Gaurav Kumar

Junior Undergraduate · Indian Institute of Technology Kanpur

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Education

Exp. 2023 **Bachelor of Technology**, Department of Aerospace Engineering, IIT Kanpur, India — *GPA: 8.8/10*
Minor, Control Systems, Department of Electrical Engineering, IIT Kanpur

May 2019 **Grade XII (CBSE)**, Kendriya Vidyalaya, Asansol — *Percentage: 95.4%*

May 2017 **Grade X (CBSE)**, Kendriya Vidyalaya, Asansol — *CGPA: 10/10*

Research Interests

Spacecraft Guidance, Control and Dynamics, Astrodynamics, Space Automation and Robotics, Optimal and Non-linear control

Publication

On-Track Optimal Rendezvous and Docking of Spacecrafts using Hybrid Coulomb Control — *Under Review: AIAA-JSR*

Gaurav Kumar, Dipak Giri and Shashi Ranjan Kumar — *Sep. 2021*

- Rendezvous and docking system of spacecrafts using optimal hybrid Coulomb force is developed
- New method of calculating Coulomb interaction and chaser dynamics coupling is proposed
- Developed optimal controller is compared with an existing voltage feedback control for both linear and non-linear simulations in MATLAB

Experience

SURGE'21, IIT Kanpur — *[Report]*

Research Intern — *Jun. 2021 - Aug. 2021*

- Optimal control for high precision rendezvous and docking of Coulomb satellites is developed.
- Relative attitude dynamics is derived using quaternions and Euler equation
- Receding Horizon Modern Predictive Control (RHMPC) with constraints is used to do constrained optimisation of cost function
- Inequality constraint on state and equality constraint on path is applied to implement object avoidance from space debris during docking.
- Simulated developed docking system for both 15-3 meters and 3 meters-80mm docking with derived control law in basilisk framework and MATLAB for verifying terminal docking performance.

Research Projects

Improved Linear Quadratic Regulator for Spacecraft Docking using Krotov Conditions — *[Report]*

Prof. Dipak Kumar Giri — *Dec. 2019 - May. 2021*

- Designed control algorithm using Krotov conditions overcoming non-differentiability constraint of cost function issue in Hamilton-Jacobi-Bellman (HJB) equation solution.
- Improved robustness of existing algorithm by developing global optimum solutions for mission scenarios under various parametric constraints in terminal docking phase.
- Asymptotic stability of the improved controller is shown using Lyapunov Direct Method by generating energy like Lyapunov functions.
- Simulated and tested derived algorithms on MATLAB to confirm results.

Technical Projects

PetCAT — *[Github]*

Robotics Club, IIT Kanpur — *Apr. 2020 - Dec. 2020*

- Developed biologically inspired robot that mimics structure and behaviour of Cats under obstacle-avoidance team.
- Implemented and tested a new method of Advanced Fuzzy Potential Field Method (AFPMF) which solved the problem of local minimum field disturbances at low computation.

Autonomous Navigation in Rough Mars Terrain Environment *[Report] [Github]*

Robotics Club, IIT Kanpur *May. 2020 - Jul. 2020*

- Developed and tested GPS and ArUco-marker based navigation on Mars environment in Gazebo using OpenCV and ROS.
- Developed a new and efficient algorithm of combining Depth maps and A* algorithm for obstacle avoidance.

3D Shape Completion for Autonomous Vehicles *[Report]*

Robotics Club, IIT Kanpur *Sept. 2020 - Dec. 2020*

- Implemented Semantic Segmentation on KITTI data set using UNet for pixel segmentation to recognise objects.
- Developed algorithms for completing and classifying the shape of 3D objects using point cloud.

Skills

Programming Languages	C/C++, Python, Bash
Robotics	ROS, basilisk, OpenCV, Gazebo, Rviz
Utilities	MATLAB, LabView, Linux, Git, Autocad, Arduino IDE, LaTeX
Frameworks	PyTorch, OpenCV, NumPy,MatPlotLib

Coursework

Aerospace Engineering	Rigid Body Dynamics (ESO209) | Flight Mechanics (AE321)^{i}
	Incompressible Aerodynamics (AE211)* | Compressible Aerodynamics^{i}
	Aerospace Structures (AE311)^{i} | Thermodynamics (ESO 201)
Control Systems	Classical Control System (EE250)^{i} | Basics of Modern Control Systems (EE650)^{g}
	Optimal Control and Reinforcement Learning (AE691A)^{g}
Mathematics & Statistics	Partial Differential Equations (MSO203)* | Linear Algebra & ODE (MTH102)
	Real Analysis & Multivariate Calculus (MTH101)* | Complex Analysis (MSO202)
Miscellaneous	Introduction to Economics (ECO101)| Sociology (SOC171)
	Life Sciences (LIF101)

: Awarded A grade for outstanding performance
^{i}: Ongoing Course
^{g}: Graduate level Course

Positions of Responsibility

Coordinator — Anime Club, IITK *Apr. 2021 - Current*

- Motivated campus students in appreciating Anime and Manga as an art style.
- Promoted cross cultural understanding in campus.
- Organized Anime quiz, Discussions and OST challenges in online mode.

Secretary — Research Wing, IITK *Jul. 2020 - Jul. 2021*

- Increased awareness about the variety of research going on in the campus through Departmental Orientation
- Promoted research among the campus community in the form of Research News letter and sessions.
- Organized Students' Research Convention (SRC'21) with participation from 50+ researchers across the nation.

Achievements and Accolades

2021	**Top 5**, Undergraduate department rank	*IIT Kanpur*
2019	**National top 1%** , JEE Advanced 2019 among the 2.3 lakhs shortlisted candidates	*India*
2019	**Scholarship** , MHRD, Government of India for being in top 5 percentile in Grade XII all over the country	*India*
2017	**1st Place**, National Science Congress'17 under KVS	*Delhi, India*
2017	**Scholarship**, MHRD, Government of India for exceptional school academics	*India*
2015	**National Rank 84**, National Science Talent Search Examination conducted by Unified Council	*India*