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
Expected Jun 2017 | Lyngby, DK
Cum. GPA: 3.94 (US), 10.76 (DK)

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

COURSEWORK

(Matlab and Python are the programming languages extensively used through courses.)

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

MASTER
Advanced Machine Learning (Python)
High Performance Computing (C/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)
Thesis: VAE for Single-Cell mRNA Counts

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

SKILLS

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

EXPERIENCE

UNIVERSITY OF COPENHAGEN | Teaching Assistant in Course: Intro to Programming for Physicists - NFYA06018U
Sep 2014 - Dec 2014 | 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
Since Aug-Dec 2017 | DTU Lyngby, DK
- Guide through and develop exercises. I supervised 3 exam projects on SegNet.

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

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.

PUBLICATIONS

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 deep learning bioRxiv 318295

RESEARCH PROFILE

Here I present you with the research activities I have been running the last year of my Masters and onwards.
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 used TensorFlow for a variational auto-encoder framework applied on single-cell gene expressions 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 interdependencies 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 probabilistic representation, we can acquire clustering of data points and thereby infer labels from a few cluster members to the whole cluster. All is implemented in Theano with the Lasagne and Parmesan wrapper, but I have also experience, and are implementing our VAE model, in TensorFlow as seen on: Github

In August 2017 I started my PhD project in Active Deep Learning for Nano-sensor systems at DTU Compute's Sections for Cognitive Systems and IDUN center of excellence. Together with Professor Jan Larsen 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 deep neural network and variational generative models. The second part of the research will be applying the achieved methods and my knowledge in data processing, physics and biology in the framework of Nano Sensor and users-in-the-loop systems in close cooperation with the projects at the IDUN center of excellence. I see myself fit for this challenge, as fundamental research in understanding and building complex intelligent systems have been the overarching goal through my studies.

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. I gained an even greater multidisciplinary profile during my Master, where machine learning was applied in 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.

I have won a poster presentation competition at the exam in "02581 Computational Data Analysis". After this I have written three top-grade projects, in the format of soon to be submitted research articles and posters, and now my Master's thesis on the topic of deep generative models under the supervision of Prof. Ole Winther at DTU Compute. I am well experienced in structuring a research project and in scientific writing.

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

Maximillian Fornitz Vording
PhD student in Active Deep Learning for Nano-sensor systems at The Technical University of Denmark
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