

Justin Saluja – Research Statement

My research interests span the engineering of intelligent systems and wireless networks. I enjoy building algorithmic models to enable new technologies in the context of society. Impacted areas are wireless perception and sensing, dynamic systems, and digital medicine. To accomplish this, inspiration is drawn from hardware design, computer networks, machine learning, and signal processing.

Upon entrance to university, I knew I wanted to pursue an advanced degree with a focus on research. So, I independently researched ongoing projects and contacted professors to request inclusion in their research teams which consisted of upper level undergraduate and graduate students. In this time, my work included designing/manufacturing support structures for passive heat spreaders, developing mobility models for network preservation in a wireless ad hoc network, and building swarmed autonomous robots.

In my junior year, I discovered the work of MIT professor Dr. Dina Katabi. I admired Dr. Katabi's ability to leverage radio frequency systems with advanced mathematical models to solve practical, real world problems. Henceforth, my research trajectory would steer me to try and augment the seemingly inimitable experiments set forth by Dr. Katabi. I chose to elect minors in Mathematics and Physics to better understand electromagnetics and signal analysis techniques, such as complex analysis, from first principles. These classes would inevitably help me derive and implement the various equations found in the literature, which was the key to understanding intricate concepts.

This same year I contacted Dr. Jenshan Lin, who had pioneered the work in wireless noncontact vital sign motion detection on the hardware side. Upon acceptance into the lab, consisting of graduate students only, I was given creative freedom to define my own project. After reviewing previous research and studying the variety of system architectures of Doppler radars proposed in the past, I noticed an apparent lack of robust signal processing. The path paved by Dr. Lin's lab had been primarily hardware improvements. This motivated me to model an algorithm to overcome the challenges that could not easily be solved in the physical domain. Using a 5.8-GHz quadrature Doppler radar, I developed an algorithm to recover a heartbeat time series waveform even when strong noise components populate the radar output. Respiration, respiration harmonics, intermodulation distortion, and Gaussian noise were learned by the supervised machine-learning algorithm and effectively filtered from the baseband signal. It was the first system to be viable for real time heartbeat analysis in a clinical setting without any contact to the patient. In acknowledgment of my thesis, I was awarded a BS with Highest Honors in Electrical Engineering and an offer to speak at the largest joint conference in microwave engineering with over 10,000 participants as first author. The results are published in the conference proceedings and will be in the IEEE Journal of Electromagnetics, RF and Microwaves in Medicine and Biology as an extended journal publication.

At this same conference, I met Dr. Christopher Rodenbeck who heads the Advanced Concepts Group at the Naval Research Lab, currently focused on millimeter wave airborne radar applications. Subsequently, I was recruited the following semester to lead algorithm development for autonomous target tracking using FMCW radar in Washington D.C. The method I derived was able to consistently achieve lower error than both the preceding tracking algorithm and other benchmark studies found in practical 3D target tracking. My method provided the backbone of the drone's autonomous movement control.

In hardware systems, a deep understanding and working knowledge of the overall system is required in order to exploit its limitations. In order to fully grasp mastery in this field, a significant effort will need to be put into Computer Science and Electrical Engineering coursework. I need to learn more about the physical and mathematical models that govern wireless systems and mature my ability to construct meaningful mathematical representations. I believe the resources provided by the MIT faculty will help me achieve this goal. There is a wealth of problems and opportunity that face many systems in microwave engineering that can be overcome with advanced models and I want to be at the forefront.

In addition to my research goals, I have made it a personal goal to be a more engaged person both socially and physically. To this end, I became a licensed NASM certified personal trainer. It was a turning point in my social and academic career as it allowed me to more effectively communicate with friends and peers and form deep interpersonal relationships. By pushing myself outside my comfort zone, I could approach professors with confidence and make the most of my university experience.

I want to be part of a team of like-minded individuals who are intellectually stimulating, self motivating, and have a passion for research. Upon completion of the graduate program, I expect to have the versatility to effectively fuse wireless hardware and software systems, mature my leadership abilities, and continue to engage in life long learning to responsibly contribute to society.