Hemant Kumawat

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SUMMARY

I possess a strong background in self-driving car technology, encompassing computer vision, planning, control, and localization. My research interests span computer vision, machine learning, and deep learning, with a focus on improving the robustness and reliability of autonomous systems. Currently, I'm actively engaged in research projects related to partial observability prediction and data-efficient computer vision for adaptive automotive sensing. I also host biweekly reading group with Cohere For AI about computer vision and robotics!

EDUCATION

GEORGIA INSTITUTE OF TECHNOLOGY — Doctor of Philosophy
School of Electrical and Computer Engineering — Jan 2021 – Present

- Advisor: **Prof. Saibal Mukopadhyay** (Green Lab), **CGPA: 4.0/4.0**

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/PREPRINTS

- H Kumawat and S. Mukhopadhyay "**RoboKoop: Learning Control Conditioned Representations from Visual Input for Stable Policy Learning in Robotics using Koopman Operator** " In preparation for ECCV 2024
- H Kumawat and S. Mukhopadhyay "**STAGE Net: Spatio-Temporal Attention-based Graph Encoding for Learning Multi-Agent Interactions with Fully Unobserved Agents** " Under review as conference submission for ICLR 2024. [Preprint]
- H Kumawat and S. Mukhopadhyay "**STEMFold: Stochastic Temporal Manifold for Multi-Agent Interactions in the Presence of Hidden Agents** " Under review as conference submission for L4DC: Learning for Dynamics Control Conference 2024 [Preprint]
- S Sharma**, H Kumawat** and S. Mukhopadhyay " **ChirpNet: Noise-Resilient Sequential Chirp based Radar Processing for Object Detection** , Accepted for IMS 2024. *Equal Contribution
- 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.

RESEARCH EXPERIENCE

HANDLING UNOBSERVABLE YET INFLUENCING AGENTS — Georgia Tech
Dr. Saibal Mukhopadhyay — Jan 2022 - Present

- Developing a spatiotemporal attention-based hierarchical generative models to address complex multiagent trajectory prediction and control under partial observations in uncertain dynamic environments
- Proposed a multi-agent behavior modeling framework to learn a stochastic temporal manifold to predict the trajectory of multi-agent systems by utilizing a dynamic spatiotemporal graph attention mechanism
- Analytically proved that using a spatiotemporal graph with time anchors to effectively map the observations of visible agents to a stochastic manifold with no prior information about interaction graph topology leads to a better representation [L4DC 2024]
- Ongoing research on estimating hidden agents states using POMDPS

ADAPTIVE CLOSED LOOP PERCEPTION FOR AUTONOMOUS ROBOTS — Georgia Tech
Dr. Saibal Mukhopadhyay — Jan 2021 - Dec 2021

- Proposed a novel closed-loop approach to perception for autonomous vehicles to introspect and reduce perception failures, and ensure the quality of decision making and planning.
- Proposed closed loop paradigm treats feature quality and resource consumption of a perception system as entities that can be balanced using a feedback control.
- Used ideas from computer vision and control theory to create a perception system using RGB and Lidar that can introspect and adapt to the real-time requirements of an Autonomous System operating in the wild. [IJCNN 2022] [IJCNN 2022] [TIV 2022]

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

Dr. Amit Sethi and Dr. 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
- Worked on enhancing the tracking speed of Spatial Pyramid Trackers by leveraging its multi-feature extractor [news]

MOTION PLANNING FOR EVASIVE AUTONOMOUS VEHICLE MANEUVERS — Carnegie Mellon University

Dr. John M Dolan , Robotics Institute, Carnegie Mellon University, 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
- 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.

SELECTED RESEARCH PROJECTS

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

Dr. 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

Dr. 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

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

Dr. 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

POSITIONS 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

STUDENT MENTORING

GEORGIA TECH SURE - INTEL REU — Georgia Tech/Intel

Initiative to enroll minority and female students in graduate science and engineering — May 2023 - Jul 2023

- Mentored a research intern as part of the Georgia Tech joint Research Experience for Undergraduates (REU) program in collaboration with Intel Corporation
- Provided guidance and mentorship to the student in the design of a ROS (Robot Operating System) framework for sensing and perception for the Unitree A1 quadruped robotic platform.

PHD STUDENT MENTORING — Georgia Tech

Provided mentorship to multiple students in the Green Lab, focusing on robotics and computer vision projects. — 2021 - Present

- Meilong M. Zhang : Energy-Efficient Object detection using Reliable Analog-to-Feature Extraction Masters Student Georgia Tech (Aug 2023 - Present)
- Micky Nmadi : Efficient task recognition utilizing Prophesee event camera (Jan 2022 - Aug 2022)
- Yixiao Hu : Carla Simulator for closed loop control (Jan 2022 - Aug 2022)

AUTONOMOUS DRIVING SUMMER INDUCTION PROGRAM — IIT Bombay

Mentored around 40 students in the field of self-driving car technology. — May 2018 - Jul 2018

- Organised and coordinated a series of weekly lectures covering a wide range of topics related to autonomous vehicle development, including localization, computer vision, planning, and control

TECHNICAL SKILLS

Programming	C/C++, Python, MATLAB
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

COURSEWORK

Robotics	Microprocessors & Automatic Control, Adaptive Control, Machine Design, Linear Systems and Controls, Robotics, Design of Mechatronic Systems, Networked Control, Engineering Mechanics, Operations Research, Manufacturing Processes, Dynamics of Machines
Computer Science	Online Decision Making, Statistical Machine Learning, Machine Learning, Data Structures & Algorithms, Computer Networks, High Performance Scientific Computing
Mathematics & Statistics	Numerical Methods for Dynamical Systems, Convex Optimization, Linear Algebra, Data Analysis & Interpretation, Calculus, Differential Equations, Optimization and Algorithms