

Tom S. Bertalan

POSTDOCTORAL FELLOW AT JOHNS HOPKINS WHITING SCHOOL OF ENGINEERING

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*Machine learning and dynamical systems researcher specialized in neural system identification and unsupervised representations.
Proficient in handling high-dimensional time-series data for both offline parameter optimization and online execution.*

SKILLS

Libraries, frameworks, & tools

- Python/C++
- NumPy+SciPy+Matplotlib
- Pytorch/TensorFlow/Keras
- Linux and shell scripting
- Git/Subversion
- VSCode/Eclipse+PyDev
- Scikit-Learn

Areas of Expertise and Training

- Computer vision
- Dimension reduction and representation learning
- Deep learning and ML
- Probabilistic modeling and theory
- Nonlinear dynamics of time series data
- Research presentation and dissemination
- Trainee and peer mentoring

Other Skills and Interests

- Home automation with Arduino, Raspberry Pi, and 3D printing
- Solo and orchestral violin performance
- Windsurfing and small-boat sailing

PROFESSIONAL EXPERIENCE AND RESEARCH AREAS

Johns Hopkins University

Baltimore, MD

POSTDOCTORAL FELLOW

3/2020-Present

• Time Series and PDE Analysis with Neural ODEs

- Advanced SotA for neural DEs for time series, including CNNs for PDEs; conceived a novel loss function for Hamiltonian systems.
- Cut RNN inference burn-in from 25 to 5 samples using manifold learning.
- Derived custom gradients for nets with constraints; promoted theory on error scaling laws; applications in biomanufacturing.
- Parallelized neural PDE solution sensitivity analysis using SLURM on GPU cluster.

• Biophysical Experiment and Simulation Enhancement

- Led a team of biophysics and ML experts in creating a suite of Python/MATLAB simulation and data processing tools.
- Created a GUI for Bayesian experimental design; mentored team members on its use and maintenance.

• Robotic Systems Development and Upgrades

- Developed a variational autoencoder for end-to-end robotic localization.
- Used Blender to create synthetic datasets for alternate-view synthesis.
- Upgraded rover with IMU and RealSense, resulting in enhanced odometry for RTAB-MAP SLAM.
- Trained a U-net on both open and custom datasets for real-time (>10hz) on-board semantic segmentation of drivable space.
- Built a GPS-guided hexacopter from 3D-printed parts.
- Inferred depth and semantic segmentation in simulation, using pre-trained transformer networks.
- Calibrated camera intrinsics for projective geometry of segmented point clouds.
- Profiled depth/segmentation pipeline to ensure pure-GPU inference for real-time inference.

• Special Projects and Innovations

- Automated conversion of seminar announcements to ICS files via OpenAI API, including curation of a 19.7k-word fine-tuning dataset.
- Administered lab GPU server for maximum uptime and ease of access for multiple concurrent users.
- Stood up local Llama2 inference server for various internal automation tasks via REST API over VPN.
- Wrote specifications and solicited bids for an upcoming multi-GPU training server destined for datacenter colocation.

The Massachusetts Institute of Technology

Cambridge, MA

POSTDOCTORAL ASSOCIATE

3/2018-3/2020

• Autonomous Vehicle Design and Pathfinding

- Developed a model AV with firmware-level speed sensing and control commanded by checksummed bus communications.
- Designed a jerk-minimizing path planner capable of planing up to two lane switches ahead at 47 mph.
- Leveraged Ipopt and CppAD to push a model-predictive path follower to a latency of 67 ms in simulation.
- Taught summer courses on OpenCV, ROS, and CNNs for lane detection, path following, and traffic sign recognition.
- Wrote wrapper APIs for using video games as robotic simulations.
- Detected dashcam obstacles via windowed SVM.
- Designed compute board mounting brackets in CAD for 3D printing.

• Nonlinear dynamics in neuroscience

- Wrote object-oriented library for fine- and coarse-grained simulation of neuronal dynamics.
- Analyzed bifurcation and resonance behavior of a mammalian circadian rhythm model.
- Played a key role in acquiring a \$1.8M grant for an industry-academic partnership.

