

# Siddharth S. Jha

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## Education

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- **Indian Institute of Technology (IIT), Kharagpur, India** **Current CGPA: 8.09/10.0**  
*B.Tech in Electrical Engineering + M.Tech in Control System Engineering,* *2014-2019 (expected)*

## Publications

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- **Optimal visual servoing of a ground robot using a Pan-Tilt-Zoom (PTZ) camera (under review)**  
*ICAPS 2019 : 21st International Conference on Automated Planning and Scheduling, Berkeley, USA*
- **Ground vehicle odometry using a non-intrusive inertial speed sensor (accepted, to appear)**  
*IEEE-ICIT 2019: 20th IEEE International Conference on Industrial Technology, Melbourne, Australia*
- **Design, Analysis & Prototyping of a Semi-Automated Staircase-Climbing Rehabilitation Robot**  
*4th International Conference on Mechatronics and Robotics Engineering (ICMRE) 2018, Valenciennes, France*
- **Modeling and Control of an Autonomous Three Wheeled Mobile Robot with Front Steer**  
*IEEE International Conference on Robotic Computing (IRC) 2017, Taichung, Taiwan*
- **Low Cost Autonomous Navigation and Control of a Mechanically Balanced Bicycle with Dual Locomotion Mode**  
*IEEE International Transportation Electrification Conference (ITEC) 2015, Chennai, India*

## Research Experience/Projects

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- **Autonomous Ground Vehicle (AGV) Research Group** **IIT Kharagpur**  
*Control Systems and Computer Vision Researcher* *Feb 2015–Present*  
**Guide:** *Prof. Debashish Chakravarty, Department of Mining Engineering*
  - Planned and implemented a robust control system and developed the vision based obstacle detection pipeline for Eklavya 5.0, a ROS-based front-driven and front-steering autonomous electric vehicle built entirely in IIT Kharagpur.
  - Also worked on lane navigation, traffic sign detection, stereo SLAM, real-time vision based road bumper detection, odometry/localization using a custom built velocity sensor data and communication networks.
  - Selected as an undergraduate representative for the university for Intelligent Ground Vehicle Competition 2016. Our team, and a newer robot (Eklavya 6.0), won the **2nd position overall at IGVC 2018**
  - Also building a self-driving car for Mahindra Rise Driverless Car Challenge, where the group has been selected among top 13 teams in the final round, out of the 600+ that applied for the same.
- **Analysis of visual state estimation for high speed vision-based flight** **Carnegie Mellon University**  
*Perception Research Intern* *May 2018–Jul 2018*  
**Guide:** *Prof. Nathan Michael, RISLab, The Robotics Institute*
  - Worked on fusion of dense and feature track-based monocular visual odometry algorithms in a pose graph stack
  - Developed a ROS wrapper for Microsoft AirSim simulator, added new sensors and data acquisition tools.
  - Researched observability analysis and dynamic camera resource sharing for a multi-camera visual-inertial odometry problem, and developed algorithms to avoid state degradation in degenerate environments, like featureless straight walls.
  - Currently working remotely, continuing research on degeneracy analysis for multi-camera visual-inertial odometry.
- **Coordinated exploration using autonomous aerial and ground robots** **IIT Kharagpur**  
*Master's Thesis Project* *Aug 2018–Present*  
**Guide:** *Prof. Alok Kanti Deb, Department of Electrical Engineering*
  - Worked on optimal visual servoing of a ground robot by a flying object, in a cluttered environment, by using a pan-tilt camera and a LASER rangefinder rigidly mounted on the robot.
  - Developed a novel single optimization problem, solving for robot positions and camera orientations in real-time. Performed testing on both ROS-based simulations and in real-world environments on a Clearpath Husky robot.
  - Submitted the result as a paper in International Conference on Automated Planning and Scheduling (ICAPS) 2019.
  - Working towards unknown area exploration using a light autonomous aircraft being followed by an autonomous ground robot, communicating with each other, localizing each other and mapping the environment together.

