Joshua M. Hanson

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Contact Information

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Summary

I am currently a PhD student in electrical engineering at the University of Illinois at Urbana-Champaign and intern at Sandia National Laboratories. My recent research focuses primarily on theoretical problems concerning nonlinear systems and neural networks and utilizes tools from dynamical systems, control theory, learning theory, and differential geometry. Some of the applications I work on include electronics modeling, circuit simulation, system identification, model order reduction, and performance characterization of machine learning algorithms and architectures.

Education

2020 – pres.	University of Illinois at Urbana-Champaign: Ph.D. in Electrical Engineering, exp. May 2024 Advisor: Maxim Raginsky
2018 – 2021	University of Illinois at Urbana-Champaign: M.S. in Mathematics, exp. Dec. 2021
2018 – 2020	University of Illinois at Urbana-Champaign: M.S. in Electrical Engineering, Aug. 2020 Thesis: *Universal Approximation of Input-Output Maps and Dynamical Systems by Neural Network Architectures* Advisor: Maxim Raginsky
2014 – 2018	Clemson University: B.S. in Electrical Engineering, *summa cum laude*, May 2018 Thesis: *Multi-plate CMOS Sensors for Estimating the Location of a Nuclear Source in a Three-Dimensional Environment* Advisor: Carl Baum
2014 – 2018	Clemson University: B.S. in Physics, *summa cum laude*, May 2018 Thesis: *Computational Modeling of Charge State Balance within an EBIT and Coulomb Crystal Formation within an RF Trap* Advisor: Joan Marler

Selected Coursework

- Nonlinear & Adaptive Control
- Geometric Control Theory
- Optimum Control Systems
- Control of Stochastic Systems
- Control of Complex Systems
- Random Processes
- Statistical Learning Theory
- Information Theory
- Detection & Estimation Theory
- Digital Signal Proc. & Comm.
- Real & Functional Analysis
- Hilbert Spaces
- Abstract Algebra
- Differentiable Manifolds
- Symplectic & Poisson Geom.

Technical Skills

- Python, Julia, MATLAB
- Circuit Simulation and EDA
- Numerical ODE Solvers
- Finite Diff., Finite Vol., and Finite Element Methods
- Automatic Differentiation and Gradient Descent
- Neural Networks and Machine Learning
- System Identification and Model Order Reduction

Research and Work Experience

2020 – pres.

Graduate Student Intern
Sandia National Laboratories, Albuquerque, NM

Performing electronics modeling research with Biliana Paskaleva and Pavel Bochev in the Component and Systems Analysis Organization (1356).

Our goal is to develop reduced-order semiconductor device models that are efficient enough to implement in large-scale circuit simulations, but remain faithful to canonical physics-based models. We utilize techniques from numerical analysis, machine learning, and dynamical systems.

2018 – pres.

Graduate Research Assistant
University of Illinois at Urbana-Champaign, Urbana, IL

Performing research in machine learning and nonlinear systems and control with Maxim Raginsky.

Our current focus is characterizing the performance capacity and expressivity of neural networks for modeling nonlinear systems, with an emphasis on quantitative results. We aim to integrate powerful mathematical tools from dynamical systems and control theory into the theoretical analysis of novel machine learning algorithms and architectures.

2017 – 2018

Undergraduate Research Assistant
Clemson University, Clemson, SC

Performed estimation and detection theory research with Carl Baum.

The objective of this project was to design and simulate algorithms to estimate the unknown location of a radioactive source within a three-dimensional search space making use of novel detector geometries and multi-sensor network configurations. I developed skills in statistics and probability, Monte Carlo simulation, scientific programming in Python, and high-performance cluster computing.

2017 – 2018	Undergraduate Research Assistant Clemson University, Clemson, SC Performed atomic physics research with Joan Marler. The objective of this project was to simulate dynamic ion-ion and ion-electron interactions in an electron beam ion trap (EBIT) and the formation of Coulomb crystals from laser-cooled ions in a radio-frequency Paul trap. I developed skills in molecular dynamics simulation, finite difference analysis, scientific programming in Python, and atomic and molecular physics.
Summer 2017	Summer Undergraduate Research Fellowship (REU Program) National Institute of Standards and Technology, Gaithersburg, MD Continuation of previous atomic physics research with Joseph Tan. I improved my previous computational models to account for thermal behavior, ion-ion interactions, and additional finely-tuned trapping parameters. We found agreement between simulation results and experimental measurements of ion capturing efficiency using different trap configurations. This project culminated in a research paper which was published in Journal of Applied Physics.
Summer 2016	Summer Undergraduate Research Fellowship (REU Program) National Institute of Standards and Technology, Gaithersburg, MD Performed atomic physics research with Joseph Tan in the Atomic Spectroscopy Group, Quantum Measurement Division, Physical Measurement Laboratory. I created computational models of the NIST electron beam ion trap (EBIT) and used the results from ion dynamics simulations to create stability diagrams showing ranges of trapping parameters that would successfully capture highly charged ions produced in the EBIT. I presented my results and conclusions at end of the REU program and at the Clemson 2016 Physics and Astronomy Symposium (SIRPA).

Publications

- J. Hanson, B. Paskaleva, P. Bochev, C. Hembree, and E. Keiter, "A hybrid analytic-numerical compact model for radiation induced photocurrent effects", *IEEE Transactions on Nuclear Science*, 2022

  Submitted for publication, under review.

- J. Hanson, M. Raginsky, and E. Sontag, "Learning Recurrent Net Models of Nonlinear Systems," *Proceedings of Machine Learning Research*, 2021

  Accepted for a poster presentation at the Learning for Dynamics and Control (L4DC 2021) conference (held virtually).

- J. Hanson, P. Bochev, and B. Paskaleva, "Learning compact physics-aware delayed photocurrent models using dynamic mode decomposition," Wiley Statistical Analysis and Data Mining Journal (CoDA 2020 Special Issue), 2020

- J. Hanson and M. Raginsky, "Universal simulation of stable dynamical systems by recurrent neural nets," *Proceedings of Machine Learning Research*, 2020

  Accepted for an oral presentation at the Learning for Dynamics and Control (L4DC 2020) conference in Berkeley, CA (held virtually).

- J. Hanson and M. Raginsky, "Universal approximation of input-output maps by temporal convolutional nets," *Advances in Neural Information Processing Systems*, 2019

  Accepted for a poster presentation at the NeurIPS 2019 conference in Vancouver, BC.

- J. M. Dreiling, A. S. Naing, J. N. Tan, J. M. Hanson, S. F. Hoogerheide, and S. M. Brewer, "Capture of highly charged ions in a pseudo-hyperbolic Paul trap," *Journal of Applied Physics* **126**, 024501 (2019)

Honors and Awards

- Faculty Scholarship Award, Clemson University, May 2018
- Outstanding Senior Award in Electrical Engineering, Clemson University, April 2018
- Phi Kappa Phi Certificate of Merit, Clemson University, April 2018
- L. D. Huff Junior Award for Excellence in Physics and Astronomy, Clemson University, April 2017
- L. D. Huff Sophomore Award for Excellence in Physics and Astronomy, Clemson University, April 2016

Extracurriculars

- Treasurer of the Illini Cycling Club at the University of Illinois, August 2020 - pres.
- Member of the Society of Physics Students at Clemson University, August 2016 - May 2018