

# Max Horn

MACHINE LEARNING IN HEALTHCARE · DEEP LEARNING · INTERPRETABLE ML  
TIME SERIES · PROBABILISTIC MODELLING

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## EDUCATION

MAR. 2018 – NOV. 2021 <sup>1</sup>	<b>PH.D. IN MACHINE LEARNING AND COMPUTATIONAL BIOLOGY</b> ETH ZÜRICH, SWITZERLAND I develop <b>deep learning</b> methods for real world <b>medical time series data</b> where I focus on the property of <b>irregular sampling</b> . Furthermore, I am interested in <b>dimensionality reduction</b> using methods from <b>topology</b> 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. <b>Supervisor:</b> Prof. Dr. Karsten M. Borgwardt
OCT. 2015 – OCT. 2017	<b>M.Sc. IN MOLECULAR BIOSCIENCES: SYSTEMS BIOLOGY</b> HEIDELBERG UNIVERSITY, GERMANY <b>Thesis title:</b> “Fully Bayesian Modelling of Covariate Effects on the Gut Microbiome Using Horseshoe Priors for Sparsity Induction” <b>Supervisors:</b> Prof. Dr. Ursula Kummer, Dr. Frederik Graw & Prof. Eran Elinav <b>Final grade:</b> 1.0/very good
OCT. 2012 – OCT. 2015	<b>B.Sc. MOLECULAR BIOTECHNOLOGY</b> HEIDELBERG UNIVERSITY, GERMANY <b>Thesis title:</b> “Clustering and Scoring the Druggability of Transient Protein Pockets” <b>Supervisor:</b> Prof. Dr. Rebecca Wade <b>Final grade:</b> 1.5/very good
OCT. 2004 – JUL. 2012	<b>GENERAL UNIVERSITY ENTRANCE QUALIFICATION (ABITUR)</b> GYMANSIUM GERABRONN, GERMANY <b>Final grade:</b> 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 37<sup>th</sup> International Conference on Machine Learning (ICML)*, 2020
2. Michael Moor<sup>†</sup>, **Max Horn**<sup>†</sup>, Bastian Rieck, and Karsten Borgwardt. Topological Autoencoders. In *Proceedings of the 37<sup>th</sup> International Conference on Machine Learning (ICML)*, 2020
3. Caroline Weis<sup>†</sup>, **Max Horn**<sup>†</sup>, Bastian Rieck<sup>†</sup>, 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<sup>†</sup>, Martin Faltys<sup>†</sup>, Matthias Hüser<sup>†</sup>, Xinrui Lyu<sup>†</sup>, Thomas Gumbsch<sup>†</sup>, 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 4<sup>th</sup> Machine Learning for Healthcare Conference (MLHC)*, 2019
6. Bastian Rieck<sup>†</sup>, Matteo Togninalli<sup>†</sup>, Christian Bock<sup>†</sup>, 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 7<sup>th</sup> International Conference on Learning Representations (ICLR)*, 2019

<sup>1</sup> 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<sup>†</sup>, **Max Horn**<sup>†</sup>, Bastian Rieck<sup>†</sup>, 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	37 <sup>TH</sup> 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 <sup>2</sup> .
C++	Good knowledge of C++ and experienced in the implementation of CUDA kernels for accelerating computations using GPUs <sup>3</sup> .
Deep Learning	Excellent experience in the development and application of Deep Learning models in both TensorFlow and PyTorch <sup>4</sup> .
Probabilistic Modelling	Excellent experience in probabilistic modelling, in particular in the utilization of probabilistic programming frameworks such as PyMC3 <sup>5</sup> .
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 $\approx$ 300 downloads/month
SeFT	Implementation of Set Function for Time Series model in TensorFlow and Keras. 📦 BorgwardtLab/Set_Functions_for_Time_Series $\approx$ 30 users
TopoAE	Implementation of Topological Autoencoders model in PyTorch. 📦 BorgwardtLab/topological-autoencoders $\approx$ 25 users
sklearn-jax-kernels	Composable kernels for scikit-learn classes implemented in JAX. 📦 ExpectationMax/sklearn-jax-kernels $\approx$ 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
bactSim	C++ Library for large-scale simulations of interacting bacterial populations using GPUs. 📦 ExpectationMax/bactSim

<sup>2</sup> See projects simple-gpu-scheduler, sklearn-jax-kernels, and uea-ucr-datasets.

<sup>3</sup> See project bactSim.

<sup>4</sup> See projects SeFT, medical-ts-datasets and topological-autoencoders.

<sup>5</sup> See project HorseshoeDMRegression.

## SERVICE TO THE SCIENTIFIC COMMUNITY

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### 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

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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 Machine Learning Frontiers in Precision Medicine summer school which consisted of one week of lectures and discussions with experts at the intersection of machine learning and precision medicine.	

## PERSONAL

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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.