

Nathanael Bosch

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Research Interests

Probabilistic machine learning *for* and *with* dynamical systems: probabilistic numerics, scientific machine learning, differential equations, state-space models, Bayesian filtering and smoothing, Gaussian processes.

Education

University of Tübingen <i>Ph.D. candidate in Computer Science</i> With the International Max Planck Research School for Intelligent Systems (IMPRS-IS). Doctoral thesis: "A Flexible and Efficient Framework for Probabilistic Numerical Simulation and Inference". Advisor: Philipp Hennig.	Tübingen, Germany 2020/05 – today
Technical University of Munich <i>M.Sc. Data Engineering and Analytics</i> Passed with Distinction. German Grade 1.3, American GPA 3.7 Master thesis: "Learning Gaussian Process Dynamics Models from Visual Observations for Control".	Munich, Germany 2018/04 – 2019/10
Technical University of Munich <i>M.Sc. Mathematics</i> Passed with High Distinction. German Grade 1.2, American GPA 3.8. Master thesis: "Evolutionary Games for Global Function Minimization".	Munich, Germany 2016/10 – 2018/10
Technical University of Munich <i>B.Sc. Mathematics</i> Passed with Distinction. German Grade 1.8, American GPA 3.2. Bachelor thesis: "Different Noise Models in Variable Density Compressed Sensing".	Munich, Germany 2012/10 – 2016/06
Landesgymnasium für Hochbegabte <i>Abitur</i> German Grade 1.4, American GPA 3.6.	Schwäbisch Gmünd, Germany 2007/09 – 2012/06

Professional Experience

Amazon Web Services <i>Applied Scientist Intern</i> Automatic machine learning for time series forecasting. With Oleksandr Shchur and Caner Türkmen.	Berlin, Germany 2024/08 – 2025/01
University of Tübingen <i>Research Assistant</i> Supervised by Philipp Hennig, in the Methods of Machine Learning group. Researching and developing probabilistic numerical solvers for differential equations.	Tübingen, Germany 2020/05 – 2024/06
Max Planck Institute for Intelligent Systems, Embodied Vision Group <i>Student Assistant</i> Master's thesis project on "Learning Gaussian Process Dynamics Models from Visual Observations for Control". Supervised by Jörg Stückler.	Tübingen, Germany 2019/03 – 2019/10
Horváth&Partners <i>Data Science Intern</i> Basket analysis of a large quantity of real-world retail sales data. Methods and results were published as part of a german business analytics book ("Strategische Unternehmensführung mit Advanced Analytics").	Munich, Germany 2016/05 – 2016/07

Publications

Peer-reviewed articles

Jonas Beck, **Nathanael Bosch**, Michael Deistler, Kyra L. Kadhim, Jakob H. Macke, Philipp Hennig, and Philipp Berens. “Diffusion Tempering Improves Parameter Estimation with Probabilistic Integrators for Ordinary Differential Equations”. International Conference on Machine Learning, **ICML**, 2024.

Nathanael Bosch. “ProbNumDiffEq.jl: Probabilistic Numerical Solvers for Ordinary Differential Equations in Julia”. Journal of Open Source Software, **JOSS**, 2024.

Nathanael Bosch, Adrien Corenflos, Fatemeh Yaghoobi, Filip Tronarp, Philipp Hennig, and Simo Särkkä. “Parallel-in-Time Probabilistic Numerical ODE Solvers”. Journal of Machine Learning Research, **JMLR**, 2024.

Amon Lahr, Filip Tronarp, **Nathanael Bosch**, Jonathan Schmidt, Philipp Hennig, and Melanie N. Zeilinger. “Probabilistic ODE Solvers for Integration Error-aware Numerical Optimal Control”. Learning for Dynamics & Control Conference, **L4DC**, 2024.

Nathanael Bosch, Philipp Hennig, and Filip Tronarp. “Probabilistic Exponential Integrators”. Conference on Neural Information Processing Systems, **NeurIPS**, 2023.

Nathanael Bosch, Filip Tronarp, and Philipp Hennig. “Pick-and-Mix Information Operators for Probabilistic ODE Solvers”. International Conference on Artificial Intelligence and Statistics, **AISTATS**, 2022.

Nicholas Krämer*, **Nathanael Bosch***, Jonathan Schmidt*, and Philipp Hennig. “Probabilistic ODE Solutions in Millions of Dimensions”. International Conference on Machine Learning, **ICML**, 2022.

Filip Tronarp*, **Nathanael Bosch***, and Philipp Hennig. “Fenrir: Physics-Enhanced Regression for Initial Value Problems”. International Conference on Machine Learning, **ICML**, 2022.

Nathanael Bosch, Philipp Hennig, and Filip Tronarp. “Calibrated Adaptive Probabilistic ODE Solvers”. International Conference on Artificial Intelligence and Statistics, **AISTATS**, 2021.

Nathanael Bosch*, Jan Achterhold*, Laura Leal-Taixé, and Jörg Stückler. “Planning from Images with Deep Latent Gaussian Process Dynamics”. Learning for Dynamics & Control Conference, **L4DC**, 2020.

Preprints

Joanna Sliwa, Frank Schneider, **Nathanael Bosch**, Agustinus Kristiadi, and Philipp Hennig. “Efficient Weight-Space Laplace-Gaussian Filtering and Smoothing for Sequential Deep Learning”. arXiv, 2024.