- **Monocular Visual Odometry and Loop Closures for SLAM** **Carnegie Mellon University**  
May 2017–Jul 2017  
  - *Perception Research Intern*  
**Guide:** Prof. Nathan Michael, RASL, The Robotics Institute
  - Worked on an implementation of a keyframe-based robust visual odometry framework using RGBD sensors, with a focus on accurate and robust loop closures for trajectory optimization.
  - Implemented the entire framework in C++ from scratch, including robust loop closures using bag-of-words, trajectory estimation via graph optimization, perspective n-points solving using optimization and dense visual tracking.
  - Also worked on building custom embedded Linux distributions using bitbake, especially for Intel Aero Drones.
  - Continued this work as my bachelor's thesis project (Aug 2017–Apr 2018), to produce an improved version of the algorithm, based on robust feature trails, using regular monocular cameras instead of RGBD and high-frequency inertial readings for scale estimation.
- **SKALA: A stair climbing mobile robot** **IIT Kharagpur**  
Nov 2016–April 2017  
  - *Embedded Systems and Computer Vision Team Captain*
  - Led the development of a large robot to carry people up and down stairs while also being able to move on floors.
  - Worked on an autonomous vision-based control system using real time object tracking, EEG signal based control, voice control, touch interface development, mechanical design and overall embedded architecture.
  - Recipient of the Gold medal in the inter-hall hardware exhibition 2017 at IIT Kharagpur.
- **THAWR (Teachable Human Augmentation Workstation Robot)** **IIT Kharagpur**  
Jan 2016–April 2016  
  - *Embedded Systems and Computer Vision Team Member*
  - Developed a large scale industrial mobile robot with 4-DOF arms capable of storing and replicating human actions.
  - Worked on control of high torque actuators, object recognition on a RPi 2, multi-sensor interfacing and voice recognition.
  - Recipient of the Silver medal in the inter-hall hardware exhibition 2016 at IIT Kharagpur.
- **i-Bike : Low-Cost Autonomous Bicycle with Dual Locomotion Mode** **IIT Kharagpur**  
Jan 2015–April 2015  
  - *Embedded Systems and Control Team Member*
  - Built a low cost, modular and user friendly three-way hybrid bicycle [Manual, Electric, Autonomous] for the visually impaired and partially disabled people by modifying an ordinary bicycle.
  - Worked on sensor interfacing, motor control and implementation of motion planning on a network of Arduinos.
  - Recipient of the Gold medal in the inter-hall hardware exhibition 2015 at IIT Kharagpur.
- **3D Homing for quadcopters using visual servoing** **IIT Bombay**  
Dec 2016–Jan 2017  
  - *Vision and Control Intern*  
**Guide:** Prof. Leena Vachhani, Systems & Control Engineering
  - Implemented a bearing-only homing method under a visual servoing implementation on Parrot AR Drone v2.
  - Extracted image features, simulated the convergence of the algorithm, programmed the motion planner and developed the ROS architecture as a part of a month-long internship. Github Repository Link.
- **Retina<sup>2</sup> : Navigation and Tracking System for Visually Impaired** **IIT Kharagpur**  
Aug 2016–Apr 2017  
  - *Team Leader and Developer*  
**Guide:** Prof. Debdoot Sheet, Department of Electrical Engineering
  - Top 10 Finalist of Analog Devices Inc.'s fully funded Anveshan 2016 Internet-of-things student developer challenge.
  - Developed a geo-navigation and tracking system for the visually impaired using computer vision for obstacle avoidance, Kalman filters for sensor fusion, haptic touch control and actual human gait analysis.

