Gaurav Budhwani

Senior Undergraduate · Modelling & Optimization · Machine Learning

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EDUCATION

Indian Institute of Technology, Gandhinagar [Transcript] CPI: 8.59/10
B.Tech. (Dual Majors) - Chemical and Computer Science Engineering 2022 – Present

INTERNSHIPS

Research Scholar - PMTL Lab, University of Miami *Jun '25 – Jul '25*
Advisor — Prof. Yang Wang, University of Miami

- Built **Random Forest** and advanced **ensemble models (XGBoost, LightGBM, SVM, MLP)** to predict **New Particle Formation (NPF)** events, achieving **ROC–AUC $>$ 0.92** via **SMOTE-based balancing**.
- Extracted and ranked atmospheric predictors (SO_2, solar irradiance, relative humidity) using **feature importance** and **partial dependence plots**, cross-validating them with established **NPF mechanisms**.
- Performed comprehensive **algorithm benchmarking** on **SGP atmospheric datasets**, comparing training time, accuracy, and scalability to support future **research publications**.

PUBLICATIONS

- Hao, W., Mehra, M., **Budhwani, G.**, T. C. Chakraborty, Fan Mei, and Yang Wang. "Employing Machine Learning for New Particle Formation Identification and Mechanistic Analysis: Insights from a Six-Year Observational Study in the Southern Great Plains." **Under Review, AGU Journals**.

PROJECTS

TCP Congestion Control Simulator *Aug '25 – Nov '25*
Advisor — Prof. Sameer G. Kulkarni, IIT Gandhinagar | [Project Link]

- Developed an interactive **TCP congestion-control visualizer** with a **Python–Flask backend** and **React frontend**, enabling real-time plots of cwnd, throughput, and packet loss for TCP **Reno, CUBIC, and BBR**.
- Implemented a custom **discrete-packet simulation engine** and an **ns-3 packet-level backend**, providing support for single-flow and multi-flow scenarios with programmable bandwidth and routing.
- Engineered **Custom-topology support** (parallel, series, triangle, mesh) with dynamic route selection to visualize congestion.

API Gateway Core *Nov '25 – Dec '25*
Independent Project | [Project Link]

- Designed and implemented a **production-style API Gateway core** in **C++17** using a **middleware-based request processing pipeline** (Chain of Responsibility) supporting authentication, rate limiting, and logging.
- Developed a **concurrent request execution model** using a custom **thread pool** and **request-scoped context objects**, ensuring thread safety, isolation of per-request state, and correct behavior under parallel workloads.
- Implemented **prefix-based routing** and clean **backend service abstractions**, enabling modular service integration and graceful handling of failure scenarios including **401 (Unauthorized), 404 (Not Found), and 429 (Too Many Requests)**.

VisuAlgo CSP Solver for N-Queens and KenKen *Oct '25 – Nov '25*
Advisor - Prof. Neeldhara Misra, IIT Gandhinagar | [Project Link]

- Developed an interactive web app to visualize Constraint Satisfaction Problem (CSP) algorithms using **React and TypeScript**.
- Implemented complex solving strategies including **Backtracking, Forward Checking, and Arc Consistency (AC-3)** to demonstrate constraint propagation in real-time.
- Designed a dynamic user interface with **React Router** that features interactive puzzle generation, step-by-step solution playback, and visual feedback for constraint violations.

Human Activity Recognition (HAR) Analysis *Aug '25 – Sep '25*
Advisor - Prof. Nipun Batra, IIT Gandhinagar | [Project Link]

- Analyzed the **UCI-HAR dataset** consisting of time-series sensor data from 30 subjects performing 6 daily activities, and applied **Principal Component Analysis (PCA)** to reduce dimensionality and visualize activity clusters.
- Utilized the **TSFEL library** to extract diverse statistical, temporal, and spectral features, and trained a **Decision Tree model** on the featurized dataset to classify human activities.
- Collected real-world activity data using the **Physics Toolbox Suite** app for model validation, achieving **70% precision** and **70% accuracy**, demonstrating the feasibility of deploying the pipeline beyond benchmark datasets.

Modeling and Parameter Estimation for Pyrolysis of Wood Particles *Mar '25 – Apr '25*
Advisor - Prof. Karthik S. Pushpavanam, IIT Gandhinagar | [Project Link]

- Developed a **multiphysics simulation in COMSOL** for wood pyrolysis under inert conditions, coupling **heat transfer, mass transport, and chemical kinetics** using anisotropic material properties.
- Conducted **parameter estimation using nonlinear least squares** to optimize kinetic and thermal parameters, improving alignment with experimental temperature and mass loss data.
- Performed **parametric studies** varying porosity, particle size, reaction kinetics, and ambient temperature to analyze their impact on thermal degradation, volatile release, and internal transport mechanisms.

