

Tom S. Bertalan

POSTDOCTORAL FELLOW AT JOHNS HOPKINS WHITING SCHOOL OF ENGINEERING

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SKILLS

Software

LIBRARIES, PACKAGES, FRAMEWORKS, & TOOLS

- NumPy+SciPy+Matplotlib
- TensorFlow/Keras
- Linux and shell scripting
- Git and Subversion
- Eclipse+PyDev
- Scikit-Learn
- Python multiprocessing
- Amazon Elastic Compute Cloud
- Apache+MySQL

Languages

PROGRAMMING & MARKUP

- Python
- MATLAB
- \LaTeX
- C/C++
- Java
- HTML+Javascript

Selected Graduate Classes

- Computer Vision
- Machine Learning and Artificial Intelligence
- Foundations of Probabilistic Modeling
- Probability Theory
- Mathematical Neuroscience
- Computation and Coding in Microcircuits
- Neuroscience
- Applied Dynamical Systems
- Mathematical Analysis of Massive Data Sets
- Introduction to Nonlinear Dynamics
- Chemical Reactor Engineering
- Mathematical Methods for Engineering Analysis
- Software Engineering for Scientific Computing

Selected Undergraduate Classes

- Mathematical Statistics with Applications
- Process Dynamics & Control
- Introduction to Linear Algebra
- Human Anatomy & Physiology
- Applied Differential Equations

Teaching

AT PRINCETON; AS ASSISTANT INSTRUCTOR

- Chemical & Biological Engineering Lab
- Differential Equations

Other Skills and Interests

- Arduino and Raspberry Pi
- Autonomous robotics with Robot Operating System (ROS)
- Small electronics manufacture
- Solo and orchestral violin performance

PROJECTS

1:10 scale autonomous vehicles (AVs)

Built a series of differential-drive and Ackermann rovers with LIDAR, and depth cameras, wheel encoders, and IMU; building experience in hardware, low-level embedded firmware, Robot Operating System (ROS) driver software, and high-level perception and planning software.

Simulation of circadian rhythms

Contributed to a successful \$1.8MM grant for multi-university research project. Implemented core simulation, coarse-graining, and pseudo-arclength continuation. (Collaboration with Wash. U. St. Louis and U. Mass Amherst.)

Neural approximation of dynamical systems

Recast existing neural differential equation (DE) methods for time series analysis as recurrent networks, including extensions to convolutional neural networks (CNNs) for learning PDEs. Applied an unconventional loss for learning DEs with a conserved quantity. Implemented custom gradients for training neural networks with constraints.

EDUCATION

Princeton University

M.A. AND PH.D

Chemical and Biological Engineering
Advised by Prof. Yannis Kevrekidis

The University of Alabama

B.S., MAGNA CUM LAUDE

Chemical and Biological Engineering, minor in Mathematics
Advised by Prof. Eric Carlson and Prof. Ryan Earley

Unsupervised learning (UL) for dynamical systems

Used UL to characterize the slow manifold underlying high-dimensional simulation dynamics. Helped develop a new variational autoencoder and applied it to end-to-end robotic localization (collaboration with Yale and The Technion).

Extraction of an emergent space and partial differential equation (PDE) underlying coupled oscillators

Used UL to obtain an pseudo-spatial ordering for a simulation of coupled biological neurons. Supervised a graduate student in using a CNN to train a PDE to approximate the dynamics.

Course in computer vision and control for AVs

Helped develop and teach a recurring summer course for high school and freshman students on using ROS, OpenCV, and CNNs to follow a road and stop at a traffic sign.

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
- University president's list
- $\Phi\text{H}\Sigma$, $\Omega\text{X}\text{E}$, and $\text{T}\text{B}\text{I}\text{I}$ honor societies

