“Shielding the Pandemic Frontline with Robots and Graphs”

(Application for Master of Science Information System with a Concentration in Health Tech)

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“Never expected this COVID-19 birthday would turn out to be a great surprise and this close to my family” (loosely translated from Telugu) were the words of Mrs. Devi just after talking with her family through Robots, which we developed at Invento for the covid pandemic. The smile on Mrs. Devi’s face after celebrating her birthday with her grandchildren and children through technology in whose development I contributed, advocated my decision to delve further and streamline my energies, skill into how technology can change the way we look and manage health, hygiene both at a personal and global scale.

When the Business Standard and India Today which have a combined readership of over 9 million people published articles on C-Astra (A UV based disinfectant Robot) and RoboDoc (A patient screening robot) developed at Invento Robotics, I knew my contributions to autonomous navigation and software for C-Astra and Computer Vision-based screening for RoboDoc are creating a positive impact on how frontline workers and healthcare units in India are operating during the covid pandemic. Algorithms in the field of Computer Vision and Robotics in whose development I have played a pivotal role as a Research Engineer at Invento, to date have screened over 12,000 patients and sanitized multiple leading hospital chains across India. Currently, our work on navigation algorithms for hospitals, Human-Robot Interaction between robots and patients is under review in ACM HRI 2021 and IEEE RAM 2021. The MS IT with a concentration in Health Tech aligns with my vision to augment healthcare by infusing technology. With long term goals of being an entrepreneur after a doctorate to create products for Healthcare, the course structure and its emphasis on healthcare and studio make Cornell Tech as a destination for my graduate school an easy choice.

My association with creating products for hygiene and health care started 3 years before the pandemic, as an intern under Dr.Anil Kumar Gupta (Padma Shri Recipient). At the National Innovation Foundation (NIF), Government of India I was able to connect with farmers. I had discussions on parameters affecting crop yield with farmers which help them supply healthy and nutritious crops to the society. This discussion opened up a problem. Natural crops were being destroyed by wild cattle. This resulted in farmers using chemicals to boost crop growth to meet the demand. A team of interns I was leading wanted to develop a solution. We started exploring Computer Vision solutions to deal with this problem. To start my team implemented the Paul Viola and Michel Jones paper titled ‘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. To counter this, we took a deep learning-based approach and used the Faster_RCNN_Resnet to develop a lightweight cattle detection model reaching accuracies of 95%. After training and comparing results over tuned hyperparameters, we published our results at TEAMC 2018, an undergraduate research paper conference, where we won the Best Research Paper for Societal Impact again aligning with Cornell Tech’s vision of solving problems through empathy.

Health Tech doesn't necessarily mean changing how we treat, diagnose patients but also reducing casualties in the first place. One such experience of trying to reduce casualties ahead of anything was my experience at GeorgiaTech. Road Signs play a vital role when it comes to safe travel in urban environments. Millions of people have lost their lives due to missing traffic signs or poor quality of

Traffic Signs. Having research experience in Computer Vision and Robotics, I was offered a fully-funded Summer Research Internship (2019) at GeorgiaTech, Atlanta by Dr. Yi-Chang Tsai, to develop Computer Vision, LiDAR-based algorithms to identify traffic signs and also establish health metrics to determine the quality of traffic signs. The importance of this research project is associated with the amount of permanent health damage caused due to accidents. 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. The novelty of the research work allowed Dr. Yi-Chang James Tsai's lab to win the High Impact Research Award at AASHTO, USA. It is a matter of great satisfaction that research work I undertook beyond the scope of my curriculum and time allotted for GRE preparation, is currently being used by researchers in GeorgiaTech's transportation lab on a daily basis.

Coming back to India for my final 2 semesters at Thapar, I was roped in by the much-coveted Indian Institute of Science, Bangalore as a Research Assistant for spring 2020 right before the pandemic. As India's best University, IISc took it upon itself to provide tools and technology to tackle the pandemic for India. I was part of the Distributed Research Lab Group under Dr. Yogesh Simmhan. At IISc, I was part of the team developing a Distributed Graph-based Contact Tracing Application for COVID. Unlike regular contact tracing applications that maintain local phone databases, my approach was to develop a centralized graph for effective contact tracing. Each node in the graph represents a human. The edge between two people represents an interaction between them. We also add weight to the edge which corresponds to the amount of time two nodes were interacting with each other (calculated via Bluetooth). The size of each node is proportional to the cumulative sum of edge weights and their neighbors' node size. A person who is spending lots of time interacting with people, instead of socially distancing himself carries a huge node size. People interacting with huge node sizes will proportionally keep growing their node size. A visual representation of themselves in the graph allows them to evaluate their social distancing and make sure they keep their node size small to stay safe. A graph-based approach makes contact tracing as simple as finding 1-hop and 2-hop nodes in the graph. The app was well received and has over 1000+ installations within IISc and also got featured in Economic Times. During the same time, making the best use of country lockdown, I was able to publish my Independent research at **ACM Multimedia 2020** (workshop) and **IEEE GLOBECOM 2020**.

As a contributor at Google Developer Group, Mumbai, and co-founder of a non-profit social media community (@must_grow: Instagram) I have been vocal about creating awareness of technology and their applications among students of different verticals. Cornell is a place where research meets empathy, compassion, and leadership. Work at Cornell has impacted millions of lives around the globe. My previous experiences, research papers, and internships align strongly with the HealthTech program at Cornell. An admit to Cornell will allow me to work with a diverse peer group under the able guidance of elite professors and undertake research and development in building healthcare, safety solutions using technology. I see myself in the future as a Doctoral Student, part of research labs, and further ensure that research results are not confined to journals and conferences but reach masses through entrepreneurship.