Max Horn

Machine Learning in Healthcare · Deep Learning · Interpretable ML
Time Series · Probabilistic Modelling

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EDUCATION

Mar. 2018 – Oct. 2021[1]	**Ph.D.** IN MACHINE LEARNING AND COMPUTATIONAL BIOLOGY ETH ZÜRICH, SWITZERLAND

I develop **deep learning** methods for real world **medical time series data** where I focus on the property of **irregular sampling**. Furthermore, I am interested in **dimensionality reduction** using methods from **topology** in order to preserve the underlying manifold structure of the data. I also use probabilistic modelling to gain insights into real world biological and chemical problems.
Supervisor: Prof. Dr. Karsten M. Borgwardt

Oct. 2015 – Oct. 2017	**M.Sc.** IN MOLECULAR BIOSCIENCES: SYSTEMS BIOLOGY HEIDELBERG UNIVERSITY, GERMANY

Thesis title: "Fully Bayesian Modelling of Covariate Effects on the Gut Microbiome Using Horseshoe Priors for Sparsity Induction"
Supervisors: Prof. Dr. Ursula Kummer, Dr. Frederik Graw & Prof. Eran Elinav
Final grade: 1.0/very good

Oct. 2012 – Oct. 2015	**B.Sc.** MOLECULAR BIOTECHNOLOGY HEIDELBERG UNIVERSITY, GERMANY

Thesis title: "Clustering and Scoring the Druggability of Transient Protein Pockets"
Supervisor: Prof. Dr. Rebecca Wade
Final grade: 1.5/very good

Oct. 2004 – Jul. 2012	GENERAL UNIVERSITY ENTRANCE QUALIFICATION (ABITUR) GYMANSIUM GERABRONN, GERMANY

Final grade: 1.5/very good, awards for excellent performance in mathematics and physics

PUBLICATIONS

Authors who equally contributed to a publication are marked with a †.

CONFERENCE AND JOURNAL PUBLICATIONS

1. **Max Horn**, Michael Moor, Christian Bock, Bastian Rieck, and Karsten Borgwardt. Set Functions for Time Series. In *Proceedings of the 37th International Conference on Machine Learning (ICML)*, 2020

2. Michael Moor†, **Max Horn**†, Bastian Rieck, and Karsten Borgwardt. Topological Autoencoders. In *Proceedings of the 37th International Conference on Machine Learning (ICML)*, 2020

3. Caroline Weis†, **Max Horn**†, Bastian Rieck†, Aline Cuénod, Adrian Egli, and Karsten Borgwardt. Topological and kernel-based microbial phenotype prediction from MALDI-TOF mass spectra. In *Bioinformatics 36*, 2020

4. Stephanie L. Hyland†, Martin Faltys†, Matthias Hüser†, Xinrui Lyu†, Thomas Gumbsch†, Cristóbal Esteban, Christian Bock, **Max Horn**, Michael Moor, et al. Machine learning for early prediction of circulatory failure in the intensive care unit. In *Nature Medicine 26 (3)*, 2019

5. Michael Moor, **Max Horn**, Bastian Rieck, Damian Roqueiro, and Karsten Borgwardt. Early Recognition of Sepsis with Gaussian Process Temporal Convolutional Networks and Dynamic Time Warping. In *Proceedings of the 4th Machine Learning for Healthcare Conference (MLHC)*, 2019

6. Bastian Rieck†, Matteo Togninalli†, Christian Bock†, Michael Moor, **Max Horn**, Thomas Gumbsch, and Karsten Borgwardt. Neural Persistence: A Complexity Measure for Deep Neural Networks Using Algebraic Topology. In *Proceedings of the 7th International Conference on Learning Representations (ICLR)*, 2019

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[1]   Expected graduation date

7. Jotham Suez, Niv Zmora, Gili Zilberman-Schapira, Uria Mor, Mally Dori-Bachash, Stavros Bashiardes, Maya Zur, Dana Regev-Lehavi, Rotem Ben-Zeev Brik, Sara Federici, **Max Horn**, et al. Post-Antibiotic Gut Mucosal Microbiome Reconstitution Is Impaired by Probiotics and Improved by Autologous FMT. In *Cell 174.6*, 2018

8. Antonia Stank, Daria Kokh, **Max Horn**, Elena Sizikova, Rebecca Neil, Joanna Panecka, Stefan Richter, and Rebecca C Wade. TRAPP webserver: predicting protein binding site flexibility and detecting transient binding pockets. In *Nucleic acids research 45.W1*, 2017

