

Dr. Harsh Kumar Narula

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Professional Summary

Computational scientist with expertise in mathematical modeling, numerical methods, and scientific software development. Educated entirely at IIT Bombay (B.Tech., M.Tech., and Ph.D.), with over a decade of experience building computational algorithms in C++ and Python for complex engineering and materials science problems, including stochastic simulation, parameter estimation, and physics-informed modeling. Interested in applying advanced data analytics and machine learning to accelerate industrial R&D.

Key Technical Themes

- **Stochastic & Deterministic Optimization:** parameter estimation from noisy/indirect measurements (solar-cell circuit parameters from I-V data, microstructure reconstruction from grain statistics, SEM image registration)
- **Physics-Informed Modeling:** coupling mechanistic (thermal, flow, phase-transformation) models with empirical/statistical corrections to match real-world behavior
- **Scientific Software Development:** cross-platform GUI tools and simulation engines in C++, Qt, and Python for research and industrial use
- **Signal & Sensor Data Analysis:** diagnosing and correcting systematic bias in closed-loop control systems — deriving calibration models from manufacturer data, solving for analytical failure/crossover points, and quantifying uncertainty via bootstrap resampling and parameter sensitivity analysis (ventilator tidal-volume correction, PAVC)

Education

Ph.D., Mechanical Engineering — IIT Bombay

2014 – 2024

Thesis: Mathematical Modeling of Microstructure and Microtexture Evolution CGPA: 9.86/10

- Developed physics-informed stochastic and mechanistic models for reconstructing structured information from sparse, indirect measurements (grain volumes and centroids), applying deterministic and stochastic optimization to high-dimensional inverse problems.
- Built EvoSim, a generic algorithm and cross-platform GUI software (C++, Qt, Python) to simulate stochastic nucleation-growth kinetics in discretized spatial domains.
- Developed REvoSim, a novel recursive algorithm to reconstruct 3D polycrystalline structure purely from grain-volume and centroid statistics — an inverse parameter-estimation problem under uncertainty.
- Derived a unified tessellation model quantifying the significance of fitting parameters in existing tessellation approaches.

M.Tech. (Dual Degree), Metallurgical Process Engineering — IIT Bombay

2005 – 2010

Thesis: Modeling Process during Hot Rolling CGPA: 10/10

- Built a coupled 2D thermo-mechanical model (C++, MATLAB) for mass flow, strain, and thermal fields, integrating dynamic recrystallization and empirical grain-size relationships; results validated against literature.

B.Tech. (Dual Degree), Metallurgical Engineering and Materials Science — IIT Bombay

2005 – 2010

CGPA: 8.79/10

Professional Experience

Project Research Scientist — IIT Bombay

Nov 2024 – Jun 2025

Jaipur, Rajasthan, India (Remote)

- Explored applying PhD-developed nucleation-growth and tessellation models to spatial mineral prediction, using multi-angle, multi-depth borehole assay data to predict subsurface mineral distribution across a mining region.

Project Research Associate — IIT Bombay

Jun 2023 – Nov 2024

Remote

- Successfully defended Ph.D. thesis, “Mathematical Modeling of Microstructure and Microtexture Evolution,” while simultaneously serving as primary caregiver, managing home-based ICU-level care for a family member with ALS.
- Maintained, extended, and documented EvoSim, a scientific simulation software developed during PhD research, on a hydrogen pressure-vessel manufacturing project (TeCoPV India).

Home ICU Caregiver-Engineer

2019 – June 2026

- Independently designed, built, and managed a home-based invasive ventilation ICU (tracheostomy care, ventilator monitoring, emergency response) for a family member on long-term invasive mechanical ventilation, while concurrently completing PhD research and short-term technical projects remotely.
- Diagnosed a systematic tidal-volume measurement bias in a closed-loop ventilator control system (ResMed iVAPS) caused by exhalation-valve substitution: derived power-law flow calibration models from manufacturer data (including pixel-level digitization of a published curve), analytically solved for the pressure at which the two valves’ flow characteristics cross over, and quantified prediction uncertainty via bootstrap resampling and parameter sensitivity analysis. Proposed a bedside correction heuristic (Pressure-Anchored V_T Correction, PAVC) that re-anchors the closed-loop controller on a physical variable unaffected by the sensor bias; published as an engineering case report (“*When the Machine Lies*”), <https://livewithals.github.io/when-the-machine-lies>.

Project Engineer — National Centre for Aerospace Innovation and Research (NCAIR), IIT Bombay

Jan 2013 – Dec 2013

- Developed a MATLAB algorithm and GUI combining stochastic search and steepest-descent methods to automatically generate montages of multiple SEM images; presented at IMTEX-2014.

Senior Research Fellow — Powder Metallurgy Lab, IIT Bombay

Apr 2011 – Jun 2011

- Developed a stochastic-search algorithm to estimate five equivalent-circuit parameters for Dye-Sensitized Solar Cells directly from noisy experimental current-voltage data; results confirmed the existence of multiple valid solution sets, consistent with subsequent literature.

Researcher — Tata Research Development and Design Centre (TRDDC), Pune Aug 2010 – Mar 2011

- Built an integrated, physics-based FEM model for carburizing and quenching of steels to predict phase distribution and hardness, with time-resolved visualization of phase evolution.
- Developed a MATLAB tool to generate TTT/CCT diagrams for arbitrary steel compositions using the Kirkaldy-Venugopalan phase-kinetics model.

Teaching Assistant — IIT Bombay

2011 – 2019 (multiple terms)

- Computational Methods in Metal Forming, Stereology and Image Analysis, Engineering Data Mining and Applications, Mechanics of Materials, and other UG/PG courses.

Selected Publications

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- Vasavada, J., Narula, H.K., Mishra, S., Nandy, T.K., Tewari, A. “Development of novel Moving Wave Front image processing algorithm and microstructural quantification of Tungsten Heavy Alloy.” *Computational Materials Science*, 170 (2019): 109181. doi.org/10.1016/j.commatsci.2019.109181
 - Prita, P., Sushil, M., Shanta, C., Harsh, N. “Development of materials model based on microstructure evolution for formability analysis of low-Ni austenitic stainless steel.” *IOP Conference Series: Materials Science and Engineering*, 82.1 (2015): 012-017. me.iitb.ac.in/faculty/prof-sushil-mishra/publications
 - Jena, A., et al. “Dye sensitized solar cells: a review.” *Transactions of the Indian Ceramic Society*, 71.1 (2012): 1-16. doi.org/10.1080/0371750X.2012.689503

Technical Skills

- **Programming & Numerical Computing:** Python, C++, MATLAB, Octave, Maxima, Maple, Cython, Pybind11
- **Modeling & Optimization:** finite element methods, stochastic & deterministic optimization, PDE solvers, numerical methods
- **Imaging & Vision:** OpenCV, VTK, ITK
- **Tools:** PyQt5, LaTeX, Shell Scripting, Git
- **Platforms:** Ubuntu, openSUSE, Windows

Scholastic Achievements

- IIT-JEE 2005 — All India Rank 2645 | AIEEE 2005 — All India Rank 4056 | Rajasthan Pre-Engineering Test 2005 — State Rank 7