Process Design and Simulation for Cumene Production *Feb '25 – Apr '25*
Advisor - Prof. Hari S. Ganesh, IIT Gandhinagar | [Project Link]

- Designed a complete **cumene production process** in **Aspen Plus** and **MATLAB**, integrating reaction, separation, and heat recovery units for sustainable and optimized performance.
- Modeled a **plug flow reactor** with primary and secondary reactions using **mass and energy balances**, and validated the results against Aspen simulations with $<$**2% error** for key components.
- Performed **multi-variable optimization using MATLAB's** `fmincon`, achieving an optimal benzene-to-propylene ratio and inlet temperature that **maximized cumene yield** while minimizing side-product formation.

Optimization of Heat Loss and Boundary Layer Thickness *Oct '24 – Nov '24*
Advisor - Prof. Hari S. Ganesh, IIT Gandhinagar | [Project Link]

- Modeled and optimized **thermal boundary layer thickness** and **heat loss** using **Pyomo** and **MATLAB**, enhancing **convective heat transfer efficiency** for laminar airflow over a heated plate.
- Analyzed **trade-offs** between **heat dissipation** and **boundary layer** control under constrained flow conditions, demonstrating **optimal configurations** for improving thermal performance in engineering applications.

Saffman-Taylor Instability Using Hele-Shaw Cells *Oct '24 – Nov '24*
Advisor - Prof. Kartik Subramaniam, IIT Gandhinagar | [Project Link]

- Simulated **viscous fingering patterns** through **numerical modeling** (Darcy's Law, Diffusion-Limited Aggregation) to analyze the Saffman-Taylor instability, emphasizing computational approaches at the chemical-engineering interface.
- Designed and conducted controlled **experiments with Hele-Shaw cells** to validate simulations, investigating the interplay of viscosity, surface tension, and flow dynamics for interfacial instability.

Quiz App as Attendance Taking App *May '24 – Jun '24*
Advisor - Prof. Balgopal Komrath, IIT Gandhinagar | [Project Link]

- Designed and deployed a **web-based** quiz and attendance system using **Flask, JavaScript, Jinja2,** and **SQLite** to support **real-time quizzes** and **automated attendance** tracking.
- Implemented **geolocation validation**, **randomized number generation**, and **admin-approval workflows** to prevent cheating and enable secure session management with **automated reporting**.

Helical Fins in a Double Heat Exchanger *Jan '24 – May '24*
Advisor - Prof. Biswajit Saha, IIT Gandhinagar | [Project Link]

- Conducted comprehensive calculations to determine the **heat transfer coefficient of circular finned pipes**, taking into account various parameters such as fluid properties, flow rates, and temperature gradients.
- Evaluated the **thermal efficiency** and **effectiveness** of the fin by analyzing its ability to enhance heat transfer and improve overall system performance.
- Developed a detailed **comparative analysis** between the circular finned pipe and a standard double heat exchanger.

Transient Thermal Analysis of a Car Brake System *Aug '23 – Nov '23*
Advisor - Prof. Dilip Srinivas Sundaram & Prof. Akshaa Vatwani | [Project Link]

- Executed detailed **numerical simulations** to assess the transient thermal behavior of a car brake system during braking, **analyzing heat distribution** and **temperature changes** over time to evaluate system performance.
- Utilized **advanced computational tools** and **finite element analysis (FEA)** to model the heat distribution and dissipation patterns across brake components, including the rotor, pads, and calipers.

Increasing Efficiency of Rankine Cycle *Oct '23 – Nov '23*
Advisor - Prof. Atul Bhargav, IIT Gandhinagar | [Project Link]

- Implemented **thermodynamic analysis** and **simulation techniques** to identify and **adjust key cycle parameters**, such as turbine inlet temperature and condenser pressure, to maximize thermal efficiency and overall power output.
- Developed **graphical representations** to illustrate the relationship between cycle adjustments and performance metrics, providing clear visual insights into how different parameters influence efficiency and steam quality.

Analysis of Datasets using Probability, ML & Stats *Jan '23 – Apr '23*
Advisor - Prof. Shanmugathan Raman, IIT Gandhinagar | [Project Link]

- Conducted analysis of Airbnb hosts' data, implementing comprehensive **data cleaning** to ensure dataset accuracy. Extracted valuable insights into host performance and guest interactions.
- Applied **advanced statistical techniques**, including **correlation analysis**, **regression** models, and **clustering**, to uncover significant trends related to pricing, location, and guest reviews.

Personal Portfolio Website *May '24 – Jun '24*
Self Initiated | [Website Link]

- Designed and developed a personal **portfolio website** using **HTML, CSS,** and **JavaScript** to showcase projects, skills, and achievements, featuring a **responsive design** for optimal viewing on various devices.
- Conceptualised **dynamic elements** and **user-friendly navigation**, including interactive project galleries, animated elements, and contact forms to enhance user engagement and experience.

