Dhruv Shah

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Research Interests

I am fascinated by problems at the intersection of geometrical and learning-based methods in perception, localization, mapping and control for robotics. I am also interested in computational photography & imaging, graphics, compressive sensing, statistical learning and information-theoretic approaches to vision.

Education

Indian Institute of Technology, Bombay
Bachelor of Technology, Department of Electrical Engineering **June '15 – Present**

- **Major CGPA**: 9.51/10
- Awarded the **Institute Academic Prize** 2017-18 (ranked 1st/137)
- Pursuing a **Minor Degree** in *Computer Science & Engineering*

City International School *Pune, India*
High School **April 2015**

- **Overall Performance**: 96.80%

Publications

- **Dhruv Shah** and Leena Vachhani, *Swarm Aggregation without Communication and Global Positioning.* (Submitted to the IEEE Robotics & Automation Letters)
- **Dhruv Shah**†, Alankar Kotwal† and Ajit Rajwade, *Designing Constrained Projections for Compressed Sensing: Mean Errors and Anomalies with Coherence.* (To be presented at IEEE GlobalSIP 2018)
- Weikun Zhen†, **Dhruv Shah**†, Michael Lee, Matthew Hanczor and Sebastian Scherer, *Combining 3D Mapping and Radiation Source Localization in Nuclear Sites.* (Submitted to the Journal of Field Robotics)
- **Dhruv Shah** and Sebastian Scherer, *Robust Localization of an Arbitrary Distribution of Radioactive Sources for Aerial Inspection.* (Proceedings of the WM2018 Conference, Phoenix, Arizona)

(† equal contribution)

Research Internships & Projects

Visual Servoing for Aerial Manipulation *May '18 – Present*
Prof. Stefan Leutenegger, Department of Computing **Imperial College London**

- Developed a 3D Position-Based Visual Servoing (PBVS) system for the joint manipulation of a drone and onboard delta arm along intricate trajectories for writing or additive building manufacturing (ABM).
- Working on the development of a realtime full-state non-linear Model Predictive Controller (MPC).

Aerial Inspection of Nuclear Facilities *Summer 2017*
Dr. Sebastian Scherer, Robotics Institute **Carnegie Mellon University**

- Proposed a novel scalable algorithm for the robust *localization* of an arbitrary distribution of radiation sources, for *inspection by UAVs* in a confined environment using *sequential Monte Carlo methods & filtering.*
- Demonstrated significant improvements over the state-of-the-art, in terms of F1-scores and localization error, while allowing better scalability to higher dimensional parameter spaces.
- The proposed method was coupled with a novel Error State Kalman Filter based SLAM algorithm for rotating LiDARs on aerial & ground for extensive field experiments.

Optimizing Projections for Compressed Sensing *Jan. '18 – Present*
Prof. Ajit Rajwade, Department of Computer Science & Engineering **IIT Bombay**

- Proposed a novel algorithm for the design of sensing matrices for the compressive imaging of natural scenes, using statistical priors and optical constraints on the imaging system.
- Demonstrated improvements over existing methods in projection design, imposing optical constraints.

Multi-agent Control without Communication *July '17 – Present*
Prof. Leena Vachhani, School of Systems and Control Engineering **IIT Bombay**

- Developed a decentralized controller for the aggregation of a robotic swarm in the absence of global positioning and inter-agent communication.
- Demonstrated stability of the algorithm with convergence guarantees in the presence of static obstacles, further validated by extensive simulations and real-world experiments.

The IITB Mars Rover Project *Sep. '15 – Jan. '18*
Mars Society India

- Served as the head of the *Computer Vision & Navigation* subsystem; responsible for the autonomous navigation & path planning algorithms for field operations of the rover.
- Active contributor to the GUI subsystem to ensure accurate simulation and interfacing of the sensors and vehicle model using ROS and Gazebo.
- The team will be participating in the University Rover Challenge 2018 (Utah, USA) [Media Coverage]

Miscellaneous Projects

Digitally Programmable Analog Computer (DPAC) *Spring 2018*
EE344: Electronics Design Laboratory **IIT Bombay**
Designed and developed a standalone digitally programmable analog computer, capable of solving linear dynamical systems upto the fifth order, demonstrating *hardware-in-loop* capabilities. [Project Page]

Vector-Valued Image Regularization with PDEs *Fall 2017*
CS663: Digital Image Processing **IIT Bombay**
Implemented a generic PDE-based regularization framework using variational calculus and demonstrated exciting results in image restoration, inpainting, text removal, flow visualization etc. [Project Page]

Pipelined Reduced Instruction Set Computer (IITB-RISC) *Fall 2017*
EE309: Microprocessors **IIT Bombay**
Designed and demonstrated a 6-stage pipelined 16-bit computer system from scratch, using VHDL. The architecture was optimized for performance, with hazard mitigation techniques, including data forwarding.

