelligent behavior. During my Master's program at DTU, applied machine learning various contexts, like cognitive science, musical genre recognition, melody generation and identification of new cell types from single cell transcriptomes.
This multidisciplinary profile will help me in communicating results and ideas beyond my own field of study with analogies and concepts from a broad range of research areas. Complex machine learning models and our hypothesis generation are data driven, so how and what data is collected is crucial for the generalisation performance due to experimental bias and the balance in different classes of data points. Therefore it is important for me to be a part of the data collection from beginning to end, using my broad knowledge of the different fields of research involved in it.
I will be using my broad educational background and cognitive science in developing users-in-the-loop machine learning applications. Here gathering domain knowledge in an efficient way, also means considering the human perception, attention and range of knowledge, so the quality and density of information in the data can be kept high and effort and cost spend by the user low.

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References

1. D. Kingma and M. Welling (2014), Auto-Encoding Variational Bayes, ICLR 2014 [pdf]
2. Dilokthanakul - Deep Unsupervised Clustering With Gaussian Mixture Variational Autoencoders, arXiv e-prints, Nov 2016
3. Ranganath et al. "Hierachical Variational Auto-encoders"
4. Nalisnick (2016 NIPS) - Approximate Inference for Deep Latent Gaussian Mixtures
7. Chung et al., "A Recurrent Latent Variable Model for Sequential Data", ArXiv e-prints, June 2015
8. Fraccaro et al, "Sequential Neural Models with Stochastic Layers"
9. Macosko et al., "Highly Parallel Genome-wide Expression Profiling of Individual Cells Using Nanoliter Droplets", Cell, May 2014