Shabarish Balaji Rajkumar

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Education

Indian Institute of Technology Madras GPA: 8.34/10

Bachelor of Technology in Mechanical Engineering; Minor in Machine Learning and Artificial Intelligence *2026*

Maharishi Vidya Mandir 484/500

Class 12-Science Stream(CBSE) *2022*

Publications

[1] **Shabarish Balaji**, Mahesh V Panchangula, Revanth Madabathula, Debjit Kundu, Mukesh K. **"Hierarchical Modeling for Synthetic Turbulence Generation"** In *78th Annual Meeting of APS Division of Fluid Dynamics 2025* APS Abstract

[2] **Shabarish Balaji**, Priyabrat Dash, Konduri Aditya, Nikhil Verma, Aritra Roy Choudhury, R. V. Ravikrishna. **"A Temporal Deep Learning Model for Non-Intrusive Identification of Recirculation Zones in Trapped Vortex Combustor"** Submitted to *ASME 2026 Turbomachinery Technical Conference & Exposition.*

[3] Ruthwik Chivukula, Sriram Pillutla, Anirudh Kalyan, **Shabarish Balaji**, Akshay Govind Srinivasan, Yash Gawande, Nagabhushana Rao Vadlamani, Bharath Govindarajan **"Gradient-Based Regularization for Inverse Airfoil Design"** In *Physics of Fluids*, Volume 37, Issue 11, AIP 2025. Physics of Fluids 2025

Research Experience

Gradient-Based Regularization for Inverse Airfoil Design June 2023 - May 2024

Guide:Dr. Nagabhushana Rao Vadlamani, Aerospace Engineering, IIT Madras *Chennai, India*

- Developed gradient based regularization for incorporating geometric smoothness in inverse airfoil design
- Achieved model generalization across aerodynamic conditions, varying angles of attack and Reynolds numbers
- Paper accepted in the American Institute of Physics-*Physics of Fluids* Journal 37 (11) - [Paper, Poster]

Hierarchal Modeling for Synthetic Turbulence Generation March 2025 - Oct 2025

Guide: Dr. Mahesh Panchangula, Applied Mechanics, IIT Madras *Chennai, India*

- Developed a hierarchical framework for long turbulence time-series generation with BRITS and ARIMA models
- Implemented PSD scaling and structure functions test to ensure statistical fidelity across all stages
- Presented as contributed session in *78th Annual Meeting of APS Division of Fluid Dynamics* 2025 - [Presentation]

Physics-Informed Super Resolution of 3D Turbulence Dec 2024 - Present

Guide: Dr. Konduri Aditya, Computational and Data Science, IISc Bangalore *Bangalore, India*

- Built a 3D Swin Transformer for 4× turbulence super-resolution leveraging scale similarity principles
- Enhanced feature extraction using channel attention, enabling accurate reconstruction of small-scale structures
- Building an interpretability framework through gradient-based attribution maps which quantify how differnent spatial regions affect reconstruction performance for optimal model selection

Velocity Field Predictions in Recirculation zones using Deep Learning July 2025 - Nov 2025

Guide: Dr. Konduri Aditya, Computational and Data Science, IISc Bangalore *Bangalore, India*

- Built a physics-informed SWIN-LSTM for velocity field predictions from experimental PLIF images
- Experimented with RNNs, Conv-LSTMs, etc. to determine optimal architecture for capturing flame propagation

Identification of Individuals based on Exhaled Breath Biometrics Sep 2024 - June 2025

Guide:Dr. Mahesh Panchagnula, Applied Mechanics, IIT Madras *Chennai, India*

- Built a CNN-LSTM embedding model achieving 83.13% identification accuracy from breath signatures
- Tested multiple embeddings to best capture the data's multifractality and physiological features - [Report]

Physics-Informed Surrogate Modelling for Data-center Airflow Aug 2025 - Present

Guide:Dr. Chakravarthy Balaji, Mechanical Engineering, IIT Madras *Chennai, India*

