Hemant Kumawat

Email Webpage Github Linkedin

SUMMARY

I'm interested in computer vision, machine learning, deep learning, optimization, and non-linear control. Much of my research is about the robustness and vulnerability of deep learning models as well as broader issues of safety and reliability in machine learning with applications to autonomous systems.

EDUCATION

GEORGIA INSTITUTE OF TECHNOLOGY — Doctor of Philosophy

School of Electrical and Computer Engineering — Jan 2021 – Present

- Advisor: **Prof. Saibal Mukopadhyay**
- CGPA: 4.0/4.0
- **Qualcomm Innovation Fellowship Finalists 2022**
  Title: "**Moving from Black box to Self Introspecting Engine for Autonomous Vehicles**"

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY — Bachelor of Technology

Department of Mechanical Engineering — July 2016 – May 2020

- B.Tech with **Honors** in **Mechanical Engineering** , **Department Rank: 4**
- **Minor** in **Computer Science and Engineering**
- CGPA: 9.37/10

PUBLICATIONS

- K. Samal*, **H. Kumawat*** , M. Wolf and S. Mukhopadhyay, " **Methodology for Understanding the Origins of False Negatives in DNN based Object Detectors** ," International Joint Conference on Neural Networks 2022 [Accepted].
- **H. Kumawat** , and S. Mukhopadhyay, " **Radar Guided Dynamic Visual Attention for Resource-Efficient RGB Object Detection** ",International Joint Conference on Neural Networks 2022 [Accepted].
- K. Samal, **H. Kumawat** , P. Saha, M. Wolf and S. Mukhopadhyay, "**Task-driven RGB-Lidar Fusion for Object Tracking in Resource-Efficient Autonomous System** ," in IEEE Transactions on Intelligent Vehicles, doi: 10.1109/TIV.2021.3087664.

* equal contribution

RESEARCH EXPERIENCE

GRADUATE RESEARCH ASSISTANT — Georgia Tech

Prof. Saibal Mukhopadhyay — Jan 2021 - Present

- **Introspective Closed-loop Perception for Autonomous Systems:** Developing a closed-loop approach to perception for autonomous vehicles to introspect and reduce perception failures, and ensure quality of decision making and planning.
- **Neural Visual Control:** Designing algorithms for dynamics of a complex system to enable control of the system through images or event data stream.

PROJECT HEAD, SELF DRIVING CAR | SeDriCa TEAM — Mahindra Rise Challenge

Prof. Amit Sethi and Prof. Shabbir Merchant, Department of Electrical Engineering — 2018 - 2020

- Led a team of over **25+ students** to build India's 1^{st} Level 5 autonomy car in a 5-tier challenge **(prize money- $1 million)**
- Amongst the top **11 teams out of 259** to be awarded Mahindra e20 electric vehicle for further research and development
- Headed the **Sensing and Perception module** of SeDriCa to implement various vision algorithms for object detection, object tracking and image & pointcloud segmentation of the acquired visual input from the vehicle to achieve robust perception
- Developed **dynamic object detection and tracking architecture** for an autonomous vehicle with sensor information from 2D LiDARs, Radars, Cameras, GPS & IMU using grid-based **Bayesian Occupation Filter** to achieve robust obstacle tracking
- Designed **Simultaneous Localisation and Mapping (SLAM) framework** of the vehicle for static and dynamic environments

MOTION PLANNING FOR EVASIVE AUTONOMOUS VEHICLE MANEUVERS — Carnegie Mellon University

Prof. John M Dolan, Robotics Institute, Carnegie Mellon University — May 2019 - Aug 2019

- Developed **motion planning and control algorithms** that can utilize complex maneuvers such as **drifting** in order to equip autonomous vehicles to effectively plan and execute evasive maneuvers like reckless drivers and suddenly appearing wildlife
- Implemented **iterative linear quadratic regulator (iLQR)** algorithm with RRT* to plan evasive maneuvers with large tire slip
- Formulated obstacle cost as a dynamic potential field to account for both position and velocity of the robot relative to obstacle
- Experimented with **negative cost** (reward) for **transverse velocity** to encourage the optimizer to find trajectories with drift
- Implemented and tested the motion planner in ROS simulation framework using 1/10-scale autonomous vehicle parameters
- Demonstrated that the RC robot could avoid a suddenly-appearing obstacle **4m** away while travelling at **6m/s** - a maneuver that is impossible to pull off by automatic braking or human operation.

