

GURDIP (GARY) UPPAL

EDUCATION

University of Notre Dame, IN

December 2020

PhD Physics

California State University Fullerton, CA

May 2014

MS Physics

University of California, Davis, CA

December 2011

BS Physics

PROFESSIONAL EXPERIENCE

Postdoctoral Research Fellow: Computational Pathology

June 2021 - Present

Harvard Medical School/Brigham and Women's Hospital, Boston, MA

- Developed Bayesian machine learning model to infer human-interpretable microbial communities from noisy spatial sequencing data. Implemented as software package using custom Variational Inference algorithm.
- Developed Bayesian machine learning model to learn human-interpretable rules of interactions from time-series microbe sequencing data.
- Analyzed 16S and metagenomic data from mouse experiments to assess effects of dietary and fecal transplantation perturbations.
- Worked in collaboration with experimentalists in designing and analyzing mouse studies to learn spatial structure and dynamical rules of the microbiome in response to experimental perturbations.

Research Scientist: Computational Biology & Medicine

December 2020 - June 2021

CFD Research, Huntsville, AL

- Developed physiology-based pharmacokinetic (PBPK) models for various drug formulations and transdermal delivery methods such as iontophoresis and microneedles.
- Expanded and analyzed PBPK models for *Xenopus laevis* tadpoles in collaboration with experimental group. Communicated findings to peers and collaborators.
- Assisted in grant and proposal writing for projects involving biomechanical response to blasts and transdermal PBPK models.

Graduate Researcher: Theoretical Physics & Biology

August 2014 - December 2020

University of Notre Dame, IN

- Investigated effects of fluid dynamics and physical forces on microbial evolution using multi-physics, multi-scale models and simulations resulting in high impact publications and media coverage.
- Investigated physical mechanisms to control microbial evolution and effectively communicated technical results to DARPA funding agency through written reports, figures, and simulation videos.
- Studied effects of fluid flows and interdependence on aging of cells in cross-functional collaboration with bioengineers. Assisted bioengineering team in narrowing focus and optimizing microfluidic experiments with theoretical models, and co-authored paper.
- Advised undergraduate students in summer projects, resulting in journal publication.
- Mentored teaching assistants as a lead TA in classes of over 40 students. Managed class projects and resources and led students in performing experiments in mechanics and electrodynamics.

Graduate Researcher: Theoretical Condensed Matter

August 2012 - May 2014

California State University, Fullerton, CA

- Modeled and simulated theoretical T-shaped quantum dot system to understand how to develop materials with enhanced thermoelectric efficiency, a key ingredient for energy conversion technologies.
- Developed analytic and numerical solutions to electrical and thermal conductivities as function of model parameters for various approximations. Showed presence of Fano resonances lead to system's enhanced thermoelectric efficiency and published results in European Physical Journal B.

Undergraduate researcher: Mathematical Physics

January 2011 - December 2011

University of California, Davis

- Explored reformulating physics to make local Weyl invariance (scale symmetry) manifest using 6-dimensional multi-linear mathematical objects called "tractors." Investigated reformulating the supersymmetric free particle in a Weyl-invariant theory.
- Awarded the Vertical Integration of Research and Education in the Mathematical Sciences (VIGRE) grant for summer research in 2011.

PUBLICATIONS

Uppal, G., Gerber, G. (2023). MC-SPACE: Microbial communities from spatially associated counts engine. ICML CompBio.

Uppal, G., & Vural, D. C. Evolution of hitchhiking interactions in microbes (accepted)

Uppal, G., Zorlutuna, P. and Vural, D.C., 2021. Circulatory systems and mortality rates. bioRxiv, pp.2021-05.

Uppal, G., Bahcecioglu, G., Zorlutuna, P., & Vural, D. C. (2020). Tissue failure propagation as mediated by circulatory flow. Biophysical Journal.

