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
Orbital Mechanics
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.
- Proposed optimal controller is compared with an existing voltage feedback control for both linear and non-linear simulations in MATLAB.

Experience

Undergraduate Research Programme- SURGE'21, IIT Kanpur — *[Report]*

RESEARCH INTERN — *Jun. 2021 - Aug. 2021*

- Optimal control for high precision rendezvous and docking of Coulomb satellites is investigated.
- Relative attitude dynamics is derived using quaternions and Euler equation.
- Receding Horizon Model Predictive Control (RHMPC) with constraints is used to do constrained optimisation of performance index.
- 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

Optimality of Error Dynamics in Missile Guidance — *[Proposal]*

COURSE RESEARCH PROJECT: AE691A — *Aug.2021 - Present*

- System model for missile guidance is studied and dynamical equations are derived.
- The optimal convergence of the tracking error and an optimal error dynamics that achieves this optimal pattern as well as guarantees the finite-time convergence for guidance law design is proposed.
- Developed laws will be compared with proportional navigation and guidance (PNG) and sliding motion control (SMC) to comapare results and illustrate performance.

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

ADVISOR: PROF. DIPAK KUMAR GIRI — *Dec. 2019 - May. 2021*

- Designed control algorithm using Krotov conditions, overcoming issue of non-differentiability constraint for cost function 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*

- Implemented 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, 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	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 conducted by DST, GoV of India	*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*