Modeling Noisy Channels *Spring 2017*
EE702: Information Theory & Coding **IIT Bombay**
Implemented various encoder-decoder pairs, including a typical decoder (asymptotic) to achieve channel capacity with negligible BER, demonstrating channel coding.

An Information Theoretic Approach to Understanding Scenes *Fall 2017*
EE325: Probability & Random Processes **IIT Bombay**
Survey and analysis of information theoretic measures, theories and principles in the domain of computer vision. Implemented algorithms for feature point identification, tracking, clustering, etc. [Project Page]

Statistical Signal Processing (Jupyter Notebooks) *Summer 2016*
The Web and Coding Club **IIT Bombay**
Built Jupyter notebooks implementing iconic algorithms and applications in statistical signal processing, including ICA (FOBI and fastICA backends) to solve the *Cocktail Party Problem* and the Poisson Solver (Jacobi and Gauss-Siedel backends) for *seamless image cloning*. [Tutorial].

Technical Skills

▷ **Experienced:** Python, C/C++, ROS, MATLAB/Octave, Git, Mathematica, Spice, VHDL & Verilog

▷ **Familiar:** Gazebo, TensorFlow, Keras, Java, Bash, OpenCV, AVR, JavaScript, BoneScript, Wireshark

Relevant Coursework

▷ **Electrical Engineering:** Information Theory & Universal Schemes, Estimation & Identification†, Digital Signal Processing, Digital & Analog Comm., Control Systems, Network Theory, Microprocessors

▷ **Computer Science & Engineering:** Machine Learning, Computer Vision, Graphics†, Intelligent Agents†, Advanced Image Processing, Data Structures & Alg., Operating Systems, Computer Networks

▷ **Inter-Disciplinary:** Optimization†, Calculus, Linear Algebra, Advanced Probability, Complex Analysis, Economics, Game Theory, Ordinary & Partial Differential Equations, Quantum Physics, Linguistics

(†courses to be completed by the end of Fall 2018)

Scholastic Achievements

- Awarded the **Institute Academic Prize** 2017-18 for outstanding academic performance (ranked 1^{st}/137)
- **Gold Medal and Certificate of Merit** in *Indian National Chemistry Olympiad*, 2015 for being among national top 35 out of ≈ 10000 students
- **Silver Medal** in the Medical Imaging Challenge at the 6^{th} Inter IIT Technical Meet, 2018.
- **All India Rank 111** in *JEE Advanced* 2015, among *125,000* participants for entrance to the IITs
- Placed 21^{st} at **Online Physics Brawl 2016** (≈ 250 teams across major universities around the world)
- Attended the **Orientation-cum-Selection Camp** for the *46^{th} International Chemistry Olympiad 2015*
- **Certificate of Merit** in *National Standard Examination in Physics*, 2014 and 2015 for being among top 1% of the participants
- Scored **414/450** in *BITSAT* examination 2015, for admission to the BITS Institutes. *(99.9 percentile)*
- Awarded **AP grade** (*given to top 1%*) for *exceptional performance* in Engineering Graphics & Drawing
- Recipient of the *National Talent Search Examination (**NTSE**) Scholarship* awarded by the National Council for Educational Research and Training since **2011**

Mentoring Experience

Teaching Assistant

MA207 (Differential Equations II)	Prof. Swapneel Mahajan	*Fall 2018*
CS101 (Computer Programming & Utilization)	Prof. D.B.Phatak	*Summer 2016*

***Convener*, Maths and Physics Club** *2016-17*

References

Prof. Stefan Leutenegger
Department of Computing
Imperial College London

Dr. Sebastian Scherer
Robotics Insitute
Carnegie Mellon University

Prof. Leena Vachhani
School of Systems & Control
Indian Institute of Technology, Bombay

Prof. Ajit Rajwade
Dept. of Computer Science & Engineering
Indian Institute of Technology, Bombay