

# Tom S. Bertalan

RESEARCH SOFTWARE ENGINEER · THE UNIVERSITY OF MASSACHUSETTS, LOWELL; CHEMICAL ENGINEERING

☎ (256) 613-3760 | ✉ Tom@TomBertalan.com | 🏠 TomSB.net | 📺 TSBertalan | 📄 Tom-Bertalan-00764640

*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

### University of Massachusetts

RESEARCH SOFTWARE ENGINEER

Lowell, MA

1/2024-Present

#### • **Model Predictive Control of CHO Bioreactor**

- Collect targeted experimental data from a 3-liter bioreactor, characterizing dynamics and responses to control inputs.
- Train physics-based and neural-network bioreactor models to predict behavior under relevant conditions.
- Develop an optimal online model-predictive controller in Aspen DMC to maximize combined quality attributes.
- Lead weekly group meetings, targeting both academic publication and technology transfer to industry partners

### 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**

- 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.
- 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**

- 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

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.
- 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**

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 - 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
- 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 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 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 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

---

<b>Certified Invertibility in Neural Networks via Mixed-Integer Programming</b> Tianqi Cui, <a href="#">Tom Bertalan</a> , George J. Pappas, Manfred Morari, Ioannis Kevrekidis, Mahyar Fazlyab	2023 <i>Learning for Dyn. Sys.</i>
<b>Coarse-grained and emergent distributed-parameter systems from data</b> Hassan Arbabi, Felix Kemeth, <a href="#">Tom Bertalan</a> , Ioannis Kevrekidis	2021 <i>American Control Conf.</i>
<b>Data-driven model reduction and discovery</b> Thomas Thiem, <a href="#">Tom Bertalan</a> , Felix Kemeth, Yorgos Psarellis, Ioannis Kevrekidis	2020 <i>AICHE</i>
<b>Dynamical-systems-guided learning of PDEs from data</b> Hassan Arbabi, <a href="#">Tom Bertalan</a> , Anthony Roberts, Ioannis Kevrekidis	2020 <i>AICHE</i>
<b>On the data-driven discovery and calibration of closures</b> Seungjoon Lee, Yorgos Psarellis, Constantinos Siettos, <a href="#">Tom Bertalan</a> , Daniel Amchin, Tapomoy Bhat-tacharjee, Sujit Datta, Ioannis Kevrekidis	2020 <i>AICHE</i>
<b>Connections between residual networks and explicit numerical integrators, and applications to identification of noninvertible dynamical systems</b> Tianqi Cui, <a href="#">Tom Bertalan</a> , Yorgos Psarellis, Ioannis Kevrekidis	2020 <i>AICHE</i>
<b>Neural network approach to reduced order modeling of multiphase flows</b> Cristina Linares, <a href="#">Tom Bertalan</a> , Seungjoon Lee, Jicai Lu, Gretar Tryggvason, Ioannis Kevrekidis	2020 <i>APS Div. of Fluid Dyn.</i>
<b>PDE+PINN: Learning and Solving a PDE at the Same Time</b> <a href="#">Tom Bertalan</a> , Felix Kemeth, Tianqi Cui, Ioannis Kevrekidis	2020 <i>AICHE</i>
<b>Learning Partial Differential Equations from Discrete Space Time Data: Convolutional and Recurrent Networks, and Their Relations to Traditional Numerical Methods</b> <a href="#">Tom Bertalan</a> , Felix Dietrich, Thomas Thiem, Rob Farber, Ioannis Kevrekidis, Anthony Roberts	2019 <i>AICHE</i>
<b>Recurrent Neural Networks, Numerical Integrators and Nonlinear System Identification</b> <a href="#">Tom Bertalan</a> , Rob Farber, Thomas Thiem, Felix Dietrich, Ioannis Kevrekidis	2018 <i>AICHE</i>
<b>Coarse-Scale PDEs from Microscopic Observations Via Machine Learning</b> Seungjoon Lee, Mahdi Kooshkbaghi, Constantinos Siettos, <a href="#">Tom Bertalan</a> , and Ioannis Kevrekidis	2019 <i>AICHE</i>
<b>When Have Two Networks Learned the Same Task? Data-Driven Transformations between System Representations</b> <a href="#">Tom Bertalan</a> , Felix Dietrich, Thomas Thiem, Ioannis Kevrekidis	2019 <i>AICHE</i>
<b>Coarse modeling of circadian rhythms in heterogeneous neural networks</b> <a href="#">Tom Bertalan</a> , C. William Gear, Yannis G. Kevrekidis, Michael Henson, Erik Herzog, and Carlo Laing	2017; 2016 <i>Dyn. Days 2017; AICHE</i>
<b>Coarse-graining of heterogeneous neural dynamics</b> <a href="#">Tom Bertalan</a> , Minseok Choi, Carlo Laing, Ioannis Kevrekidis	2015 <i>AICHE</i>
<b>Heterogeneity and reduction for complex network dynamics</b> Ioannis Kevrekidis, Alexander Holiday, <a href="#">Tom Bertalan</a> , and Carlo Laing	2014 <i>AICHE</i>
<b>Polynomial representations of populations with multiple heterogeneities</b> <a href="#">Tom Bertalan</a> , Yan Wu, Brianna Hnath, and Yannis Kevrekidis	2014 <i>Princeton Grad. Student Symp.</i>
<b>Coarse-graining Network Dynamics</b> Alexander Holiday and <a href="#">Tom Bertalan</a>	2013 <i>Network Front.</i>
<b>nSpyres: an open-source, Python-based framework for simulation of flow through porous media</b> Eric Carlson, Akand Islam, Francis Dumkwu, and <a href="#">Tom Bertalan</a>	2012 <i>Interpore 2012</i>
<b>OpenMG: a new multigrid implementation in Python</b> <a href="#">Tom Bertalan</a> , Akand Islam, Roger Sidje, and Eric Carlson	2012 <i>Proc. 11<sup>th</sup> Python in Sci. Conf.</i>
<b>ESIM: a framework for simulation of dominance hierarchy formation in small animal groups</b> <a href="#">Tom Bertalan</a> and Ryan Earley	2012 <i>UA Hon. Undergr. Res. Conf.</i>
<b>An open-source computing cluster for virtual experiments with variable parameters</b> <a href="#">Tom Bertalan</a> and Eric Carlson	2011 <i>UA Hon. Undergr. Res. Conf.</i>