Naveen Balaji

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Education

- **Indian Institute of Technology Kanpur** — **Kanpur, India**
  Bachelors of Technology in Aerospace Engineering, ***CPI: 9.1/10.0*** — *Fall 2017 - Summer 2021**

Research Experience

- **Undergraduate Student Researcher** — **March 2019 - present**
  Intelligent Guidance & Control Laboratory, — *Guide: Prof.Mangal Kothari*
  - Created attitude and position estimator using procedures such as Least-Square, EKF, Particle filter with range-based sensor for indoor localization.
  - Investigated the observability of current relative localization methods for UAVs in GPS denied environment.
  - Developed optimal sensor placement and optimal control law strategies for the quadcopter to increase indoor localization accuracy.
- **Research Intern,** — **Mar.2020-Dec.2020**
  Mitsubishi Heavy Industries — *Guide: Dr.Abhishek & Dr.Mangal*
  - Designed a novel fail-safe system for drone Positioning and Posture estimation without a GPS module.
  - Developed the localization scheme using Ultra-Wide Band sensors and GPS for multirotor systems.
  - Created platform for optimal beacon placement in industrial environment for robot navigation.
  - Automated the inspection process of large cranes using the quadcopter system.
- **Team Head** — **Nov. 2017 - April 2019**
  Aerial Robotics IITK — *IIT Kanpur*
  - Designed and developed various Quadcopter models with different sensors and dynamics
  - Developed a robust vision-based drone landing system on the color box, with a precise object tracking technique for search and rescue competition.
  - Created Aruco Marker-based localization in an indoor environment for quadcopters.
  - Improved sensor fusion techniques with (AHRS) inertial sensors and optical flow integration.
  - Explored current state of the art Visual Inertial Odometry methods such as VINS, ROVIO for the drone.
  - Experimented aself-designed PID controller and an available Model Predictive controller on real drones.

Publications

➢: N. Balaji, M. Kothari, and A. Abhishek. Gps denied localization and magnetometer-free yaw estimation for multi-rotor uavs. In *2020 International Conference on Unmanned Aircraft Systems (ICUAS)*, pages 983–990

➢: N. Balaji and M. Kothari. Range sensor based Localization and control of mobile robots . SURGE 2019 Poster Presentation, IIT Kanpur [Poster]

Patent

➢: N. Balaji, M. Kothari, and A. Abhishek. System and method for estimation of yaw angle for an aerial vehicle for autonomous navigation, 2019. Indian Provisional Patent

Selected Projects

Indoor localization of multi-rotors

Bachelors thesis, report *Sept–Dec '20*

- Implemented a **range based SLAM** using the wireless beacons for quadcopter localization in an indoor environment.
- Automated the noise tuning part in the Gaussian filter using the Particle Swarm Optimization method.
- Proposed a **novel way of estimating the drone's orientation** and position in an indoor environment without the use of magnetometer and external sensors.

Reinforcement learning

Coursera-Online specialization, certificate *May–Jul '20*

- Learned to formalize the control task as a RL problem and to implement the solution.
- Performed the neural network function approximation to train the agent on the simulated problem.
- Implemented the q-learning, actor-critic algorithms to maintain the position on cart-pole, moon lander, and simulated quadcopter.

Swarm Robotics

Electronics Club IITK summer project, report *May–Jul '19*

- Designed five ground bots with interconnected WiFi communication and Localized the bots based on aruco markers and infrared sensors
- Implemented Centralized Multiagent path planning algorithm (**Conflict Based Search**) on the bots for desired **shape formation**.

Wall following Quadcopter Navigation

InterIIT contest, report *Nov '18–Dec '18*

- Worked on an embedded quadcopter module fitted with sonar sensors for autonomous movement.
- Developed a position controller for drone navigation along the wall, robust to outlier sensor noises.

Desktopography

Electronics Club IITK summer project, report *May–Jul '18*

- Developed a **computer interface** by using the depth-camera and projector.
- Implemented **gesture** recognition of the hand by depth images and transformed those actions to move the computer pointer.
- Explored **sift, surf, orb** image feature algorithms for finger segmentation and tracking using the **OpenCV** library.

