

Gaurav Kumar

JUNIOR UNDERGRADUATE · INDIAN INSTITUTE OF TECHNOLOGY KANPUR

☎ (+91) 8927935045 | ✉ grvk@iitk.ac.in | 🏠 home.iitk.ac.in/~grvk | 📞 grvk02 | 🌐 grvk

Education

Exp. 2023 **Bachelor of Technology**, Department of Aerospace Engineering, IIT Kanpur, India

GPA: 9.1/10

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 Non-linear control

Publication

On-Track Optimal Rendezvous and Docking of Spacecrafts using Hybrid Coulomb Control

IAC-2022, Paris

GAURAV KUMAR, DIPAK KUMAR GIRI AND SHASHI RANJAN KUMAR

Sep. 2022

- 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.

MagLev based 3-DOF experimental Platform for Autonomous Spacecraft Rendezvous and Docking

IAC-2022, Paris

NITIKA JAGGI, GAURAV KUMAR, ADITYA PRAKASH, PRIYANK DUBEY AND DIPAK KUMAR GIRI

Sep. 2022

- Magnetic levitation based robotic experiential platform is developed using Ansys
- Optimal thrusting mechanism is designed and integrated into the dynamics in Simscape
- Multiple guidance and control algorithms are tested.

Novel Coulomb Staged-Docking with Bipolar Electrospray Thrusters using Predefined-Time Sliding Mode Control

Under Review: JGCD

GAURAV KUMAR AND DIPAK KUMAR GIRI

June. 2022

- This paper introduces a novel method of spacecraft-docking that utilizes Coulomb control with staged bipolar electrospray thrusters in binary switching mode.
- A new predefined-time sliding mode controller is derived with a fixed time converging sliding manifold, which guarantees pre-set time convergence along with robustness to unmodeled perturbations and system uncertainties.
- The result is compared with a Lyapunov based control to demonstrate the superiority of proposed method.

Experience

Computer Modelling of Spacecraft Constellations, Carleton University, Ottawa, Canada

Research Intern

MENTOR: ALEX ELLERY

May. 2022 - Jul. 2022

- The aim of the project is to develop spacecraft constellation controlled using solar sail.
- The small constellation will require the use of robotic manipulators on the spacecraft for relative precision position control
- The large constellation will require the use of decentralised control mechanisms to be implemented for solar sails
- Differential correction is used around L1 Lagrangian to find stable periodic orbit.
- Simulation is done using STK and Matlab for showing the correctness of the controlled system.

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 (RHMP) 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

Predefined-Time Nonlinear Sliding Mode Attitude Tracking of Spacecraft

[\[Report\]](#)

COURSE RESEARCH PROJECT: EE691A

Jan. 2022 - Apr. 2022

- We consider the attitude tracking control problem for rigid spacecraft with bounded external disturbances. We implement and analyze a predefined-time predefined-bounded attitude tracking control scheme based on sliding mode control.
- Two mathematical formulations are discussed which can be used to derive control law and their proof of stability is given. Finally, numerical simulations are carried out to evaluate the performance of both the control law and compare them.

Trajectory Tracking Control Algorithm for a Wheeled Mobile Robot

[\[Report\]](#)

COURSE RESEARCH PROJECT: AE322A

Jan. 2022 - Apr. 2022

- A recently developed trajectory tracking control system for a wheeled mobile robot is presented in this study, which includes hierarchical sliding mode and backstepping control algorithms.
- The closed-loop stability and zero tracking error are guaranteed by the backstepping hierarchical sliding mode tracking control. The method's usefulness and aptitude for practical applications are demonstrated by numerical simulation results.

Optimality of Error Dynamics in Flight Guidance

[\[Report\]](#)

COURSE RESEARCH PROJECT: AE691A

Aug. 2021 - Dec. 2021

- 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 compare 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.

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	Space Dynamics(AE641) ^g Flight Mechanics (AE321) Incompressible Aerodynamics (AE211)* Compressible Aerodynamics(AE311) Aerospace Structures (AE331) Air Breathing Propulsion (AE341)
Control Systems	Classical Control System (EE250) Basics of Modern Control Systems (EE650) ^g Non-linear Systems (EE651)* ^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 exceptional performance

^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	<i>IIT Kanpur</i>
2019	National top 1% , JEE Advanced 2019 among the 2.3 lakhs shortlisted candidates	<i>India</i>
2019	Scholarship , MHRD, Government of India for being in top 5 percentile in Grade XII all over the country	<i>India</i>
2017	1st Place , National Science Congress'17 conducted by DST, GoV of India	<i>Delhi, India</i>
2017	Scholarship , MHRD, Government of India for exceptional school academics	<i>India</i>
2015	National Rank 84 , National Science Talent Search Examination conducted by Unified Council	<i>India</i>