PUBLICATIONS

- “Machine Learning Approaches to Problem Well-Posedness”** *In Preparation*
Tom Bertalan, George Kevrekidis, Elizaveta Rebrova, Siddhartha Mishra, Yannis Kevrekidis
- “Some of the variables, some of the parameters, some of the times, with some things known: Identification with partial information”** *In Preparation*
Saurabh Malani, Tom Bertalan, Tianqi Cui, Michael Betenbaugh, Jose L. Avalos, Ioannis Kevrekidis
- “Data-driven and Physics Informed Modelling of Chinese Hamster Ovary (CHO) Cell Bioreactors”** *In Preparation*
Tianqi Cui, Tom Bertalan, Nelson Ndaïro, Pratik Khare, Michael Betenbaugh, Costas Maranas, Ioannis Kevrekidis
- “Implementation and (Inverse Modified) Error Analysis for implicitly-templated ODE nets”** *In Preparation*
Aiqing Zhu, Beibei Zhu, Tom Bertalan, Yifa Tang, Ioannis Kevrekidis
- “Learning effective stochastic differential equations from microscopic simulations: linking stochastic numerics to deep learning”** 2023
CHAOS
Felix Dietrich, Alexei Makeev, George Kevrekidis, Nikolaos Evangelou, Tom Bertalan, Sebastian Reich, Ioannis Kevrekidis
- “Learning emergent PDEs in a learned emergent space”** 2022
NATURE COMMUNICATIONS
Felix Kemeth, Tom Bertalan, Thomas Thiem, Seungjoon Moon, Carlo Laing, Ioannis Kevrekidis
- “Personalized Algorithm Generation: A Case Study in Meta-Learning ODE Integrators”** 2022
SIAM J. SCI. COMP.
Y. Guo, Felix Dietrich, Tom Bertalan, D. T. Doncevic, M. Dahmen, Ioannis Kevrekidis, Qianxiao Li
- “Initializing LSTM internal states via manifold learning”** 2021
CHAOS
Felix Kemeth, Tom Bertalan, Nikolaos Evangelou, Tianqi Cui, Saurabh Malfani, Ioannis Kevrekidis
- “Development of closures for coarse-scale modeling of multiphase and free surface flows using machine learning”** 2021
BULLETIN OF THE AMERICAN PHYSICAL SOCIETY
Cristina Linares, Tom Bertalan, Eleni Koronaki, Jicai Lu, Gretar Tryggvason, Ioannis Kevrekidis
- “Global and local reduced models for interacting, heterogeneous agents”** 2021
CHAOS
Thomas Thiem, Felix Kemeth, Tom Bertalan, Carlo Liang, Ioannis Kevrekidis
- “Local conformal autoencoder for standardized data coordinates”** 2020
PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES
Erez Peterfreund, Ofir Lindenbaum, Felix Dietrich, Tom Bertalan, Matan Gavish, Ioannis Kevrekidis, Ronald Coifman
- “Transformations between deep neural networks** 2020
PREPRINT
Tom Bertalan, Felix Dietrich, Ioannis Kevrekidis
- “Emergent spaces for coupled oscillators”** 2020
FRONTIERS IN COMPUTATIONAL NEUROSCIENCE
Thomas Thiem, Mahdi Kooshkbaghi, Tom Bertalan, Carol Laing, Ioannis Kevrekidis
- “Coarse-scale PDEs from fine-scale observations via machine learning”** 2020
CHAOS
Seungjoon Lee, Mahdi Kooshkbaghi, Konstantinos Spiliotis, Constantinos Siettos, and Ioannis Kevrekidis

“On Learning Hamiltonian Systems from Data”

CHAOS

Tom Bertalan, Felix Dietrich, Igor Mezic, and Ioannis Kevrekidis

2019

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

IEEE ACCESS

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

2017

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

FRONTIERS IN COMPUTATIONAL NEUROSCIENCE

Tom Bertalan, Yan Wu, Carlo Laing, C. William Gear, and Ioannis Kevrekidis.

2017

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

EUROPEAN PHYSICAL JOURNAL, SPECIAL TOPICS ISSUE

Minseok Choi, Tom Bertalan, Carlo Laing, and Ioannis Kevrekidis.

2016

“OpenMG: a new multigrid implementation in Python”

NUMERICAL LINEAR ALGEBRA WITH APPLICATIONS

Tom Bertalan, Akand Islam, Roger Sidje, and Eric Carlson

2014

CONFERENCES

“Certified Invertibility in Neural Networks via Mixed-Integer Programming”

LEARNING FOR DYNAMICAL SYSTEMS

Tianqi Cui, Thomas Bertalan, George J. Pappas, Manfred Morari, Ioannis Kevrekidis, Mahyar Fazlyab

Poster and Paper

2023

“Coarse-grained and emergent distributed-parameter systems from data”

AMERICAN CONTROL CONFERENCE

Hassan Arbabi, Felix Kemeth, Tom Bertalan, Ioannis Kevrekidis

2021

“Data-driven model reduction and discovery”

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS ANNUAL MEETING

Thomas Thiem, Tom Bertalan, Felix Kemeth, Yorgos Psarellis, Ioannis Kevrekidis

Poster and Talk

2020

“Dynamical-systems-guided learning of PDEs from data”

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS ANNUAL MEETING

Hassan Arbabi, Tom Bertalan, Anthony Roberts, Ioannis Kevrekidis

Talk

2020

“On the data-driven discovery and calibration of closures”

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS ANNUAL MEETING

Seungjoon Lee, Yorgos Psarellis, Constantinos Siettos, Tom Bertalan, Daniel Amchin, Tapomoy Bhattacharjee, Sujit Datta, Ioannis Kevrekidis

Poster and Talk

2020

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

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS ANNUAL MEETING

Tianqi Cui, Tom Bertalan, Yorgos Psarellis, Ioannis Kevrekidis

Poster and Talk

2020

“Neural network approach to reduced order modeling of multiphase flows”