Course Projects

Optimal Control of Electric-sail spacecraft

Automatic Control of Aircraft Rockets and Spacecraft, report *Sept–Dec '20*

- Derived dynamics of the spacecraft with its novel propulsive system.
- Implemented the linearized attitude and orbital control of the spacecraft.
- Investigated the optimal control techniques to develop minimum time trajectories.

Observability based Sensor Placement

Autonomous navigation , report *Sep '20–Dec '20*

- Formulated the network constraint on beacon based localization based on non-linear observability analysis.
- Presented a solution for sensor placement on the industrial structure using PSO method.
- Investigated the optimal control problem around beacon to improve the estimation accuracy.

Aircraft Design and Analysis

Aerospace experiments, report *Jan–Nov '20*

- Analyzed the aerodynamics, performance, and stability of different aircraft models.
- Designed a full light-weight aircraft model based on the system requirements .
- Constructed a prototype model of **twin-boom pusher** aircraft and added autopilot for loitering operations.

Linear programming techniques

Optimization Methods in Engineering, report *Jan–Apr '20*

- Studied and analyzed the algorithms available to solve large linear constrained problems
- Compared the **simplex and Interior point method**, based on their time complexity.
- Illustrated the complexity and visualization of their problem-specific usage.

Achievements

2019: **First** in **Inter-IIT Techmeet** for Aerial Robotics search & rescue competition by IIT Roorkee
2019: Awarded the **Summer Undergraduate Research Grant for Excellence** (SURGE) by IIT Kanpur
2019: Summer **Best Project** award by Sn-T Council IIT-Kanpur for Swarm Robotics.
2018: **Second** in **Inter-IIT Techmeet** for Aerial Robotics wall-navigation competition by IIT Bombay
2018: Summer **Best Project** award by Sn-T Council IIT-Kanpur for Desktopography.
2017: **All India Rank 924** in Engineering entrance [JEE Mains] among 1.2 million students
2016: **Kishore Vaigyanik Protsahan Yojana** (KVPY) Fellowship by Indian Institute of Science

Technical skills

Robotics: ROS, Gazebo, Arduino, OpenCV, Keras
Languages: Python, C++, C, MATLAB
Softwares: GITHUB, HTML, AUTOCAD, LaTeX

Relevant Coursework

Robotics:: Autonomous Navigation, Aircraft Design, Helicopter theory , Manufacturing Processes, Unmanned Aerial Systems.

Controls:: Automatic Control of Aircraft Rockets and Spacecraft, Optimal Space Flight Control, Aircraft Control Systems, Flight dynamics

Mathematics:: Linear Algebra, Complex Variables, Ordinary and Partial Differential Equations

Programming:: Optimization Methods, Data Structures and Algorithms, Fundamentals of Programming.

Coursera Online:: Probability and Statistics, Neural Networks and Deep Learning, Convolutional Neural Networks, Reinforcement Learning Specialization

Positions of Responsibility

Counseling Service **IIT Kanpur**
Academic Mentor *Sep '18–Mar '19*
- Provided tutoring to academically weak students for the introductory **Mechanics** course
- Assisted freshmen students in adjusting to the college environment

Electronics Club **IIT Kanpur**
Secretary *Sep '18–Mar '19*
- Worked with various onboard computers, micro-controllers, visual sensors & sensors circuits.
- Demonstrated and mentored various small projects like home automation, gaming console, radar, optical mouse measurements and *IoT* applications.
- Organized winter lecture series for freshmen on *Introduction to ROS*, *sensors* & *automation*, and *quadcopter assembly*

Miscellaneous

➢: Participated in Aeromodelling competitions to design a glider model and to pilot quadcopters
➢: Participated in Microsoft's CodeFunDo, qualified up to phase-2
➢: Volunteered and worked in AntarAgni and Udghosh (IITK cultural and sports festival)