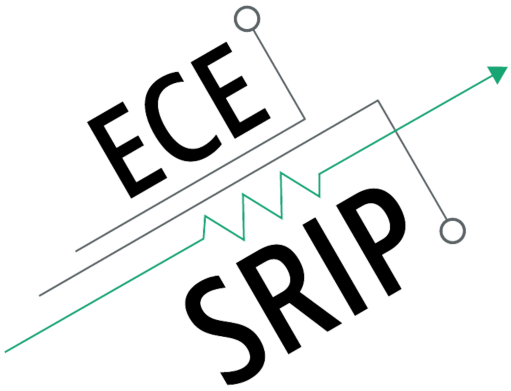


FACULTY MENTOR
Dinesh Bharadia

PROJECT TITLE
Securing Wireless Networks Through Spectrum Awareness and Analytics

PROJECT DESCRIPTION
The umpteen wireless devices around us transmit and receive information at mind-boggling rates. Some of this information contains sensitive information, such as passwords, identification numbers, and credit card information. What's more: by listening to what our devices transmit, an attacker can figure out who we are, our browsing habits, and our location, among other things. The large number of already connected wireless devices makes it difficult for us to properly patch all security flaws.

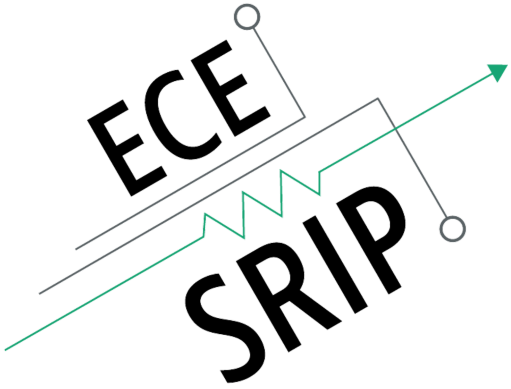
In this project, we propose to use spectrum awareness as a tool to monitor and improve security issues in wireless networks for the end-user. We envision a network of spec-boxes: devices that can sense activity in the wireless spectrum and selectively upload them to the cloud. Using the data from these spec-boxes, the goal of this project would be to build efficient spectrum analytics and control tools to best observe the spectrum, identify anomalies, and enforce security policies. This is a project that would combine expertise in wireless communication, machine learning, and software engineering. As a systems-oriented research group, we work hands-on with hardware and learn while designing and implementing solutions. The pertinent research questions are summarized below:

- Specifying and designing the spec-box hardware
- Ref: http://wcsng.ucsd.edu/spectrum_sensing.html
- Aggregating sensor data and performing inference
- Algorithms and tools to optimally control the spec-box agents

This project can accommodate both remote and in-person students.

INTERNS NEEDED
3-4 Students

PREREQUISITES
- MS or rising Senior/Junior students
- Exposure to machine learning and inference tools
- Experience with Python/Matlab/C++ or any other programming language
- Exposure to working with SDRs or hardware
- Good to have some wireless communication systems and protocols (Wi-Fi, LTE, etc.)



FACULTY MENTOR
Dinesh Bharadia

PROJECT TITLE
Compute and Memory Efficient SLAM by Leveraging RF-signals

PROJECT DESCRIPTION
Localization and mapping for robots are fundamental requirements to enable downstream applications of autonomous navigation or exploration. Unfortunately, SLAM (Simultaneous Localization and Mapping) is challenging on low-compute hardware like those present on drones or AR/VR headsets. In recent research, we have observed marked improvements (4x) in compute and memory efficiency when employing WiFi and UWB (Ultra-wide band) based sensing into the SLAM framework. Additionally, these ideas can further be extended to allow for a more effective collaborative SLAM for a team of robots.

This project will explore three major fronts:

- Extending the current framework, which relies on a multi-antenna WiFi/UWB receiver on the robot, to a single antenna receiver.
- Leveraging inter-robot WiFi/UWB measurements to improve mapping and localization in multi-robot collaborative efforts
- Large-scale system integration of the current research to incorporate aspects of real-time mapping and navigation

This project will be in person.

