

# Neeraj Balachandar



## Education

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### Indian Institute of Technology Hyderabad

*Dual Degree BTech in Mechanical Eng. and MTech in Aerospace Eng. with a Minor in Robotics*

- CGPA: 8.67/10

Hyderabad, India  
Nov 2022 – Present

### Kuriakose Elias English Medium School

*Higher Secondary*

- Grade: 97.8%

Kerala, India  
Aug 2020 – Jul 2022

### Marian Senior Secondary School

*High School (CBSE)*

- Grade: 95.8%

Kerala, India  
Aug 2019 – Apr 2020

## Relevant Coursework

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### Courses:

- **Matrix Theory**, Linear Algebra, Probability and Random Processes, **Information Theory**
- Control Systems, **Optimal Control**, Convex Optimisation
- **Incompressible Fluid Flows**, FEM, CFD
- Scientific Parallel Computing, **Machine Learning**, Autonomous Robotics, Soft Robotics

### Self-taught:

- Advanced Learning Algorithms, Deep Learning, **Data-driven modelling and control**, Physics Informed Machine Learning
- **Non-linear Dynamics**, Numerical methods for PDEs, Variational Methods for programming

## Research Contributions

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### Conferences

- **Neeraj Balachandar**, Yashwanth M., and Vishnu R. Unni. “Physics Informed Fourier Neural Operator to Map Reformulated Vortex Particle Field to Eulerian Velocity Field”. *Accepted for presentation at the 14th International Symposium on Turbulence and Shear Flow Phenomena (TSFP14), July 2026, Heidelberg, Germany.*
- **Neeraj Balachandar**, Shriram Hari, Yashwanth M., and Vishnu R. Unni. “Optimal Trajectory Planning for Drone to Drone Docking”. *Accepted for presentation at the 2026 AIAA SciTech Forum, Session IS-24: Autonomy III, January 15, 2026, Orlando, FL (In-Person Technical Paper Session).*
- **Neeraj Balachandar**, Yashwanth M., Akash M., Mahathi Kesavan, and Vishnu R. Unni. “Actuator System for Directional Manoeuvre of a Flapping Wing Aerial Vehicle.” *Presented at the 2025 AIAA SciTech Forum, Session AS-08: Bio-inspired Adaptive Structures, January 8, 2025, Orlando, FL (In-Person Technical Paper Session).*

## Experience

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### Dynamics and Control Lab, IITH

Supervised by *Dr Vishnu R. Unni*

Hyderabad, India  
Mar 2024 - Present

- Developing high-fidelity **Vortex Particle Method (rVPM)** simulation codes to characterise unsteady flapping-wing wakes and apply a **complex-systems** approach for analysing vortex-evolution patterns.
- Exploring **data-driven** methods for solving a family of PDEs (**Neural Operators, PINNs, DMD, and SINDy**) to reduce the computational overhead incurred in post-processing velocity fields for rVPM.
- Developing an **aeroelastic solver** (Julia-based), using **scientific computing** techniques, coupling Finite

Element Method (FEM) and rVPM, using Implicit coupling techniques.

- Developed an algorithm for **drone-to-drone docking** using **sequential convex programming** and **analytically modelled** the paddling action of soft membranes for biomimetic jellyfish.
- Conducted extensive **experiments** to validate simulation and modelling results.
- Teaching Assistant for the course **Spacecraft Dynamics and Control** (Spring '26)

**Swarm Rescue Challenge**, CIEDS-Ecole Polytechnique de Paris *Palaiseau, France (hybrid)*  
Supervised by *Dr David Filliat* and *Emmanuel Battesti* *Nov 2024 - Mar 2025*

- A **simulation** challenge organised by CIEDS, AMIAD and DRDO.
- Developed algorithm (Python engine) for **autonomous exploration and rescue**, including obstacle-aware navigation, swarm coordination under communication constraints, and resource-bounded decision logic.

**Indian Institute of Science Research Intern** *Bangalore, India*  
Supervised by *Dr SN Omkar* *May 2024 - Aug 2024*

- A three-month research project in the Aerospace Dept. of IISc, evaluating the fatigue in muscle activity caused to astronauts due to **microgravity** environments
- Designed and developed an **exoskeleton** to faithfully mimic near-microgravity environment, and validated open-source **biomechanical** sim models using time series obtained from exoskeleton

## Projects

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**Neural Operator** based surrogates to **Fast Multipole for the Vortex particle simulations** *Sep 2025- Present*  
*Dr. Vishnu R. Unni*

- An efficient **surrogate** to the **Fast Multipole** method preserving conservation laws for the **N-body** problem of **vortex** particles
- Enabling **super-resolution** reconstruction of velocity fields in 2D flows trailing an airfoil from vortex particle characterisation and positional embeddings

**Development of a variable fidelity aeroelastic solver VarFLEXI** using **rVPM** *May 2025 - Present*  
*Dr. Vishnu R. Unni*

- Writing problem-specific **adapters** in **Julia** for coupling meshless rVPM with Fenics solver using Precice library based implicit coupling, and in-house partitioned explicit coupling.
- Validation of our **VarFLEXI** framework for cases involving pitching, plunging airfoils and flutter cases.