Developing Games and Puzzles with C and C++ Using DSA *Jan '24 – Apr '24*
Self Initiated | [Website Link]

- Designed and implemented **Connect4** and **Up-it-Up games** utilizing optimal move strategies and **graph traversal algorithms** for strategic gameplay and decision-making.
- Developed **Sudoku Solver** and **2x2x2 Rubik's Cube Solver**, employing **advanced algorithms** to enhance solving efficiency and optimal move calculations.

TECHNICAL SKILLS

- **Languages:** Python, C, C++, MATLAB, HTML, CSS, Javascript, SQL, Rust.
- **Tools:** Git, LaTeX, Quarto, GitHub, Adobe Illustrator, Arduino IDE, Autodesk Inventor, Tableau, Data Modelling.
- **Libraries:** PyTorch, NumPy, Pandas, Scikit-learn, SciPy, Plotly, Seaborn, Flask, SQLite, SMOTE, XGBoost, LightGBM.

ACHIEVEMENTS

- Received the **Academic Excellence Award** for achieving the highest CPI in AY 2023-24.
- Felicitated with **Dean's List Award** IITGN for **Semester II** for excellent academic performance.
- Awarded **Academic Research Ranking 2** (out of 50 students) for the Academic Year 2024-2025, recommended for institute-led academic internship and exchange programmes.
- Secured a grade of **A+** (11/10) for outstanding performance in the course of Numerical Methods by successfully doing the project and simulation on **"Transient Thermal Analysis of a Car Brake System."**
- Completed **Deloitte Australia Data Analytics** Virtual Internship (Forage, Jun 2025), involving **Tableau dashboards, Excel-based classification**, and **business insight generation**. [Certificate]
- Earned the Specialist rank on Codeforces, highlighting strong competitive programming skills.

RELEVANT COURSES

Computer Science Courses
- CS 330: Operating Systems
- CS 331: Computer Networks
- CS 431: Computer and Network Security
- CS 202: Software Tools & Techniques
- ES 242: Data Structures and Algorithms I
- ES 204: Digital Systems
- ES 214: Discrete Mathematics
- CS 201: Theory of Computing

AI / ML Courses
- ES 335: Machine Learning
- CS 329: Foundations of AI: Multiagent Systems

Chemical Engineering Courses
- ES 211: Thermodynamics
- CL 201: Chemical Process Calculations
- CL 202: Chemical Engineering Thermodynamics
- CL 203: Process Fluid Mechanics
- CL 204: Heat Transfer
- CL 205: Chemical Reaction Engineering I
- CL 313: Chemical Reaction Engineering II
- CL 314: Separation Processes I
- CL 315: Process Dynamics and Control
- CL 326: Integrated Chemical Engineering Lab I
- CL 316: Separation Processes II
- CL 317: Process Synthesis, Design & Simulation
- CL 325: Transport Phenomena
- CL 327: Integrated Chemical Engineering Lab II
- ES 604: Engineering Optimization

- `ES 617`: Design of Experiments
- `CL 427`: Formulation Science and Engineering

Mathematics, Statistics & Electrical Courses
- `ES 114`: Probability, Statistics, and Data Visualization
- `MA 103`: Calculus of Single Variable and Linear Algebra
- `MA 203`: Numerical Methods
- `MA 204`: Introduction to Partial Differential Equations
- `MA 104`: Ordinary Differential Equations
- `ES 116`: Principles and Applications of Electrical Engineering

TEACHING EXPERIENCE

Undergraduate Teaching Assistant (UGTA) *Aug '24 – Nov '24*
Course: ES 604 Engineering Optimization | Prof. Hari S. Ganesh
- Facilitated weekly doubt-clearing sessions and assignment discussions, assisting students with various optimization concepts.
- Evaluated and provided constructive feedback on course projects, ensuring alignment with course objectives.

POSITIONS OF RESPONSIBILITY

Design Team Member, Amalthea '23 *Dec '22 – Feb '24*
(Annual Technical Summit of IIT Gandhinagar)
- Created engaging social media designs for diverse platforms, utilizing Adobe Illustrator, Canva, and other graphic design software.
- Developed and executed visually compelling social media content for various platforms using Adobe Illustrator, Canva, and other graphic design tools.

Team Member, Vinteo *Jul '24 – May '25*
(Film Making Club of IIT Gandhinagar)
- Contributed to a short film's production, handling concept development, and filming. Ensured smooth execution.

Team Member, MAPRC *Jul '24 – May '25*
(Media and Public Relations Committee of IIT Gandhinagar)
- Designer for "ETHEREAL," IIT Gandhinagar's official monthly magazine, crafting visuals to showcase campus life, student achievements, events, and engaging stories.