INTERNS NEEDED
4 Students

PREREQUISITES
- Strongly motivated Junior/Senior or MS students, with
- Strong fundamental knowledge in signal processing, probability, and linear algebra
- Experience with Robot Operating System (ROS), hardware/systems integration
- Proficiency in Python/C++

Preferred Skills:

- Prior experience working with WiFi/UWB radios
- Knowledge of RF-based sensing or localization
- Hands-on experience with training and deploying computer vision or other AI/ML models

FACULTY MENTOR
Dinesh Bharadia

PROJECT TITLE
Smartphone Enabled Ubiquitous Indoor Navigation and Mapping

PROJECT DESCRIPTION
Localization in GPS-denied environments has been a long-researched problem, falling under the broader field of Simultaneous Localization and Mapping (SLAM). Aided by multiple sensors' fusion (cameras, lidars, inertial measurement sensors), computer-vision-based feature detection, and graph-based optimization, significant progress has enabled robots to autonomously navigate alien environments. Unfortunately, these techniques cannot easily be applied with smartphones to localize users due to the lack of sophisticated sensors and computing power. An attractive alternative to vision-based localization is to use WiFi signals. In simple terms, the WiFi signals which are propagating in the environment create unique signatures that can be used to localize the user. But the current state-of-the-art systems, which provide up to 50 cm error in localization, either require extensive mapping of the environment or perform well only in the absence of multiple propagation paths.

The aim of this project is to overcome the above challenges and develop a robust smartphone application to enable the mapping and localization of an environment. Mapping will consist of developing algorithms to generate 2D floor plans or 3D point clouds using an RGB-D camera. Localization will involve developing a data-collection pipeline and methods to perform centimeter-level reverse localization of deployed WiFi access points and decimeter-level forward localization of users.

This project will be in person.

INTERNS NEEDED
2 Students

PREREQUISITES
- Strong experience in python programming, basic data processing, and Android/iOS programming.
- Preferred qualifications are background knowledge in SLAM, wireless communications or image/signal processing, and MatLab/python background.

FACULTY MENTOR
Dinesh Bharadia

PROJECT TITLE
Ubiquitous Ultra-wideband Based 6 DoF Tracking and Localization

PROJECT DESCRIPTION
A myriad of AR/VR/xR/metaverse applications, ranging from tracking equipment in Hospitals, Logistics, and Construction Industries to Indoor tracking for large indoor spaces, demand cm-accurate localization of the sensors that are robust to blockages from hands, furniture, or other obstacles in the environment. With this need, in the recent past, UWB-based localization and tracking have become popular. Its popularity is driven by its cm-accurate localization despite occlusions in the environment. The high accuracy arises from its large bandwidth. Despite almost two decades of research towards UWB-based localization, few implementations targeting the above applications are present. We find that high latency of two-way-ranging (TWR) and/or high energy consumption of concurrent ranging algorithms are the major culprits which prevent a system from deploying multiple tags and readers in the environment. In this project, we seek to fill in the gaps in current UWB technologies and extend them to track all 6 degrees of freedom as required in VR systems.

This project will be in person.

INTERNS NEEDED
2 Students

PREREQUISITES
- Knowledge of digital signal processing techniques, embedded system development, strong PCB design skills, and firmware design and programming background.