Princeton University

NSF RESEARCH ASSISTANT

Princeton, NJ

9/2012-3/2018

- **Robotic Hardware, Integration, and Computer Vision Software Development**

- Built a differential-drive rover for research in particle-filter SLAM via LIDAR, against a ROS baseline.
- Modeled robot in Gazebo for fast algorithm prototyping.
- Architected an OpenCV library inspired by TensorFlow 1 for compile-time optimization of graph-structured pipelines.

- **High-Performance Computation for Neuroscience and Behavioral Ecology**

- Coarse-grained bifurcation analysis of simulations of up to several thousand Biological neurons, using measure-orthogonal polynomial expansion..
- Used OpenMP to accelerate C++ object-oriented simulation animal social dynamics.

The University of Alabama

STUDENT RESEARCH ASSISTANT

Tuscaloosa, AL

9/2009-5/2012

- **High-Performance Computing Cluster Development**

- Created a 10-node Beowulf cluster from scratch in PHP using surplus hardware.
- Explored CUDA for PDE acceleration.
- Built a social network for collaborative story-writing on a LAMP stack.

- **Advanced Simulation Techniques**

- Simulated hierarchy formation in social animals, generating hypotheses for future wet-lab experiments.
- Wrote and presented a multigrid subsurface-flow solver.

EDUCATION & TRAINING

Institutions

• Johns Hopkins University	2020 - Present
Postdoctoral Fellow	ChBE
• The Massachusetts Institute of Technology	2018 - 2020
Postdoctoral Associate	ME
• Princeton University	2012 - 2018
NSF Research Fellow	PhD & MA, ChBE
• The University of Alabama	2008 - 2012
Student Research Assistant	BS ChBE; Minor in Math

Awards

- Princeton Program in Plasma Science and Technology research and academic fellowship
- National Science Foundation research fellowship
- William R. Schowalter fund for scholarly conferences
- National merit finalist scholarship
- University honors program and president's list
- $\Phi\chi\Sigma$, $\Omega\chi E$, and $TB\Pi$ honor societies

Teaching

- Volunteered in a recurring summer course for high-school seniors and freshmen on employing ROS, OpenCV, and CNNs for lane detection and traffic sign recognition.
- Supervised operations and measurement activities in junior Chemical & Biological Engineering practicum.
- Instructed in recitation, office hours, and grading as assistant instructor for senior differential equations course.

SELECTED PUBLICATIONS

A longer list of publications and presentations is available upon request.

Implementation and (Inverse Modified) Error Analysis for implicitly-templated ODE nets

Aiqing Zhu, Beibei Zhu, [Tom Bertalan](#), Yifa Tang, Ioannis Kevrekidis

Under Review
arXiv:2303.17824

Transformations between deep neural networks

[Tom Bertalan](#), Felix Dietrich, Ioannis Kevrekidis

Under Review
arXiv:2007.05646

Certified Invertibility in Neural Networks via Mixed-Integer Programming

Tianqi Cui, [Tom Bertalan](#), George J. Pappas, Manfred Morari, Ioannis Kevrekidis, Mahyar Fazlyab

2023
L4DC 2023 — PMLR

Learning emergent PDEs in a learned emergent space

Felix Kemeth, [Tom Bertalan](#), Thomas Thiem, Seungjoon Moon, Carlo Laing, Ioannis Kevrekidis

2022
Nature Comm.

Initializing LSTM internal states via manifold learning

Felix Kemeth, [Tom Bertalan](#), Nikolaos Evangelou, Tianqi Cui, Saurabh Malfani, Ioannis Kevrekidis

2021
Chaos

Local conformal autoencoder for standardized data coordinates

Erez Peterfreund, Ofir Lindenbaum, Felix Dietrich, [Tom Bertalan](#), Matan Gavish, Ioannis Kevrekidis, Ronald Coifman

2020
PNAS

On Learning Hamiltonian Systems from Data

[Tom Bertalan](#), Felix Dietrich, Igor Mezic, and Ioannis Kevrekidis

2019
Chaos

PUBLICATIONS

Machine Learning Approaches to Problem Well-Posedness

Tom Bertalan, George Kevrekidis, Elizaveta Rebrova, Siddhartha Mishra, Yannis Kevrekidis

In Preparation

Data-driven and Physics Informed Modelling of Chinese Hamster Ovary (CHO) Cell Bioreactors

Tianqi Cui, [Tom Bertalan](#), Nelson Ndaïro, Pratik Khare, Michael Betenbaugh, Costas Maranas, Ioannis Kevrekidis