MULTI-OBJECT SEGMENTATION AND TRACKING FOR AUTONOMOUS DRIVING — Carnegie Mellon University

Prof. John M Dolan, Robotics Institute, Carnegie Mellon University — Aug 2019 - Mar 2020

- Developed an integrated framework of multi object detection and tracking using **3D LiDAR** geared toward urban use
- Implemented algorithms for **3D point cloud segmentation** for data received from LiDAR in a fast and low complexity manner
- Developed **3D Ackerman-steering model** based tracking method using **Rao-Blackwellized particle filter** and **scaling series particle filter** to track high-dimensional states of the target vehicle including its position, orientation, motion, and geometry
- Developed a python based tool to analyse motion trackers and benchmarking them based on their accuracy and robustness

MOTION PLANNING AND CONTROL FOR PARKING AN AUTONOMOUS VEHICLE — IIT Bombay

Prof. Shashikant Suryanarayana, Department of Mechanical Engineering — Aug 2019 - Dec 2019

- Developed autonomous parking system with circumstance recognition, open-loop motion planning and closed-loop control
- Developed switching control laws based path planning algorithm that drives two virtual cars to a target line to obtain a forward and a reverse path which are finally connected along target line path to get complete obstacle-free maneuverable path
- Implemented lateral closed loop control with non linear brush tire model and performed simulations for various parking cases

OTHER LEAD PROJECTS

TEAM LEADER, SOLDIER ASSISTING ALL-TERRAIN VEHICLE — DRDO DRUSE

Prof. Shabbir Merchant, Department of Electrical Engineering — 2017 - 2018

- Led a **12 member** team involved in conceptualizing and building a **military grade autonomous soldier following vehicle** that localises itself and performs realistic missions based on feedback from cameras, lidars, inertial sensors and depth cameras
- Built **human following capabilities** up to 20m through a fiducial marker and detection algorithm designed to use opponent colors to limit and quickly reject initial false detections and grayscale for precise localization
- Successfully implemented collision free auto-path-trackback capabilities by SLAM in vehicle using Unscented Kalman Filter
- Demonstrated a working prototype as representative of whole team at the **student conference round** held at DIAT, Pune

DESIGN ENGINEER, INTERNATIONAL ROBOWARS — Techfest

Prof. Shabbir Merchant, Department of Electrical Engineering — 2017

- Conceptualized and built **a fighting robot under 120lbs** for International Robowars organized by Techfest, IIT Bombay
- Designed and manufactured a mechatronic model consisting of **high speed rotating drum** using precision motor drivers to obliterate the competing bot and optimized total mass by 20%, Qualified for 2^{nd} **level of screening** in a 3-tier challenge

ACADEMIC PROJECTS

AUTOMATED MACHINE CHATTER IDENTIFICATION | IMAGE PROCESSING — IIT Bombay

Prof. Ramesh Kumar Singh, Department of Mechanical Engineering — 2019

- Automated the process of chatter identification in machine operation using a non-contact process to reduce the human effort
- Performed texture analysis using **Gray Level Correlation Matrix** and probability distribution of intensity of the image's pixels
- Sharpened the image to highlight blurred regions using a **Laplacian filter** and predicted the work-piece's **surface roughness**
- Compared average **gray intensity levels** of the enhanced gray-scale images of several chatter-rich & chatter-free specimens

REGENERATIVE BRAKING SYSTEM FOR E-BIKE | MECHATRONICS — IIT Bombay

Prof. Prasanna K. Gandhi, Department of Mechanical Engineering — 2018

- Implemented **regenerative braking** on a E-bike with real-time sensing and crowd sourcing to improve the cycling experience
- Designed control strategy for power control during braking by controlling BLDC motor's three phase input invertor pulses
- Optimized the control strategy and tested the regenerative mode on a electric cycle to regenerate 5% of the battery power

ORNITHOPTER | ROBOTICS — IIT Bombay

Prof. Abhishek Gupta, Department of Mechanical Engineering — 2019

- Designed a robot with flapping wing mechanism using a **planetary gear mechanism** to mimic the flying motion of a bird
- Fabricated and assembled the **wings, body and the gears** of the Ornithopter achieving a weight of less than 400 gm

VOICE BASED GENDER RECOGNITION | MACHINE LEARNING — IIT Bombay

Advisor: Prof. Sunita Sarawagi, Department of Computer Science and Engineering — 2018

- Designed a neural network to identify the gender of the main speaker in a recording by extracting speech parameters using R
- Used Adam Optimizer and Cross Entropy Loss to train a network in PyTorch on a dataset prepared by pre-processing .mp3 files