FACULTY MENTOR
Dinesh Bharadia

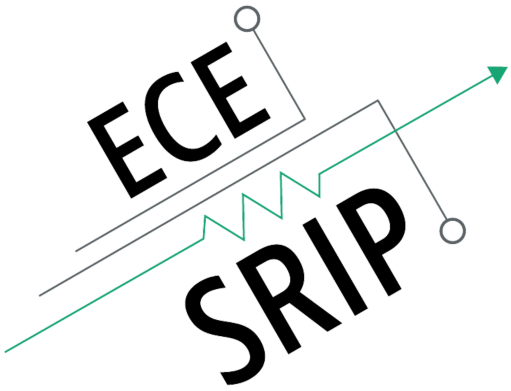
PROJECT TITLE
Towards Ubiquitous Blood Pressure Sensing with Ambient Light

PROJECT DESCRIPTION
Blood pressure (BP) is important for human health. The existing cuff-based BP sensing requires heavy workloads and is not ubiquitous. The state-of-the-art smartphone or wearable-based BP sensing techniques suffer from the vulnerability of the dynamic environment (e.g., movement artifact and ambient light), are invasive, and cannot continuously sense the BP on the go. To this end, we propose a system that can continuously and wirelessly sense the BP with ambient light and force sensors. Our sensor design is battery-less, small-form-factor, and non-invasive, which will enable it to be widely used for future BP sensing on a large scale. To further push the limit of accurate BP sensing, we will employ machine learning models to mitigate the impact of the dynamic environment.

This project will be in person.

INTERNS NEEDED
2 Students

PREREQUISITES
- Machine learning, signal processing, PCB design, and basic programming background.



FACULTY MENTOR
Dinesh Bharadia

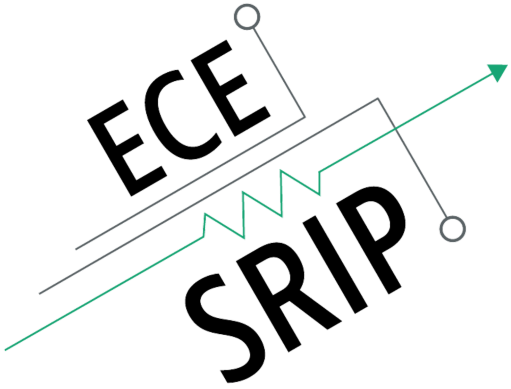
PROJECT TITLE
Designing a 3-D Printed Smart Orthopedic Implant with WiForceSticker for Implant Health Monitoring

PROJECT DESCRIPTION
In our lab, we have designed batteryless and wireless WiForceStickers which are thin sticker-like force sensors. In this project, we would explore the orthopedic implant application of WiForceSticker. 3-D printed personalized implants are gaining a lot of traction both within the medical community as well as engineering fields. With our WiForceSticker technology, we can sense the impact forces sustained by these implants to characterize the implant's health and if the implant fits well within the body. We have so far demonstrated this on a small-scale knee model with lower forces. For this project, we would be designing a new 3-D printed knee implant and a test setup to apply close to real-world forces on the implant, as well as generalizing the WiForceSticker design to fit these newly designed implants and force ranges.

This project will be in person.

INTERNS NEEDED
2 Students

PREREQUISITES
- 3-D printing, CAD, PCB design, and basic programming background.



FACULTY MENTOR
Dinesh Bharadia

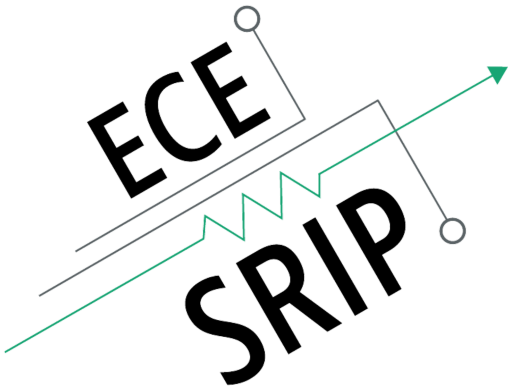
PROJECT TITLE
Low Power IoT Sensor Testbed Based on Backscatter Communication Platform

PROJECT DESCRIPTION
Conventional Radio Transmitters and Receivers consume a lot of energy and are not suitable to be deployed for low-power wireless sensing applications like IoT devices. For the low-power IoT use case, we have developed a backscatter tag that consumes many orders of low power compared to conventional transceivers while being able to communicate with a WiFi access point. So far, no one has built an end-to-end communication platform using backscatter tags. We want to build an IoT platform that can be used with the developed backscatter tag and demonstrate low-power sensing applications. For this project, we would work on integrating an IoT sensor testbed(Eg: temperature sensor) with the backscatter tag and transfer the IoT sensor data to the cloud. We would also work on integrating the testbed with energy harvesting hardware, like using a solar cell to power up the backscatter platform.