Under Review
arXiv:2305.03257

Implementation and (Inverse Modified) Error Analysis for implicitly-templated ODE nets

Aiqing Zhu, Beibei Zhu, [Tom Bertalan](#), Yifa Tang, Ioannis Kevrekidis

Under Review
arXiv:2303.17824

Transformations between deep neural networks

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arXiv:2007.05646

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Tianqi Cui, [Tom Bertalan](#), George J. Pappas, Manfred Morari, Ioannis Kevrekidis, Mahyar Fazlyab

2023
L4DC 2023 — PMLR

Some of the variables, some of the parameters, some of the times, with some things known: Identification with partial information

Saurabh Malani, [Tom Bertalan](#), Tianqi Cui, Michael Betenbaugh, Jose L. Avalos, Ioannis Kevrekidis

2023
Comp. & Chem. Engr.

Learning effective stochastic differential equations from microscopic simulations: linking stochastic numerics to deep learning

Felix Dietrich, Alexei Makeev, George Kevrekidis, Nikolaos Evangelou, [Tom Bertalan](#), Sebastian Reich, Ioannis Kevrekidis

2023
Chaos

Learning emergent PDEs in a learned emergent space

Felix Kemeth, [Tom Bertalan](#), Thomas Thiem, Seungjoon Moon, Carlo Laing, Ioannis Kevrekidis

2022
Nature Comm.

Personalized Algorithm Generation: A Case Study in Meta-Learning ODE Integrators

Y. Guo, Felix Dietrich, [Tom Bertalan](#), D. T. Doncevic, M. Dahmen, Ioannis Kevrekidis, Qianxiao Li

2022
SIAM J. Sci. Comp.

Initializing LSTM internal states via manifold learning

Felix Kemeth, [Tom Bertalan](#), Nikolaos Evangelou, Tianqi Cui, Saurabh Malfani, Ioannis Kevrekidis

2021
Chaos

Development of closures for coarse-scale modeling of multiphase and free surface flows using machine learning

Cristina Linares, [Tom Bertalan](#), Eleni Koronaki, Jicai Lu, Gretar Tryggvason, Ioannis Kevrekidis

2021
APS Bulletin

Global and local reduced models for interacting, heterogeneous agents

Thomas Thiem, Felix Kemeth, [Tom Bertalan](#), Carlo Liang, Ioannis Kevrekidis

2021
Chaos

Local conformal autoencoder for standardized data coordinates

Erez Peterfreund, Ofir Lindenbaum, Felix Dietrich, [Tom Bertalan](#), Matan Gavish, Ioannis Kevrekidis, Ronald Coifman

2020
PNAS

Emergent spaces for coupled oscillators

Thomas Thiem, Mahdi Kooshkbaghi, [Tom Bertalan](#), Carol Laing, Ioannis Kevrekidis

2020
Front. in Comp. Neuro.

On Learning Hamiltonian Systems from Data

[Tom Bertalan](#), Felix Dietrich, Igor Mezic, and Ioannis Kevrekidis

2019
Chaos

An Emergent Space for Distributed Data with Hidden Internal Order through Manifold Learning

Felix Kemeth, Sindre Haugland, Felix Dietrich, [Tom Bertalan](#), Kevin Höhle, Qianxiao Li, Erik Bollt, Ronen Talmon, Katharina Krischer, and Ioannis Kevrekidis

2017
IEEE Access

Coarse-grained descriptions of dynamics for networks with both intrinsic and structural heterogeneities

[Tom Bertalan](#), Yan Wu, Carlo Laing, C. William Gear, and Ioannis Kevrekidis.

2017
Front. in Comp. Neuro.

Dimension reduction in heterogeneous neural networks: Generalized Polynomial Chaos (gPC) and Analysis-Of-Variance (ANOVA)

Minseok Choi, [Tom Bertalan](#), Carlo Laing, and Ioannis Kevrekidis.

2016
Euro. Phys. J., Special Topics

OpenMG: a new multigrid implementation in Python

[Tom Bertalan](#), Akand Islam, Roger Sidje, and Eric Carlson

2014
Num. Lin. Alg. with App.

PRESENTATIONS

Certified Invertibility in Neural Networks via Mixed-Integer Programming

Tianqi Cui, [Tom Bertalan](#), George J. Pappas, Manfred Morari, Ioannis Kevrekidis, Mahyar Fazlyab

2023

Learning for Dyn. Sys.