WAVE EQUATION SOLVER | PARALLEL COMPUTING — Univ of Florida & IITB

Prof. Shivasubramanian Gopalakrishnan, Department of Mechanical Engineering — 2019

- Developed an algorithm to solve a **non-dimensionalized wave equation** on 2D structure grid using finite difference methods
- Parallelized the algorithm using **MPI and CUDA** libraries and performed timing and scalability studies for large meshes

MULTI CLIENT SERVER | COMPUTER NETWORKS AND SECURITY — IIT Bombay

Prof. Mythili Vutukuru, Department of Computer Science and Engineering — 2017

- Programmed a Transmission Control Protocol serverwhich could handle multiple clients simultaneously using **epoll** algorithm
- Implemented a database that stores **key-value pairs** which can be viewed and edited by the clients connected to the server

ROSITIONS OF RESPONSIBILITY

OVERALL COORDINATOR, INNOVATION CELL (UMIC) — IIT Bombay

UMIC aims to facilitate technical start-ups and foster an atmosphere of entrepreneurship — May 2019 - June 2020

- Led the highest funded student lab with interdisciplinary team of 50 students participating in 3 international competitions
- Managing a budget of **INR 4.5 million** from the institute and created a vendor and sponsorship network worth **INR 3 million**
- Secured sponsorship worth INR 2.5 million by forging strategic alliance with **Velodyne, Ouster, Continental, Aptiv & Nvidia**
- Spearheaded publicity drives on digital platforms reaching over 5K+ students and budding entrepreneurs all over the country

ACTIVITY ASSOCIATE, NATIONAL SERVICE SCHEME (NSS) — IIT Bombay

NSS is the largest volunteer body of IITB, serving 200K+ people via public welfare activities — Apr 2017 - May 2018

- Headed a team of **30+ Volunteers** to orchestrate 2400+ hours of social service for the upliftment of underprivileged children
- Spearheaded **Open Learning Initiative** , a YouTube channel for primary and secondary level educational videos recorded in **8 regional languages** , which currently has **8.5+ million** views and **100K+ subscribers** (an increment of **400%** in the tenure)
- Pioneered Voice For Purpose, a Youtube channel to make audio-books of famous literature available for the visually impaired
- Organized weekly Prayog and Muskan sessions to hone scientific experimentation and cultural enthusiasm of 100 NGO kids

EVENTS COORDINATOR, TECHFEST — IIT Bombay

Techfest is Asia's largest science and technology festival, with a footfall of 200k+ people — Jul 2017 - Dec 2017

- Managed a team of **10 organisers** to build a comprehensive social and technical events plan of INR 5 million for Techfest'17
- Ideated **Sanitation and Health Education** , social initiative about education on menstrual hygiene and held awareness drives
- Networked with Gaming and Entertainment industry giants like Ubisoft and Tencent games to incorporate them in the festival

HONORS AND AWARDS

- Ranked **8** among **165 students** in the Department of Mechanical Engineering based on GPA — 2019
- Awarded **Technical Special Mention** for the outstanding contribution to the technical activities in IIT Bombay — 2019
- Scored a **Semester Performance Index of 10 out of 10** in the 3^{rd} Semester at IIT Bombay — 2017
- Secured **10 state rank** in RBSE secondary board examination among 2 million students — 2014
- Attained **99.84 percentile** in Joint Entrance Examination 2016 among 1.2 million aspirants — 2016

TECHNICAL SKILLS

Programming	C/C++, Python, JavaScript, Java, HTML
Software tools & Libraries	Robot Operating System (ROS), TensorFlow, PyTorch, Numpy, OpenCV, PCL, OpenCL, MPI, CUDA, Matlab, Ansys, Solidworks, AutoCad, Gazebo, Sumo, Adobe Premiere Pro, Audacity

MENTORING AND TALKS

STUDENT MENTORING — 2022

- **Micky Nmadi** : PhD Student Georgia Tech (Jan 2022 - Present)
- **Yixiao Hu** : Undergrad Student, Georgia Tech (Jan 2022 - Present)

XLR8 MENTOR — 2018

- Mentored team of four freshmen to design a bluetooth controlled four wheeled robot to participate in XLR8 competition

SUMMER INDUCTION PROGRAM — 2018

- Organised weekly lectures on various topics related to development of autonomous vehicles during summer break

TALKS

- **Summer Induction Program** : Lectures on Robot Operating System (ROS) and SLAM for freshmen and sophomores
- **'Know the Research'** : Talk on various interdisciplinary research happening in the institute to increase undergrad participation
- **Department Apping Session** : Talk on summer research internship opportunities in United States and Europe