Saurabh S. Sawant, Ph.D.

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Status: US Permanent Resident

Summary

- **Experience as a research software engineer:** 10+ years of experience in developing scalable software using modern C++, MPI, and GPUs for diverse scientific applications:
  - Developed C++11 software for modeling hypersonic flows during PhD. (largest simulation: 60b particles, 4.5b cells, 20k MPI ranks, million node-hours.)
  - Developed a GPU-accelerated open-source software for modeling nanomaterials during postdoctoral work using C++17, templates, AMReX library.
  - Select parallelized algorithms: adaptive mesh refinement, space-filling curve, ray-tracing, cut-cell volume computation, tall-&-skinny QR factorization, Broyden's method, block-tridiagonal matrix inversion, cloud-in-cell.
  - Significant experience with strategies for load balancing, communication reduction, conducting strong and weak scaling studies, debuggers and sanitizers (e.g. Allinea DDT, valgrind), profilers (e.g. Nsight). Select publications: Computers & Fluids.
  - Understanding of traditional software design patterns (certificate). Software blog on advanced design patterns such as policy-based design, optimization of fundamental CUDA kernels, just-in-time compilation, C++ templates and metaprogramming basics.
- **Expertise in diverse modeling techniques as a researcher:**
  - Specialized in Direct Simulation Monte Carlo method to model hypersonic flows.
  - Expertise in nonequilibrium Green's function method for quantum transport.
  - Skilled in data-driven techniques (e.g. proper orthogonal decomposition).
- **Contributions to collaborative, interdisciplinary projects for over 7 years.**
- **Effective communicator.** (See talk at CS postdoc symposium 2023)

Education

MS & PhD (with emphasis on **Computational Science**) *August 2013 - May 2022*
Department of Aerospace Engineering, University of Illinois Urbana-Champaign.
Supervisor: Prof. Deborah Levin
Links to **MS** & **PhD** theses. Cumulative GPA: 3.76 on a scale of 4.

Select Research & Development Experience

Link to all projects: https://saurabh-s-sawant.github.io/projects/

Postdoctoral Scholar *Jan. 2022- Present*
CCSE group at Lawrence Berkeley National Laboratory, Berkeley, CA-94709, USA.
Supervisor: Dr. Andrew Nonaka

As a part of a DOE-funded project with a goal of building an advanced chip to detect photons (e.g. from remote galaxies), I have contributed to simulation and modeling efforts:

- **GPU-accelerated Quantum Transport for Modeling Nanomaterials.**
  - Developed a 3D open-source framework ELEQTRONeX (**ele**ctrostatic-**q**uantum **tr**ansport **m**odeling **o**f **n**anomaterials at **ex**ascale), built using **the AMReX library, modern C++, templates, MPI, and GPU-acceleration**. https://github.com/AMReX-Microelectronics/ELEQTRONeX
  - Quantum transport is modeled using MPI/GPU-parallelized **nonequilibrium Green's function** (NEGF) method, and self-consistency is achieved using an MPI/GPU-parallelized **Broyden's modified second algorithm**.

– Conducted weak-scaling studies up to **512 NVIDIA A100 GPUs on NERSC's Perlmutter**, and used the solver to model field effect transistors with multiple carbon nanotubes in a single simulation to study their cross-talk.

Graduate Research Assistant during M.S. and Ph.D. *Aug. 2014- Dec. 2021*
Department of Aerospace Engineering
University of Illinois Urbana-Champaign, Champaign, IL-61801, USA
Advisor: Professor Deborah Levin

I contributed to multiple projects in the field of hypersonics, funded by AFOSR, ONR, DoD, and NASA. A brief overview of select projects is provided below.

- **Development of an exascale particle-based DSMC solver.**
  - Developed a 3-D DSMC solver, SUGAR (Scalable Unstructured Gas-dynamic Adaptive mesh-Refinement), using C++11 & MPI, with features including adaptive mesh refinement (**AMR**) for octree grids, **ray-tracing**, **3D embedded boundaries** with a robust cut-cell algorithm, Morton-based **space-filling-curve** approach for **load balancing**, techniques for reducing communication.
  - Achieved ideal **strong scaling speed-up up to 4096 processors and 87% weak scaling efficiency** for 8192 processors in hypersonic flow simulations with shocks requiring AMR depth of 4 and 24 billion particles.
  - Achieved many grants totalling over two million node-hours on supercomputers such as NSF's Bluewaters, TACC's Stampede2, FRONTERA.
- **Kinetic modeling of hypersonic shock-wave/boundary-layer interactions.**
  - Conducted challenging 3D DSMC simulations of Mach 7 Shock-wave/Boundary-layer interactions that required **60 and 4.5 billion computational particles and adaptively refined computational cells, respectively, using 20k processors and over a million node-hours**.
  - Employed MPI-parallelized data-driven techniques like **proper-orthogonal decomposition** for noise reduction and dominant mode extraction. Implemented parallel **tall-and-skinny QR** factorization. (see description)
  - Investigated linear instability mechanisms in 3D hypersonic flows that required analyzing **many terabytes of data**.

Select Achievements

– **Argonne Training Program on Extreme Scale Computing Certificate** *2022*
Argonne National Laboratory

– **FRONTERA Leadership Resource Allocation** *2020-2022*
(Over a million node-hours)

– **AE Outstanding Graduate Student Fellowship** *2020*
University of Illinois Urbana-Champaign

Journal Publications

Ten peer-reviewed journal publications in prestigious journals.
https://saurabh-s-sawant.github.io/publications/

Link to complete curriculum vitae: https://saurabh-s-sawant.github.io/cv/