

Machine Learning From Labs and Class To People

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“Congratulations on getting your research paper accepted at [ACM Multimedia 2020](#)” was the subject of an email in my inbox which reflected that walking the extra mile to pursue independent research, beyond the realm of my curriculum was fruitful. Having **papers accepted at [IEEE GLOBECOM 2020](#), [ACM Multimedia](#) (workshop), and [IEEE ICACCP](#)** motivated me to further work on Machine Learning and Deep Learning. This interest helped me bag the position of a **Research Intern** at the much-coveted **Georgia Institute of Technology**, Atlanta. I also filed a **patent** for a Computer Vision-based prototype for a widespread problem of physical abuse. This illustrates my passion for pursuing research in Machine Learning to create an impact in people’s lives. This resonates with CMU’s vision of being a research university and affect people’s lives positively.

My freshmen summer while working with Dr. Anil Kumar Gupta (Padma Shri recipient: 4th highest Indian Civilian Award) allowed me to witness the power of Machine Learning and Deep Learning to create change in people’s lives. Here my team built a Computer Vision-based surveillance system to protect crops from animal vandalism. We developed and deployed lightweight object detection architectures in IoT modules. Our work affected farming families in the region of Gujarat. We explored Computer Vision solutions to deal with this problem. We implemented the Paul Viola and Michel Jones paper ‘Rapid Object Detection using a Boosted Cascade of Simple Features’ to develop a Haar Cascade suitable for detecting cattle. Tackling detection problems through this algorithm which took only edge and pixel intensities as features were less fruitful as even the slightest change in orientation of cattle proved to be a failure. We noticed we needed to incorporate more features for detection, for which we applied transfer learning on the Faster_RCNN_Resnet model trained initially on the COCO dataset and achieved an mAP of 93%. Our work was featured in Times of India (Biggest English Daily in India) and also received the Best Undergraduate Research Project at TEAMC 2018.

A good grip on Data Structures and Algorithms along with an inclination towards research in Computer Vision has helped me get selected as a summer intern from a pool of bright undergraduate researchers by Mr. [Balaji Vishwanathan](#) (CEO Invento Robotics) in my sophomore year’s summer break. This internship allowed me to get a first-hand experience with 3D mapping using LiDAR and ROS (Robot Operating System). The robots limited hardware did not allow the deployment of dense neural networks and hence initial developers had used Cloud services for object detection. This stack was highly dependent on internet bandwidth and was time-consuming. I was able to achieve a **60% faster** performance over the previously established stack by choosing to train and deploy a less dense neural network architecture ‘tiny-YOLO’ for detection making it suitable for embedded systems on Invento’s flagship robot ‘Mitra’. Post my undergraduate (2020) I re-joined Invento Robotics to develop navigation algorithms for Invento’s COVID-19 Robotic Fleet which included UV-disinfection robots, COVID Patient engagement robots, and Tele-Medicine Robots. My navigation algorithms have covered cumulative distances of over 700 KM across 20 robots deployed across hospitals in India, the USA, UAE, and Australia. Our work was featured across all major news outlets India and abroad. My paper on Navigation and Generating Schedules for Autonomous UV Disinfection for Invento’s Robots is currently under review at **IEEE Robotics and Automation Society Magazine** January 2021 edition.

My experience with Computer Vision algorithms on ROS at Invento in 2019 paved path for a research paper at IEEE ICACCP. My team developed algorithms for establishing navigation on robots using Neural Network outputs and communicating them via the ROS framework through various nodes of a robot we developed. We **published** the performance of our algorithm at **IEEE ICACCP 2019** where we **won the Best Research Paper** ([Neural Network and ROS based Threat Detection and Patrolling](#)

[Assistance: Sai Siddartha, Tanuj, Sachin, IEEE ICACCP 2019](#)) under the computer vision and robotics category.

I shared my paper at IEEE ICACCP 2019 with Prof. Yi-Chang (James) Tsai, who then offered me a Machine Learning **summer research internship** (funded) at **GeorgiaTech, Atlanta**. During this internship, I applied the concept of perspective transform suitable for United States interstate roads for traffic sign depth estimation through a **single 2D image**. I was able to **reduce memory consumption by 50%** than the regularly used triangulation method which requires two images. One of my novel **research outcomes** as a result of this internship was that I managed to develop a 2D image and 3D LiDAR point cloud registration algorithm by using a **data structure** called **KD-Tree**. This leads to enhanced performance compared to existing work on huge LiDAR point clouds. By thresholding the LiDAR point clouds retro intensity values, I was able to accurately estimate the health of all traffic signs over the entire length of any interstate. Implementing clustering techniques such as HDBSCAN for GPS points instead of the conventional K-Means and DBSCAN allowed to eliminate computations on bogus LiDAR points making runtime quicker. My summer work helped the Transportation Lab at GeorgiaTech win the High Impact Research Nationally (USA) award at AASHTO.

For the spring of 2020, I was a **research intern** at the prestigious **Indian Institute of Science, Bangalore (Ranked 1 in India)** under [Prof. Yogesh Simmhan](#) dealing with computer vision techniques on drone feed. Here, I developed multiple algorithms to determine image similarity and reduce computational cost on object detection models. During this internship, my team has developed object detection models which work over shuffled color schemes. This development was done to aid the ongoing research trend of performing object detection on encrypted images. With the rise in COVID-19 cases in India, I was part of the 'GoCoronaGo' application development. Here we built a privacy-respecting contact tracing application. Unlike regular contract tracing applications that work on the edge, we built a centralized contact tracing application, which works on generating network graphs. Treating the problem of contract tracing as a graph makes it easier to query N-hop neighbors for every vertex making it rapid to identify and quarantine people. This app is currently being used by all the students in IISc and has also been featured in multiple leading media outlets across the country.

During the national lockdown, I have been able to submit papers of my independent research to **ACM Multimedia 2020** (workshop) and **IEEE GLOBECOM 2020**. My research here focused on using machine learning and computer vision techniques to establish a structure for sparse and unstructured cricket broadcast data. Our literature review suggested our proposed algorithms on Event segmentation in cricket broadcast, event recognition allowed us to generate the current state of the art results in terms of time taken to generate highlights for cricket matches automatically. Our innovative event segmentation technique using cricket domain knowledge allows us to determine accurate metadata corresponding to each event. I can't wait to take courses 10-718 and 10-716 and apply concepts of Statistical Machine learning and Data Analysis on the metadata generated through our proposed algorithms and see how it helps enhance the cricketing experience of 2 Billion stakeholders in cricket. Our work at ACM Multimedia 2020 proposes a machine learning supported framework to convert cricket broadcast images into Graphs. I am keen to pick courses such as 10-708 to study Probabilistic Graphical Model and develop skills in Deep Learning over graphs to augment decision making for cricket teams and coaches.

CMU is a place where research meets empathy and has impacted millions of lives around the globe. My previous experiences, research, and projects strongly aim to impact people and align with the vision of CMU. An admit to CMU will give me an opportunity of working with a diverse peer group under the able guidance of elite professors and undertake research in machine learning and deep learning to develop solutions for global problems. I see myself in the future as a Doctoral Student, part of research labs or academia to pursue research for overcoming challenges through technology and ensure that research results are not confined to journals and conferences but reach the masses.