AMERICAN PHYSICAL SOCIETY

Cristina Linares, Tom Bertalan, Seungjoon Lee, Jicai Lu, Gretar Tryggvason, Ioannis Kevrekidis

Talk

2020

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

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS ANNUAL MEETING

Tom Bertalan, Felix Kemeth, Tianqi Cui, Ioannis Kevrekidis

Poster and Talk

2020

“Learning Partial Differential Equations from Discrete Space Time Data: Convolutional and Recurrent Networks, and Their Relations to Traditional Numerical Methods”

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS ANNUAL MEETING

Tom Bertalan, Felix Dietrich, Thomas Thiem, Rob Farber, Ioannis Kevrekidis, Anthony Roberts

Talk

2019

- “Recurrent Neural Networks, Numerical Integrators and Nonlinear System Identification”** *Talk*
 AMERICAN INSTITUTE OF CHEMICAL ENGINEERS ANNUAL MEETING *October 2018*
 Tom Bertalan, Rob Farber, Thomas Thiem, Felix Dietrich, Ioannis Kevrekidis
- “Coarse-Scale PDEs from Microscopic Observations Via Machine Learning”** *Talk*
 AMERICAN INSTITUTE OF CHEMICAL ENGINEERS ANNUAL MEETING *November 2019*
 Seungjoon Lee, Mahdi Kooshkbaghi, Constantinos Siettos, Ioannis Kevrekidis, Tom Bertalan
- “When Have Two Networks Learned the Same Task? Data-Driven Transformations between System Representations”** *Talk*
 AMERICAN INSTITUTE OF CHEMICAL ENGINEERS ANNUAL MEETING *November 2019*
 Tom Bertalan, Felix Dietrich, Thomas Thiem, Ioannis Kevrekidis
- “Learning Partial Differential Equations from Discrete Space Time Data: Convolutional and Recurrent Networks, and Their Relations to Traditional Numerical Methods”** *Talk*
 AMERICAN INSTITUTE OF CHEMICAL ENGINEERS ANNUAL MEETING *November 2019*
 Tom Bertalan, Felix Dietrich, Thomas Thiem, Ioannis Kevrekidis, Rob Farber, Anthony Roberts
- “Coarse modeling of circadian rhythms in heterogeneous neural networks”** *Poster and Talk*
 DYNAMICS DAYS 2017; AMERICAN INSTITUTE OF CHEMICAL ENGINEERS ANNUAL MEETING *January 2017; November 2016*
 Tom Bertalan, C. William Gear, Yannis G. Kevrekidis, Michael Henson, Erik, and Carlo Laing.
- “Coarse-graining of heterogeneous neural dynamics”** *Talk*
 AMERICAN INSTITUTE OF CHEMICAL ENGINEERS ANNUAL MEETING *November 2015*
 Tom Bertalan, Minseok Choi, Carlo Laing, Ioannis Kevrekidis.
- “Heterogeneity and reduction for complex network dynamics”** *Talk*
 AMERICAN INSTITUTE OF CHEMICAL ENGINEERS ANNUAL MEETING *November 2014*
 Ioannis Kevrekidis, Alexander Holiday, Tom Bertalan, and Carlo Laing.
- “Polynomial representations of populations with multiple heterogeneities”** *Poster*
 PRINCETON GRADUATE STUDENT SYMPOSIUM *October 2014*
 Tom Bertalan, Yan Wu, Brianna Hnath, and Yannis Kevrekidis
- “OpenMG: a new multigrid implementation in Python”** *Talk*
 SCI-PY: SCIENTIFIC COMPUTING WITH PYTHON *July 2012*
 Tom Bertalan, Akand Islam, Roger Sidje, and Eric Carlson
- “ESIM: a framework for simulation of dominance hierarchy formation in small animal groups”** *Poster*
 UNIVERSITY OF ALABAMA SYSTEM HONORS UNDERGRADUATE RESEARCH CONFERENCE *April 2012*
 Tom Bertalan and Ryan Earley
- “An open-source computing cluster for virtual experiments with variable parameters”** *Poster*
 UNIVERSITY OF ALABAMA SYSTEM HONORS UNDERGRADUATE RESEARCH CONFERENCE *April 2011*
 Tom Bertalan and Eric Carlson

REFERENCES

- Yannis Kevrekidis:** yannisk@jhu.edu Bloomberg Distinguished Professor in Applied Mathematics and Statistics at Johns Hopkins University
- Stas Shvartsman:** stas@princeton.edu Professor of Chem. and Biol. Engineering at Princeton University and the Lewis-Sigler Institute for Integrative Genomics.
- Ryan Earley:** rearley@ua.edu Associate Professor of Biological sciences at The University of Alabama.