Uppal, G., Hu, W., & Vural, D. C. (2020). Evolution of chemotactic hitchhiking. Journal of Evolutionary Biology.

Uppal, G., & Vural, D. C. (2020). Evolution of specialized microbial cooperation in dynamic fluids. Journal of Evolutionary Biology. [Cover article]

Uppal, G., & Vural, D. C. (2018). Shearing in flow environment promotes evolution of social behavior in microbial populations. eLife, 7, e34862.

Monteros, A. L., **Uppal, G.**, McMillan, S. R., Crisan, M., & Tifrea, I. (2014). Thermoelectric transport properties of a T-shaped double quantum dot system in the Coulomb blockade regime. The European Physical Journal B, 87(12), 302.

PRESENTATIONS

Uppal, G., Gerber G. K. (2023). Probabilistic learning of microbiome spatial dynamics from high-throughput localization data. HMS Pathology Research Retreat.

Uppal, G., Gerber G. K. (2022). Interpretable Machine Learning Models for Learning Complex Multi-way Microbiome Interactions. MIT Microbiome Symposium

Uppal, G., Bahcecioglu G., Zorlutuna, P., & Vural, D. (2020). Failure propagation in multicellular tissues as mediated by advective flow. Bulletin of the American Physical Society.

Uppal, G., & Vural, D. (2020). Evolutionary game theory of sticky motile bacteria. Bulletin of the American Physical Society.

Uppal, G., & Vural, D. (2019). Evolution of Multicellular Specialization in Dynamic Fluids. Bulletin of the American Physical Society.

Uppal, G., & Vural, D. (2018) Controlling social evolution of microbial populations. Bulletin of the American Physical Society.

Uppal, G., & Vural, D. (2017) Fluid dynamics and evolution. Poster presentation. 2017 BMES ANNUAL MEETING.

Uppal, G., & Vural, D. (2017) Fluid dynamics and evolution. Poster presentation. 5th Midwest Q-Bio Symposium

WORK EXPERIENCE

Lecturer April 2022
Harvard Medical School

- Gave part of a lecture on the importance and types of interpretable machine learning models
- Gave overview of established studies and available microbiome datasets available for analysis, with emphasis on learning interpretable models

Lead Teaching Assistant August 2014 - May 2017
University of Notre Dame

- Supervised teaching assistants and assisted students in mechanics and electrodynamics laboratories
- Set up experiments for students to conduct
- Graded lab reports and provided feedback for scientific writing
- Supervised tutorial sections and answered homework and course questions

Teaching Assistant August 2012 - May 2014
California State University, Fullerton

- Instructed undergraduate mechanics and electrodynamics laboratories
- Set up experiments for students to conduct
- Assigned course work and grades to students

Physics Tutor August 2013 - May 2014
California State University, Fullerton

- Tutored students individually and in small groups in fundamental physics
- Helped students develop a more positive attitude toward learning

Reader October 2009 - January 2010
University of California, Davis

- Graded papers and examinations for introductory Astronomy class
- Organized and computed class grades

OUTREACH

Northern Indiana Regional Science and Engineering Fair Judge March 2018, 2019, 2020
University of Notre Dame

ExpaND Outreach Team May 2016 - May 2018
University of Notre Dame

- Performed physics demonstrations and outreach activities at various events in the South Bend and Elkhart, IN area

TECHNICAL SKILLS

Languages & Software: Python, C++, MATLAB, R, Mathematica, L^AT_EX, Github, Bash

Operating Systems: Mac OS, Windows, Unix/Linux

General: Data Structures, Algorithms, Object-Oriented Programming, High Performance Computing

Scientific computation: Data Visualization, Clustering, Classification, Regression, Agent-Based Simulations, Finite Element Analysis, Computational Fluid Dynamics (CFD), Reaction-Advection-Diffusion PDEs, Linear Algebra, Stochastic Analysis, Monte Carlo Simulations, Numerical Optimization

Languages: English, Punjabi, Hindi