This project will be in person.

INTERNS NEEDED
2 Students

PREREQUISITES
- Knowledge of PCB design, Embedded system development.
- Experience working with FPGA and Microcontrollers.



FACULTY MENTOR
Dinesh Bharadia

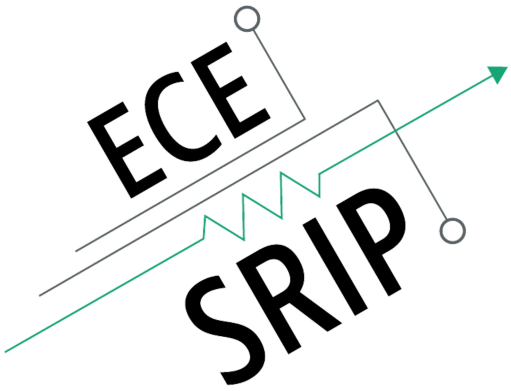
PROJECT TITLE
Augmenting Multi-Beam 5G mmWave Systems with Environment Sensing

PROJECT DESCRIPTION
Beam-management is a difficult problem in practical mmWave systems. Recently, with the development of practical constructive multi-beamforming, there is scope for designing mmWave beam-management that achieves reliable high-throughput links. In this proposal, we explore beam-management techniques for constructive multi-beam systems augmented by radar environment sensing. The ability to sense the environment and predict parameters relevant to beamforming, such as the angle of departures, and locations of users and reflectors, will allow the solution to scale to a multi-user scenario. Our technical tasks involve the development of learning-based beamforming parameter estimation and beam-management policies based on reinforcement learning for constructive multi-beam systems. Our final focus will be a demonstration of our ideas on our 5G-NR testbed in indoor and outdoor scenarios. PS: this project is sponsored by Qualcomm Innovation Fellowship, and students will actively participate in meetings with Qualcomm.

This project will be in person.

INTERNS NEEDED
3 Students

PREREQUISITES
- Knowledge of wireless communication systems is required. ECE 157A and ECE 157B or ECE 257A students are preferred.
- Knowledge of PCB design, Embedded system development. Experience working with FPGA and Microcontrollers.



FACULTY MENTOR
Dinesh Bharadia

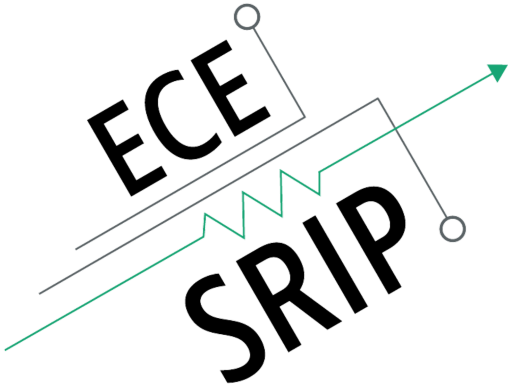
PROJECT TITLE
mmReliable-v2 Improving Reliability of a Multi-User 5G Millimeter-Wave System Using Machine Learning