**Characterisation of chaotic wake dynamics of flapping wings using low-fidelity simulation data** *Oct 2024 - Present*  
*Dr. Vishnu R. Unni*

- Defining how the evolution of vortex particles in a field can be seen as a time-evolving weighted graph network.
- Investigating the temporal and spatial resolution of **chaotic structures** in the wake, supplementing the **stability** of a **flapping wing**
- Identifying the **route to chaos** in wake through minimal fidelity solvers
- Developing an Information-theoretic approach to the described flow of vortex particle network.

**Iterative Optimal Trajectory Planning for Drone to Drone Docking** with **Sequential Convex Programming** *May 2025 - Present*  
*Dr. Vishnu R. Unni*

- Formulating the drone to drone docking as a **Sequential Convex Programming** problem under safety constraints
- Generated optimal thrust profile under **convexified** mission constraints and environmental disturbances, including rotor downwash interaction

**Analytical model** for soft robotic membranes *Nov 2024 - Present*  
*Dr. Vishnu R. Unni, Dr. Prakhar Gupta*

- Design of a **biomimetic jellyfish** actuated through tendon-based continuum lappet and estimation of

propulsive forces generated

- Utilized **Lighthill's** large amplitude hydrodynamic theory coupled with **Cosserat** theory for modelling the paddling membrane
- Ran **immersed boundary** simulations for the visualisation of wake for a simple model

### Drone Swarm Rescue Simulation Challenge

Nov 2024 - Mar 2025

Dr David Filliat [✉](#)

- Exploration of an unknown environment through an autonomous drone swarm, using **Artificial Potential Field** for exploration and **Rapidly exploring Random Trees** for transport back to the rescue centre
- Developed navigation algorithm for exploring the environment in small groups, with the drones in close vicinity forming a **coordinated polygon** while maintaining a **leader drone**.
- Ran a comparison test for the simulation with clustering algorithms, including **DBSCAN** and **K-means**
- An **average of 4.5 people** rescued and **1.5 collisions** per **2000 steps** tested over **4 different maps**

### A Neuro-Fuzzy logic for PID control

Nov 2025

Dr. Vishnu R. Unni [✉](#)

- Developed a **neuro-fuzzy PID** logic for **joint angle** control of 2R, 2D manipulators
- The excitations were injected directly into the joint angles through various profiles, including sine, parabolic and multi-frequency.

### Parallelisation of SVD Algorithm

Feb 2025

Dr. Niranjan Ghaisas [✉](#)

- Implemented parallelization scheme for Singular Value Decomposition algorithm in **C** using **OpenMP**
- Achieved significant performance gains, reducing execution time by **5 times** in **strong scaling** tests while maintaining **near-linear** growth under **weak scaling**.

### Modelling and Simulation of an Autonomous Underwater Vehicle

Jan 2025

Dr. Himabindu Allaka [✉](#)

- Developed a **hydrodynamic** model for Sparus AUV
- Designed a controller in **Simulink** for **stabilisation** of an **underactuated** Sparus **AUV** in the presence of **surface waves**

### Quasi-static elbow flexion in near-simulated microgravity environment

Apr 2024 - Jul 2024

Dr SN Omkar [✉](#)

- Investigated variations in elbow-flexor muscle activity under **simulated microgravity** conditions
- Designed and developed a wearable **exoskeleton** to replicate microgravity effects and validate the resulting **time-series** data using **OpenSim**, integrating real-time **motion-capture** inputs from OptiTrack

## Achievements

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- Ranked **Second** amongst the Indian teams for the **Swarm Rescue Challenge 2025** [✉](#) conducted by **CIEDS-Ecole Polytechnique de Paris**.
- Awarded the **Summer research Fellowship** by the **Indian Academy of Sciences** [✉](#) for research internship in **Indian Institute of Science** in the summer of 2024.
- Among the **top 0.3 percentile** of students in the JEE 2022 in India

## Technical Skills

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**Programming Languages:** Python, Julia, MATLAB, C, Embedded C

**Tools:** ROS, Gazebo, Paraview, Simulink, SolidWorks, Ansys Fluent, Simulia Abaqus, LaTeX, Github, OpenSim, Linux OS, VS Code, QP solvers

## Extracurricular activities

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Part of the **University Basketball** team (Inter IIT 2023-2025)

Completed **Trinity Grade 2 Piano** level