Gurdip (Gary) Uppal

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Experience

Postdoctoral Research Fellow June 2021 – Dec 2024

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

- Developed and implemented computational pipelines for analyzing next generation sequencing (NGS) data. Analyzed 16S amplicon and shotgun metagenomic data from mouse experiments to assess effects of dietary and fecal transplantation perturbations.
- Developed generative AI based Bayesian model to infer human-interpretable microbial communities from noisy, multi-dimensional, high-throughput spatial sequencing data. Implemented as software package `https://github.com/gerberlab/MCSPACE` using custom Variational Inference algorithm, incorporating user-friendly visualization tools and command line interface.
- Developed Bayesian dynamical systems model to learn human-interpretable rules of interactions from time-series microbe sequencing data.
- Collaborated with wet lab scientists in designing and analyzing in vivo mouse studies to investigate changes in microbial spatial structure and interactions in response to experimental perturbations.

Research Scientist Dec 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.
- Assisted in grant and proposal writing for projects involving biomechanical response to underwater blasts and transdermal PBPK models.
- Communicated project updates in regular meetings with cross-disciplinary teams and in collaborations with other companies.

Graduate Researcher Dec 2020 – June 2021

University of Notre Dame – 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.
- 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.
- Effectively communicated technical results to DARPA funding agency through written reports, figures, and simulation videos.
- Advised undergraduate students in summer projects, resulting in journal publication.

Graduate Researcher Aug 2012 – May 2014

California State University, Fullerton – 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 Jan 2011 – Dec 2011

University of California, Davis – Davis, CA

- 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.

Education

University of Notre Dame - Notre Dame, IN Sept 2014 – December 2020

PhD in Physics

- Advisor: Dervis Can Vural
- Topic: Evolution and Control of Microbial Cooperation and Specialization in Dynamic Fluids

California State University, Fullerton - Fullerton, CA Sept 2012 – May 2014

MS in Physics

- Advisor: Ionel Tifrea
- Topic: Thermoelectric transport properties of a T-shaped double quantum dot system in the Coulomb blockade regime

University of California, Davis - Davis, CA Sept 2007 – December 2011

BS in Physics

Skills

Programming & Scripting Languages: Python, C++, MATLAB, R, Mathematica, Bash

Tools & Infrastructure: Git, GitHub, Docker, Unix/Linux, High performance computing (HPC), SLURM, AWS

Libraries & Frameworks: PyTorch, TensorFlow, Scikit-learn, NumPy, Pandas, Matplotlib, Seaborn, Django

Data Analysis & Machine Learning: Deep Learning, Generative AI, Bayesian Statistics/Optimization, Uncertainty Quantification, Data Visualization, Clustering, Classification, Regression

Scientific Computation: Next Generation Sequencing (NGS) Analysis, Pharmacokinetics/Pharmacodynamics (PK/PD) Modeling, Monte Carlo Methods, Linear Algebra, Numerical Optimization, Computational Fluid Dynamics (CFD)

Spoken Languages: English, Punjabi, Hindi

Publications

Uppal, G., et al. (2024). MCSPACE: inferring microbiome spatiotemporal dynamics from high- throughput co-localization data. bioRxiv: the preprint server for biology.

Uppal, G. & Vural, D.C., (2024). On the possibility of engineering social evolution in microfluidic environments. Biophysical Journal, 123(3), pp.407-419.

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

Uppal, G., Zorlutuna, P. & 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

Volunteering experience

Northern Indiana Regional Science and Engineering Fair Judge March 2018, 2019, 2020

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

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