9. Max C. Waldhauer, Silvan N. Schmitz, Constantin Ahlmann-Eltze, Jan G. Gleixner, Carolin C. Schmelas, Anna G. Huhn, Charlotte Bunne, Magdalena Büscher, **Max Horn**, et al. Backbone circularization of Bacillus subtilis family 11 xylanase increases its thermostability and its resistance against aggregation. In *Molecular BioSystems 11 (12)*, 2015

WORKSHOPS AND PREPRINT PUBLICATIONS

10. Michael Moor, **Max Horn**, Christian Bock, Karsten Borgwardt, Bastian Rieck. Path Imputation Strategies for Signature Models. In *Artemiss Workshop, ICML*, 2020

11. Caroline Weis[†], **Max Horn**[†], Bastian Rieck[†], Aline Cuenod, Adrian Egli, Karsten Borgwardt. Kernel-based antimicrobial resistance prediction from MALDI-TOF mass spectra. In *Machine Learning for Global Health Workshop, ICML*, 2020

12. Stefan Ganscha, Vincent Fortuin, **Max Horn**, Eirini Arvaniti, and Manfred Claassen. Supervised learning on synthetic data for reverse engineering gene regulatory networks from experimental time-series. In *bioRxiv 356477*, 2018

HONORS AND AWARDS

APR. 2017 – JUN. 2017	PROMOS Scholarship	GERMAN ACADEMIC EXCHANGE SERVICE
	for master's thesis project in the group of Prof. Eran Elinav, Weizmann Institute of Science, Israel	
SEP. 2016 – JAN. 2017	PROMOS Scholarship	GERMAN ACADEMIC EXCHANGE SERVICE
	for research project in the group of Prof. Manfred Claassen, ETH Zürich, Switzerland	
JUN. 2016	MINT EXCELLENCE FINALIST	WIESLOCH, GERMANY
	Participated in the assessment center of the MINT Excellence Fellowship and was rated as one of the top 300 applicants	
NOV. 2014	GRAD PRIZE WINNER	INTERNATIONAL GENETICALLY ENGINEERED MACHINE (IGEM) COMPETITION
	as participant in the Heidelberg 2014 team we won the Grand Prize and Special Prizes of the categories: Best Foundational Advance Project, Best Supporting Software, iGEMer's prize	

PRESENTATIONS

JUL. 2020	SET FUNCTIONS FOR TIME SERIES	37TH INTERNATIONAL CONFERENCE ON MACHINE LEARNING
	I presented our work on "Set Functions for Time Series" which proposes a novel way to handle irregularly-sampled time series by treating them as sets of observation tuples.	
JUL. 2020	UNDERSTANDING NEURONS WITH NEURONS	MACHINE LEARNING SUMMER SCHOOL 2020
	I presented my work on "Understanding Neurons with Neurons – Tackling Spike Sorting with Amortized Variational Inference" where I combine techniques from object recognition and object-centric representations with simulation-based inference to tackle the inverse problem of spike-sorting in neuroscience.	
MAR. 2020	PREDICTING STABILITY OF FOSSIL-EMBEDDED DNA	MLCB GROUP SEMINAR
	In this presentation I showed how probabilistic models can be used to model the stability of DNA in a Fossil-Embedded state. This research is part of an effort to improve long-term data storage in DNA.	
NOV. 2019	TOPOLOGICAL AUTOENCODERS	SWISS MACHINE LEARNING DAY
	I presented our work on "Topological Autoencoders" which utilize concepts from topological data analysis in order to derive topology-preserving low-dimensional representations of high dimensional data.	

Aug. 2019	**CLASSIFYING THE IRREGULAR**	BAYER AG, BERLIN

In "Classifying the Irregular – Learning with Sporadically Sampled Medical Time Series" I presented multiple efforts on how to design machine learning methods for irregularly-sampled time series which are omnipresent in the medical domain.

Jul. 2019	**SCALABLE CLASSIFICATION OF IRREGULAR-SAMPLED TIME SERIES**	MLCB GROUP SEMINAR

Here I presented preliminary results on our research into the application of set functions as a model for irregularly-sampled time series.

Dec. 2018	**DENSITY ESTIMATION IN MULTIMODAL TIME SERIES**	MLCB GROUP SEMINAR

In "Density Estimation in Multimodal Time Series – A Joint Venture of Neural Processes and Normalizing Flows" I presented research on combining Neural Processes with Normalizing Flows for anomaly detection in time series.