- Developed a PDE-constrained, physics-informed U-Net to predict plane-wise temperature fields
- Exploring 3D neural operator architectures to efficiently map the input parameters to full 3D temperature fields

Technical Projects

EE5179: Deep Learning for Imaging Aug 2025 – Nov 2025
Instructor: Dr. A.N. Rajagopalan, Department of Elctrical Engineering | GitHub *IIT Madras*

- Built fully connected and convolutional VAEs using stochastic reparameterization and KL priors, analyzing latent geometry through t-SNE, sampling, and class-wise interpolations
- Analyzed the latent manifold structure of Sparse Autoencoders through representation-space noise experiments.
- Evaluated RNN and LSTM models for MNIST sequences, focusing on gradient stability and hidden-state behavior

AM5630: Computational Fluid Dynamics Jan 2025 – May 2025
Instructors: Dr.S Vengadesan & Dr.Danny Raj, Department of Applied Mechanics | GitHub *IIT Madras*

- Built a finite volume solver for convection-diffusion with source term and compared numerical results against analytical solutions and benchmarked convection schemes
- Expanded the CFD solver to implement pressure-velocity coupling for lid-driven cavity flow

AM5450: Finite Element Analysis Aug 2025 – Nov 2025
Instructor: Dr. A.Arockiarajan, Department of Applied Mechanics | GitHub *IIT Madras*

- Built CST and quad FE solvers for elasticity and heat-conduction modeling of cantilever and L-shaped domains
- Formulated 1D/2D finite element boundary value problems for transient heat transfer in a circular fin using quadratic elements to obtain temperature distribution and heat loss

Inter-IIT 2023: Adobe Behaviour Simulation Challenge Oct 2023 – Jan 2024
Inter-IIT AI Contingent, Technical Society | Report | GitHub *IIT Madras*

- Deployed a Mistral-7B model to generate tweets based on media content for unseen brands and time periods
- Achieved 0.15 R2 score with XGBoost ensemble classifier for predicting likes based on tweet content

Teaching Experience

Volunteer Math Tutor Dec 2024 – July 2025
J-PAL South Asia *MIT*

- Mentored underprivileged middle school students in problem solving skills and anaytical thinking for mathematics

Coordinator of AI Club Dec 2024 – July 2025
AI Club, Center for Innovation *IIT Madras*

- Conducted summer school sessions and workshops on AI and Machine Learning for over 800 students nationwide

Leadership and Extracurriculars

Project Lead of AI Club April 2024 – May 2025
AI Club, Center for Innovation *IIT Madras*

- Led 7 sophomores in a year-long research project on nighttime flare removal through diffusion-guided models
- Mentored the team through structured literature review sessions, deep learning theory, and model development

Member of AI Club Dec 2024 – July 2025
AI Club, Center for Innovation *IIT Madras*

- Organized seminars and workshops with industry experts to educate students about the advancements in AI
- Designed the team structure and operational framework for the newly launched Hackathon vertical of the AI Club

Relevant Coursework:

Computational and Applied Mathematics: Inverse Methods in Heat Transfer, Foundations of Computational Fluid Dynamics, Fundamentals of Finite Element Analysis*, Convex Optimization*, Intoduction to Scientific Computing
Artificial Intelligence and Machine Learning: Deep Learning for Imaging*, Pattern Recognition and Machine Learning*, Machine Learning Techniques, Machine Learning Foundations (* - Ongoing Courses)

Skills:

Programming Languages: Python, C, C++, MATLAB, ANSYS
Frameworks: PyTorch, TensorFlow, Numpy, Pandas, Sympy, OpenCV, ABACUS

Achievements:

Secured **Bronze Medal** in Adobe Behaviour simulation Challenge Medium Preparation Event in Inter-IIT Tech Meet
Semi-finalist(Novice) among 150+ teams in NALSAR Intervarsity Debating Championship(IVDC) representing IITM
Secured **99.17 percentile** out of 800,000 applicants in Joint Entrance Examination (Mains) 2022
Secured **All India Rank 386** in NEST and secured admission in National Institute of Science Education and Research