

# 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

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### 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
- Scientific computing
- 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

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### Johns Hopkins University

POSTDOCTORAL FELLOW

Baltimore, MD

3/2020-Present

#### • **Time Series and PDE Analysis with Neural ODEs**

- Advanced neural DEs for time series, including CNNs for PDEs; with a novel loss function for Hamiltonian systems.
- Cut RNN inference burn-in from 25 to 5 samples through manifold learning.
- Derived custom gradients for nets with constraints; put forward theory on error scaling laws, plus biomanufacturing applications.

#### • **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 multi-view synthesis.
- Upgraded rover with IMU and RealSense, resulting in enhanced odometry for RTAB-MAP SLAM.
- Engineered a two-step training protocol for real-time (>10hz) onboard neural segmentation of drivable space by U-net, leveraging both open and custom datasets.
- Constructed GPS-navigable hexacopter from 3D-printed parts.
- Estimated depth and segmentation by pre-trained transformer networks in simulation.
- Optimized projective geometry settings for enhanced point cloud segmentation.
- Streamlined depth-segmentation pipeline for GPU-exclusive, 10Hz execution.

#### • **Special Projects and Innovations**

- Automated conversion of seminar announcements to ICS files with OpenAI API, including curation of a 19.7k-word dataset.
- Administered lab GPU server for maximum uptime, ease of access for multiple concurrent users.
- Wrote specifications and solicited bids for an upcoming multi-GPU training server destined for datacenter colocation.

### The Massachusetts Institute of Technology

POSTDOCTORAL ASSOCIATE

Cambridge, MA

3/2018-3/2020

#### • **Autonomous Vehicle Design and Pathfinding**

- Developed a model AV with firmware-level speed sensing and control, and noise-rejecting communication protocols.
- Crafted 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 67 ms latency 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 storywriting 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

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### 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
- $\Phi\chi\Sigma$ ,  $\Omega\chi\epsilon$ , and  $\tau\beta\pi$  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

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A longer list of 19 publications and 21 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*