SKILLS

Python	Excellent knowledge in `Python`, in the creation of packages and in the utilization of `NumPy`, `pandas`, `Dask` and `JAX`[2].
C++	Good knowledge of `C++` and experienced in the implementation of `CUDA` kernels for accelerating computations using GPUs[3].
Deep Learning	Excellent experience in the development and application of Deep Learning models in both `TensorFlow` and `PyTorch`[4].
Probabilistic Modelling	Excellent experience in probabilistic modelling, in particular in the utilization of probabilistic programming frameworks such as `PyMC3`[5] .
Linux, HPC	Excellent technical skills in the maintenance of network infrastructures and Linux server environments and in setting up computation clusters using the `SLURM` scheduler.
LaTeX	Good knowledge of `LaTex` and experienced in the design of figures using `TikZ`.

SOFTWARE

`simple-gpu-scheduler`	Command line tool for handling and distributing a queue of jobs among GPUs. ⃝ `ExpectationMax/simple_gpu_scheduler` ≈ 300 downloads/month
`SeFT`	Implementation of **S**et **F**unction for **T**ime **S**eries model in `TensorFlow` and `Keras`. ⃝ `BorgwardtLab/Set_Functions_for_Time_Series` ≈ 30 users
`TopoAE`	Implementation of **Topo**logical **A**uto**e**ncoders model in `PyTorch`. ⃝ `BorgwardtLab/topological-autoencoders` ≈ 25 users
`sklearn-jax-kernels`	Composable kernels for scikit-learn classes implemented in JAX. ⃝ `ExpectationMax/sklearn-jax-kernels` ≈ 100 downloads/month
`medical-ts-datasets`	Medical time series datasets for deep learning implemented using `TensorFlow Datasets`. ⃝ `ExpectationMax/medical_ts_datasets`
`HorseshoeDMRegression`	Models for analysing microbiome-covariate effects using hierarchical Dirichlet-Multinomial regression models with sparsity inducing Horseshoe priors. ⃝ `ExpectationMax/HorseshoeDMRegression`
`uea-ucr-datasets`	Time series datasets of the UEA and UCR repository for deep learning frameworks. ⃝ `BorgwardtLab/uea_ucr_datasets`
`bastSim`	C++ Library for large-scale simulations of interacting bacterial populations using GPUs. ⃝ `ExpectationMax/bactSim`

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[2]   See projects `simple-gpu-scheduler`, `sklearn-jax-kernels`, and `uea-ucr-datasets`.
[3]   See project `bactSim`.
[4]   See projects `SeFT`, `medical-ts-datasets` and `topological-autoencoders`.
[5]   See project `HorseshoeDMRegression`.

Service To The Scientific Community

Reviewing
TDA and Beyond NeurIPS Workshop (2020), NeurIPS (2020), AAAI (2021), MLHC (2020, 2019), ISMB (2020), Swiss Machine Learning Day (2019), ECML-PKDD (2019), Springer Machine Learning (2019)

Teaching
Teaching assistant in Data Mining I – ETH Zürich (2019)

Contributions to Open source software
 tensorflow/tensorflow, tensorflow/datasets, hyperopt/hyperopt, palantir/python-language-server, PyTorchLightning/pytorch-lightning, IDSIA/sacred

Extracurricular Activities

2020 | **Machine Learning Summer School 2020** Online
Accepted as a full participant after competitive selection process (acceptance rate of $\approx 13\%$). Presented work on "Understanding Neurons with Neurons – Tackling Spike Sorting with Amortized Variational Inference". Participated in two weeks of lectures and discussion rounds with many core players in the field of Machine Learning.

2019 | **MLFPN Summer School 2019** Muttenz, Switzerland
Accepted as participant of the **M**achine **L**earning **F**rontiers in **P**recision **M**edicine summer school which consisted of one week of lectures and discussions with experts at the intersection of machine learning and precision medicine.

Personal

Blogging | One of the most important aspects of this internet is that it allows us to share experiences and information with people of similar interests. I use my blog to help others who need to deal with similar issues and to share thoughts and summaries about research I am interested in.

NeoVim | As a passionate programmer, I optimized my editor to fit my needs and be compatible with the projects I am working on. `NeoVim` has become an essential tool of my day-to-day life. I write my lab book, papers, presentations and code in `NeoVim` and occasionally blog about how to extend it into a full-fledged IDE using modern approaches such as language servers.

Reverse Engineering | In my free time I enjoy working on small electronics projects, often involving reverse engineering old devices and making them function again or adapting their use case. In my most recent project I obtained an old Flip-dot display built in the 1970's, reverse engineered it in order to understand how to display digits and repurposed it as a minimal clock.

Recreational | As recreational activities I enjoy reading popular science and science fiction books and bouldering.