Jonathan Wenger, Nicholas Krämer, Marvin Pförtner, Jonathan Schmidt, **Nathanael Bosch**, Nina Effenberger, Johannes Zenn, Alexandra Gessner, Toni Karvonen, François-Xavier Briol, Maren Mahsereci, and Philipp Hennig. “ProbNum: Probabilistic Numerics in Python”. arXiv, 2021.

* indicates equal contribution.

Software

ProbNumDiffEq.jl

Maintainer

Probabilistic Numerical Differential Equation solvers via Bayesian filtering and smoothing in Julia; compatible with the popular DifferentialEquations.jl / SciML ecosystem. Package presented at the JuliaCon 2024 in Eindhoven.

probnum

Contributor

A library for probabilistic numerics in Python, which covers not only differential equations and Bayesian state estimation, but also linear solvers, numerical quadrature, and more.

Teaching Experience

University of Tübingen

Tübingen, Germany

Co-lecturer: “Numerics of Machine Learning”

2022 / 2023

Gave two full M.Sc.-level lectures on “Ordinary Differential Equations” and “Probabilistic Numerical ODE Solvers”, as part of a course taught by Philipp Hennig and multiple other PhD students from the Methods of Machine Learning group.

Uppsala University

Uppsala, Sweden

Guest lecturer: “Probabilistic Numerics for Ordinary Differential Equations”

2022

Gave a single guest lecture as a part of a seminar on “A computational introduction to stochastic differential equations”, organized and taught by Zheng Zhao.

University of Tübingen

Tübingen, Germany

Teaching assistant: “Data Literacy”, taught by Philipp Hennig.

2021 / 2022

University of Tübingen

Tübingen, Germany

Seminar: “Machine learning for and with dynamical systems”

2021

Jointly organized with Nicholas Krämer and Philipp Hennig.

University of Tübingen

Tübingen, Germany

Teaching assistant: “Time Series”, taught by Filip Tronarp.

2020 / 2021

Technical University of Munich

Munich, Germany

Teaching assistant: “Principles of Mathematics 2”

2017

Mathematics course, aimed at B.Sc. Engineering Science students.

abiturma GbR

Munich and Stuttgart, Germany

Course instructor

2016 & 2017

Intensive five-day preparation course for the German Abitur in mathematics.

Supervision

Fabrice van der Lehr, Master’s thesis

2024

“Bayesian Filtering for Black Box Simulators”; co-supervised with Tobias Weber.

Sofiya Garkot, Essay rotation

2023 / 2024

“Exploring Probabilistic Solvers for Hodgkin-Huxley Models”; co-supervised with Jonas Beck.

Thomas Albrecht, Master’s thesis

2021 / 2022

“Bayesian Physics-Informed Neural Networks via Laplace Approximations”.

Felix Böhm, Bachelor’s thesis

2021 / 2022

“Inferring ODE Parametric Latent Forces via Neural ODEs”.

Dingling Yao, Master’s thesis

2021

“Uncertainty Propagation in Probabilistic Ordinary Differential Equation Solvers”; co-supervised with Filip Tronarp.

Joanna Sliwa, Essay rotation

2021

“Physics-Informed Neural Networks”; co-supervised with Nicholas Krämer.

Invited talks

Probabilistic Numerics Workshop (ProbNum24)

London, United Kingdom

Talk: “Robust Parameter Inference in ODEs via Physics-Enhanced Gaussian Process Regression”

2024/07

Probabilistic Numerics Spring School

Southampton, United Kingdom

Practical session: “Probabilistic Numerics for ODEs”

2024/04

International Conference on Scientific Computing and Machine Learning

Kyoto, Japan

Talk: “Probabilistic Numerical Solvers for Differential Equations”

2024/03

SIAM Conference on Uncertainty Quantification

Trieste, Italy

Talk: “Probabilistic Numerics for Ordinary Differential Equations”

2024/02

Statistics PhD seminar, University of Edinburgh

Edinburgh, United Kingdom (virtual)

Talk: “Probabilistic Numerics for Ordinary Differential Equations”

2023/05

Probabilistic Numerics Spring School <i>Practical session: "Probabilistic Numerics for ODEs"</i>	Tübingen, Germany 2023/03
Institute for Dynamic Systems and Control, ETH Zurich <i>Talk: "ODE Solvers as Gauss–Markov Regression"</i>	Zurich, Switzerland 2023/01
Sensor informatics and medical technology group, Aalto University <i>Talk: "Solving Differential Equations with Bayesian Filtering and Smoothing"</i>	Aalto, Finland 2022/05
Dagstuhl Seminar on Probabilistic Numerical Methods <i>Talk: "ProbNumDiffEq.jl: Fast and Practical ODE Filters in Julia"</i>	Wadern, Germany 2021/10

Review services

International Conference on Machine Learning (ICML)	2022, 2023, 2024
Conference on Neural Information Processing Systems (NeurIPS)	2021, 2022, 2023
International Conference on Artificial Intelligence and Statistics (AISTATS)	2021, 2022, 2023, 2024
Transactions on Machine Learning Research (TMLR)	2022 – 2023
AI4DifferentialEquations in Science (ICLR workshop)	2024

Technical skills

Working knowledge: Julia, Python, jax, NumPy/SciPy, PyTorch, git/GitHub, \LaTeX , Unix, GNU Emacs.

Basic knowledge: C/C++, SLURM, MATLAB, R, SQL.

Languages

German: Native speaker

French: Near native

English: Fluent

Spanish: Good working knowledge

Russian: Basic communication skills

Scholarships

German Academic Scholarship Foundation	2013 – 2019
Siemens Mentoring Program	2017 – 2018