Coarse-grained and emergent distributed-parameter systems from data

Hassan Arbabi, Felix Kemeth, [Tom Bertalan](#), Ioannis Kevrekidis

2021

American Control Conf.

Data-driven model reduction and discovery

Thomas Thiem, [Tom Bertalan](#), Felix Kemeth, Yorgos Psarellis, Ioannis Kevrekidis

2020

AIChE

Dynamical-systems-guided learning of PDEs from data

Hassan Arbabi, [Tom Bertalan](#), Anthony Roberts, Ioannis Kevrekidis

2020

AIChE

On the data-driven discovery and calibration of closures

Seungjoon Lee, Yorgos Psarellis, Constantinos Siettos, [Tom Bertalan](#), Daniel Amchin, Tapomoy Bhat-tacharjee, Sujit Datta, Ioannis Kevrekidis

2020

AIChE

Connections between residual networks and explicit numerical integrators, and applications to identification of noninvertible dynamical systems

Tianqi Cui, [Tom Bertalan](#), Yorgos Psarellis, Ioannis Kevrekidis

2020

AIChE

Neural network approach to reduced order modeling of multiphase flows

Cristina Linares, [Tom Bertalan](#), Seungjoon Lee, Jicai Lu, Gretar Tryggvason, Ioannis Kevrekidis

2020

APS Div. of Fluid Dyn.

PDE+PINN: Learning and Solving a PDE at the Same Time

[Tom Bertalan](#), Felix Kemeth, Tianqi Cui, Ioannis Kevrekidis

2020

AIChE

Learning Partial Differential Equations from Discrete Space Time Data: Convolutional and Re-current Networks, and Their Relations to Traditional Numerical Methods

[Tom Bertalan](#), Felix Dietrich, Thomas Thiem, Rob Farber, Ioannis Kevrekidis, Anthony Roberts

2019

AIChE

Recurrent Neural Networks, Numerical Integrators and Nonlinear System Identification

[Tom Bertalan](#), Rob Farber, Thomas Thiem, Felix Dietrich, Ioannis Kevrekidis

2018

AIChE

Coarse-Scale PDEs from Microscopic Observations Via Machine Learning

Seungjoon Lee, Mahdi Kooshkbaghi, Constantinos Siettos, [Tom Bertalan](#), and Ioannis Kevrekidis

2019

AIChE

When Have Two Networks Learned the Same Task? Data-Driven Transformations between Sys-tem Representations

[Tom Bertalan](#), Felix Dietrich, Thomas Thiem, Ioannis Kevrekidis

2019

AIChE

Coarse modeling of circadian rhythms in heterogeneous neural networks

[Tom Bertalan](#), C. William Gear, Yannis G. Kevrekidis, Michael Henson, Erik Herzog, and Carlo Laing

2017; 2016

Dyn. Days 2017; AIChE

Coarse-graining of heterogeneous neural dynamics

[Tom Bertalan](#), Minseok Choi, Carlo Laing, Ioannis Kevrekidis

2015

AIChE

Heterogeneity and reduction for complex network dynamics

Ioannis Kevrekidis, Alexander Holoday, [Tom Bertalan](#), and Carlo Laing

2014

AIChE

Polynomial representations of populations with multiple heterogeneities

[Tom Bertalan](#), Yan Wu, Brianna Hnath, and Yannis Kevrekidis

2014

Princeton Grad. Student Symp.

Coarse-graining Network Dynamics

Alexander Holoday and [Tom Bertalan](#)

2013

Network Front.

nSpyres: an open-source, Python-based framework for simulation of flow through porous me-dia

Eric Carlson, Akand Islam, Francis Dumkwu, and [Tom Bertalan](#)

2012

Interpore 2012

OpenMG: a new multigrid implementation in Python

[Tom Bertalan](#), Akand Islam, Roger Sidje, and Eric Carlson

2012

Proc. 11th Python in Sci. Conf.

ESIM: a framework for simulation of dominance hierarchy formation in small animal groups

[Tom Bertalan](#) and Ryan Earley

2012

UA Hon. Undergr. Res. Conf.

An open-source computing cluster for virtual experiments with variable parameters

[Tom Bertalan](#) and Eric Carlson

2011

UA Hon. Undergr. Res. Conf.