PROJECT DESCRIPTION
High bandwidth Millimeter-wave spectrum is poised to be a game-changer for cutting-edge wireless communication and sensing applications. Beamforming is commonly used in mmWave systems to combat the higher attenuation over the air at these frequency ranges. The traditional approach involves finding the receiver's spatial direction and creating a narrow beam toward that direction using phased arrays. While this significantly improves propagation characteristics, it creates a single point of failure that makes mmWave systems notorious for low reliability. In this project, we propose a fundamental shift in beamforming that creates channel-specific beams by utilizing the environment's inherent reflections. We propose to rigorously develop new classes of beamforming and architect management algorithms that improve link reliability. This project would involve developing Machine Learning algorithms (Bayesian learning/LSTM) for tracking a mobile user using only the wireless channel data augmented with our novel beamforming. Further, extending this framework to support multiple users would lead to a tier-1 systems conference/ journal publication. We have all the toolkits with a state-of-the-art 5G testbed at 28 GHz for rigorous testing of our algorithms in a realistic setting (Sigcomm'21 paper called mmReliable http://wcsng.ucsd.edu/mmreliable/). SRIP students work with a current Ph.D. student and co-author the paper.

This project will be in person.

INTERNS NEEDED
2 Students

PREREQUISITES
- Good understanding of wireless communication and machine learning is required.
- Experience with Python
- Understanding of LSTM/RNN etc.



FACULTY MENTOR
Dinesh Bharadia

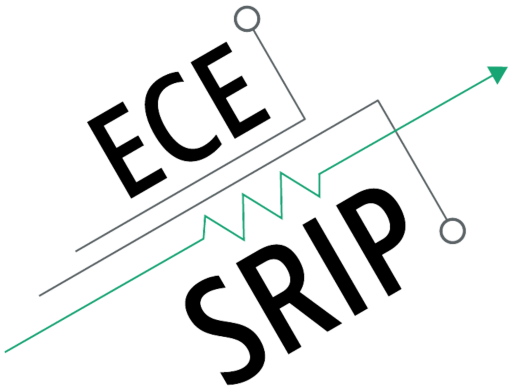
PROJECT TITLE
Developing 5G New Radio Testbed with Phased Arrays and USRP in Verilog

PROJECT DESCRIPTION
Beamforming methods need to be critically evaluated and improved to achieve the promised performance of millimeter wave (mmWave) 5G NR in high mobility applications like Vehicle-to-Everything (V2X) communication. Real system deployments and tests are required to verify new algorithms and techniques in a practical setting. In this work, we develop and extend our mMobile (http://wcsng.ucsd.edu/mmobile/) testbed, a custom 5G NR-compliant mmWave testbed, to evaluate beam management algorithms. Our current testbed is primitive without real-time beamforming support. The intern will work with Vivado to develop fast beamforming on Xilinx FPGA platform. SRIP students work with a current Ph.D. student and co-author the paper.

This project will be in person.

INTERNS NEEDED
2 Students

PREREQUISITES
- Vivado familiarity
- Good with Verilog
- HLS programming would be a plus
- C/C++ desired
- Familiarity with interfacing protocols such as SPI/ I2C



FACULTY MENTOR
Dinesh Bharadia

PROJECT TITLE
sMMart-surface: Reconfigurable Smartsurface for mmwave 5G Connectivity

PROJECT DESCRIPTION
As 5G gains wider acceptance, it becomes imperative to deliver the promised benefits to the user. While mmwave 5GNR offers the bandwidth and throughput to meet those needs, the point-point nature of the communication needs precise beamforming from the BS to the user. Recently reconfigurable Surfaces have become a widely investigated topic for their ability to "program" the channel. While it is challenging to realize such surfaces in hardware, the programmability, N^2 improvement in SNR, ability to eliminate link-outages due to occlusion, improved mobility, and true MU-MIMO make this a worthwhile problem to solve.
Interns will have the opportunity to conduct experiments with the surface, develop system-level analysis and derive meaningful insight into the functionality of such surfaces and their application in real-life wireless communication and sensing applications. The intern will work with a Ph.D. student to characterize the smartsurfaces using mmwave phased array and a 5G testbed currently in development, using an FPGA to configure and control the surface. Work done during the internship will be duly acknowledged through a co-authored paper.

This project will be in person.

INTERNS NEEDED
2 Students

PREREQUISITES
- Some knowledge of Electromagnetics and wave- propagation, RF-circuits, Ansys HFSS (or equivalent EM simulation tool), Matlab/Python, FPGA programming