

Tom S. Bertalan

RESEARCH SOFTWARE ENGINEER · BIOREACTOR CONTROLS · NEURAL NETWORKS FOR NONLINEAR DYNAMICS

West Boston, MA

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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++/Java
- NumPy+SciPy+Matplotlib
- Pytorch/TensorFlow/Keras
- Linux, shell scripting, and git
- VSCode/Eclipse+PyDev
- Aspen DMC3 Controls
- OPC-UA, ROS, and sockets

Areas of Expertise and Training

- Nonlinear dynamics of time series data
- Deep learning and ML
- Dimension reduction and representation learning
- Probabilistic modeling and theory
- Computer vision
- 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

University of Massachusetts

RESEARCH SOFTWARE ENGINEER

Lowell, MA

1/2024-Present

• *Model Predictive Control of CHO Bioreactor*

- Design and administer virtualization, certificates, remote access, and OPC-UA communication for bioreactor distributed controls.
- Lead the rewrite of Java-based event-driven pump control logic, including regular review of junior engineers' work.
- Collect targeted experimental data from a 3-liter bioreactor, characterizing dynamics and responses to control inputs.
- Supervise the implementation of more rigorous simulation methods for a SBML-encoded bioreactor digital twin.
- Develop an optimal online model-predictive controller in Aspen DMC to maximize combined quality attributes.

Johns Hopkins University

POSTDOCTORAL FELLOW

Baltimore, MD

3/2020-1/2024

• *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.
- Trained a U-net on both open and custom datasets for real-time (>10hz) on-board semantic segmentation of drivable space.
- Inferred depth and semantic segmentation in simulation, using pre-trained transformer networks.
- Profiled depth/segmentation pipeline to ensure pure-GPU inference for real-time inference.

• *Special Projects and Innovations*

- Provisioned a local LLAMA2 inference server over VPN for diverse zero-shot microservices, including document renaming, topic extraction, and categorization.
- 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.
- 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 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.

- **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

Princeton, NJ

NSF RESEARCH ASSISTANT

9/2012-3/2018

Built a rover for particle-filter SLAM with LIDAR; using Gazebo and ROS. Created a custom library for visualizing OpenCV pipelines and execution-time computation graph pruning. Simulated thousands of neurons in vectorized Numpy and MATLAB; and social agents in OpenMP-accelerated C++.

The University of Alabama

Tuscaloosa, AL

STUDENT RESEARCH ASSISTANT

9/2009-5/2012

Created a 10-node Beowulf cluster in PHP, explored CUDA for PDE acceleration, and developed a LAMP-based social network. Simulated hierarchy formation in social animals as input to wet-lab experiments. Authored a multigrid subsurface-flow solver with CUDA acceleration.

EDUCATION & TRAINING

Institutions

- **Johns Hopkins University** 2020 - 2024
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
- ΦΗΣ, ΩΧΕ, and ΤΒΠ 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.
- Lectured, held office hours, and graded assignments in 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 netsAiqing 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 Ndahiro, 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

[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

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 H hlelein, 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 <i>Learning for Dyn. Sys.</i>
Coarse-grained and emergent distributed-parameter systems from data Hassan Arbabi, Felix Kemeth, Tom Bertalan , Ioannis Kevrekidis	2021 <i>American Control Conf.</i>
Data-driven model reduction and discovery Thomas Thiem, Tom Bertalan , Felix Kemeth, Yorgos Psarellis, Ioannis Kevrekidis	2020 <i>AICHE</i>
Dynamical-systems-guided learning of PDEs from data Hassan Arbabi, Tom Bertalan , Anthony Roberts, Ioannis Kevrekidis	2020 <i>AICHE</i>
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 <i>AICHE</i>
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 <i>AICHE</i>
Neural network approach to reduced order modeling of multiphase flows Cristina Linares, Tom Bertalan , Seungjoon Lee, Jicai Lu, Gretar Tryggvason, Ioannis Kevrekidis	2020 <i>APS Div. of Fluid Dyn.</i>
PDE+PINN: Learning and Solving a PDE at the Same Time Tom Bertalan , Felix Kemeth, Tianqi Cui, Ioannis Kevrekidis	2020 <i>AICHE</i>
Learning Partial Differential Equations from Discrete Space Time Data: Convolutional and Recurrent Networks, and Their Relations to Traditional Numerical Methods Tom Bertalan , Felix Dietrich, Thomas Thiem, Rob Farber, Ioannis Kevrekidis, Anthony Roberts	2019 <i>AICHE</i>
Recurrent Neural Networks, Numerical Integrators and Nonlinear System Identification Tom Bertalan , Rob Farber, Thomas Thiem, Felix Dietrich, Ioannis Kevrekidis	2018 <i>AICHE</i>
Coarse-Scale PDEs from Microscopic Observations Via Machine Learning Seungjoon Lee, Mahdi Kooshkbaghi, Constantinos Siettos, Tom Bertalan , and Ioannis Kevrekidis	2019 <i>AICHE</i>
When Have Two Networks Learned the Same Task? Data-Driven Transformations between System Representations Tom Bertalan , Felix Dietrich, Thomas Thiem, Ioannis Kevrekidis	2019 <i>AICHE</i>
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 <i>Dyn. Days 2017; AICHE</i>
Coarse-graining of heterogeneous neural dynamics Tom Bertalan , Minseok Choi, Carlo Laing, Ioannis Kevrekidis	2015 <i>AICHE</i>
Heterogeneity and reduction for complex network dynamics Ioannis Kevrekidis, Alexander Holiday, Tom Bertalan , and Carlo Laing	2014 <i>AICHE</i>
Polynomial representations of populations with multiple heterogeneities Tom Bertalan , Yan Wu, Brianna Hnath, and Yannis Kevrekidis	2014 <i>Princeton Grad. Student Symp.</i>
Coarse-graining Network Dynamics Alexander Holiday and Tom Bertalan	2013 <i>Network Front.</i>
nSpyres: an open-source, Python-based framework for simulation of flow through porous media Eric Carlson, Akand Islam, Francis Dumkwu, and Tom Bertalan	2012 <i>Interpore 2012</i>
OpenMG: a new multigrid implementation in Python Tom Bertalan , Akand Islam, Roger Sidje, and Eric Carlson	2012 <i>Proc. 11th Python in Sci. Conf.</i>
ESIM: a framework for simulation of dominance hierarchy formation in small animal groups Tom Bertalan and Ryan Earley	2012 <i>UA Hon. Undergr. Res. Conf.</i>
An open-source computing cluster for virtual experiments with variable parameters Tom Bertalan and Eric Carlson	2011 <i>UA Hon. Undergr. Res. Conf.</i>