## Course Projects

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- **Robotics:** Developed a visual servoing framework for a 4DoF robotic arm. Built and assembled the arm, programmed real time inverse kinematics calculation and autonomous target following on a RPi 2
- **Computer Graphics** Developed an algorithm for segmenting 3D OBJ meshes based on geodesic and angular distance of triangle surface normals, and using k-means clustering
- **Soft Computing Tools in Engineering:** Developed a fuzzy logic based, parallel obstacle-avoidance and path-planning algorithm for mobile robots. Performed MATLAB simulations and also demonstrated the algorithm on a real differential-driven robot. Github Repository Link
- **Computational Neuroscience:** Simulated neuron-level learning on MATLAB by using computer-generated spiking data from 4 neurons. Used analysis of Spike triggered averages, evaluated output nonlinearities of model and performed pruning on trained models. Github Repository Link.
- **Embedded Systems Laboratory:** Developed a human motion mimicker autonomous mobile robot using digital compasses and accelerometers. Developed the communication pipeline and programmed a PI controller to make the robot follow the direction and steps of a subject.

## Research Interests

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- Robotics, Geometric Computer Vision, Nonlinear Optimization, Control Theory, Embedded Systems

## Technical Skills

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The number in brackets: (1) = Proficient (2) = Competent (3) = Beginner

- **Programming Languages:** C (1), Python (1), C++ (1), MATLAB (2), Lua (3), Java (3), L<sup>A</sup>T<sub>E</sub>X(3)
- **Hardware Programming:** Arduino and ATmega microcontrollers (1), Raspberry Pi & BeagleBone (1)
- **Specialized Libraries & Environments:** ROS (1), OpenCV (1), GTSAM (2), Git (2), PCL (3), Gazebo (3)
- **Robotics Specializations:** Control Systems (1), Computer Vision (1), Localization (2), Motion Planning (3)

## Academic Achievements

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- **2010:** Awarded National Talent Search Examination Scholarship by Government of India (99.96 percentile)
- **2013:** Awarded KVPY Fellowship by Dept. of Science & Technology, Government of India (99.67 percentile)
- **2014:** Qualified JEE Main and Advanced for science & engineering education entrance in India with percentiles of 99.98 (score 313/360) and 99.2 (All India Rank 1178) respectively.
- **2013:** Finished in top 1% in National Standard Examination(s) in Physics and Astronomy (NSEP and NSEA) in state of Delhi and qualified for Indian National Chemistry Olympiad (INChO) (top 0.2%).

## Relevant Coursework

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### • University

Robotics	Optimal Control
Control Systems Engineering	Computer Graphics
Convex Optimization in Control	Nonlinear Control
Digital Control**	Cyber Physical Systems**
Programming & Data Structures	Computer Architecture & Operating Systems
Control Theory	Embedded Systems
Estimation of Signals & Systems	Data Communication
Soft Computing Tools in Engineering	Signals & Networks
Linear Algebra	Probability & Stochastic Processes
Computational Neuroscience	Analog Electronic Circuits

### • Online

Artificial Intelligence for Robotics	Visual Navigation for Flying Robots
Control of Mobile Robots	Machine Learning
Algorithms	

\*\* denotes ongoing course

## Other Activities

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- **Technology Robotix Society** **IIT Kharagpur**  
*Head (Since Feb '16)* *Aug 2014–Jul 2016*
  - As part of the university's official robotics and hobby maker group, conducted the largest robotics related events in India, namely Robotix 2015 and 2016. Prototyped 4 robots for the events.
  - Also mentored several workshops on Autonomous robotics in IIT Kharagpur and other universities in eastern India.
- **Kharagpur Robotics and Artificial Intelligence Group** **IIT Kharagpur**  
*Instructor* *Jul 2015–Dec 2016*
  - Taught freshers and sophomores the basics of robotics in a series of lectures, often attracting participation of 200+.
  - Mentored a 7-day long autonomous robotics workshop in December 2016. Introduced 20+ freshers and sophomores to microcontroller programming and helped them build a step following autonomous robot.
- **Personal Hardware Projects**  
*Hardware Hacker/Hobby Robotacist*
  - Built more than 10 personal hardware projects for learning the concepts of robotics and programming.
  - Bronze medal recipient at IEEE IIT Kharagpur Hardware Hackathon 2015.
  - Built a 3D printed ROS-compatible rangefinder using a Raspberry Pi 2 on my own and presented it at IBM Day 2016.
  - Additional details about these projects are available on my blog.