Jason W. Rocks

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SUMMARY

- Physicist with extensive background in machine learning, data science, and scientific computing
- Experienced in developing, implementing, and applying custom statistical methods in Python and C++ to analyze complex data in a variety of settings including biology
- Co-author of 20 publications, including 9 as first author

EDUCATION

Ph.D in Physics - May 2019
University of Pennsylvania, Philadelphia, PA
Thesis: Allosteric functionality in mechanical and flow networks

B.S. in Physics (Computational Physics Track) - May 2013
Carnegie Mellon University, Pittsburgh, PA
Mellon College of Science Research Honors / University Honors
GPA: 4.00/4.00

EXPERIENCE

Boston University Department of Physics, Mehta Group
Postdoctoral Associate, *2019-Present*

- Machine Learning / Statistical Learning Theory
  - Developed theory to explain the "double-descent" phenomenon in modern deep learning, where overparameterized models avoid overfitting despite achieving near-perfect accuracy on training data
  - Applied state-of-the-art techniques from statistical mechanics to derive analytic theory extending the classical bias-variance decomposition to overparameterized models
  - Created novel geometric picture to explain how error in overparameterized models stems from a mismatch between the high-dimensional feature spaces spanned by the data distribution and model architecture
- Biophysical / Statistical Modeling for Synthetic Biology Experiments
  - Developed nonequilibrium statistical model of post-translation modification to iteratively guide experiments to create synthetic signaling pathways in eukaryotic cells
  - Wrote custom nonlinear optimization pipeline in Python to efficiently fit biophysical model and extract biophysical parameters from large experimental datasets
- Mechanical Metamaterials
  - Created generalized version of the Maxwell-Calladine index theorem based on susceptibilities to describe the mechanical behavior of discrete mechanical metamaterials
  - Used group representation theory to design mechanical metamaterials that utilize symmetry-breaking of local energetics to control their response to external forces

University of Pennsylvania Department of Physics and Astronomy, Liu Group
Doctoral Researcher, *2013-2019*

- Allosteric Mechanical Metamaterial Design and Protein Analysis
  - Developed method to create mechanical and flow networks that exhibit allostery-like behavior similar to that observed in proteins
  - Characterized the constraint-satisfaction phase transition that governs the limit of multifunctionality in such networks

  - Created and applied novel implementation of topological data analysis techniques (persistent homology) to establish the relationship between structure and function in allosteric tuned networks
  - Extended and applied analysis to identify structural features in proteins responsible for allosteric function
  - Wrote extensive custom software in Python and C++ to implement network design algorithms and topological data analysis techniques
- Prediction of Plastic Rearrangements in Soft Materials
  - Developed new method combining persistent homology with simple machine learning algorithms to identify features of local structure that predict plastic rearrangements in materials undergoing shear
  - Wrote custom software in Python and C++ to implement topological data analysis techniques
- Mechanical Signaling in the Embryonic Heart
  - Developed model of the embryonic heart as a mechanically active medium in which heartbeats are coordinated by mechanical signaling, in contrast to traditional electrical signaling models
  - Worked with experimental collaborators to confirm prediction that the embryonic heart should continue to beat even in the absence of electrical signaling when exposed to gap junction blocking drugs

SELECT PUBLICATIONS

X. Yang, **J. W. Rocks**, K. Jiang, A. J. Walters, K. Rai, J. Liu, J. Nguyen, S. D. Olson, P. Mehta, N. Darringer, and C. J. Bashor, “Engineering synthetic phospho-signaling circuits in human cells,” (in preparation).

J. W. Rocks and P. Mehta, “Memorizing without overfitting: Bias, variance and interpolation in over-parameterized models,” Phys. Rev. Research **4**, 013201 (2022) **(Editor’s Choice)**.

J. W. Rocks and P. Mehta, “The geometry of over-parameterized regression and adversarial perturbations,” arXiv:2103.14108 (2021).

J. W. Rocks S. A. Ridout, and A. J. Liu, “Learning-based approach to plasticity in athermal sheared amorphous packings: Improving softness“, APL Materials **9**, 021107 (2021).

J. W. Rocks, A. J. Liu, and E. Katifori, “Hidden topological structure of flow network functionality,” Phys. Rev. Lett. **126**, 028102 (2021).

J. W. Rocks*, H. Ronellenfitsch*, A. J. Liu, S. R. Nagel, and E. Katifori, “The limits of multifunctionality in tunable networks,” Proc. Natl. Acad. Sci. **116**, 2506-2511 (2019).

J. W. Rocks, N. Pashine, I. Bischofberger, C. P. Goodrich, A. J. Liu, and S. R. Nagel, “Designing allostery-inspired response in mechanical networks,” Proc. Natl. Acad. Sci. **114**, 2520-2525 (2017).

* denotes co-first authors

HONORS AND AWARDS

National Science Foundation Graduate Research Fellowship, 2014-2017
Lindau Nobel Laureate Meeting Alumnus, January 2016
Richard E. Cutkosky Alumni Award, Department of Physics, Carnegie Mellon, May 2013
Member, Phi Beta Kappa Honors Society, May 2013
Member, Phi Kappa Phi Honors Society, May 2013
Goldwater Scholarship Honorable Mention, April 2012

TECHNICAL SKILLS

Programming Languages: Python (advanced), C/C++ (advanced), Java (intermediate), Bash (familiar), Perl (familiar), Fortran (familiar)
Numerical/Statistical Methods: supervised learning (advanced), unsupervised learning (intermediate), deep learning models (intermediate), regression (advanced), classification (advanced), nonlinear and constrained optimization (advanced), topological data analysis / persistent homology (advanced), maximum likelihood estimation (advanced), Bayesian inference (intermediate), dense and sparse linear algebra (advanced), Monte Carlo methods (intermediate), finite element method (familiar)
Software/Libraries: scikit-learn (advanced), pytorch (intermediate), keras (familiar), Git (intermediate), Pandas (advanced), Mathematica (intermediate), MATLAB (familiar), OpenMP (intermediate), pybind11 (intermediate), ARPACK (intermediate), UMFPACK (intermediate), Eigen (advanced), COMSOL (familiar)