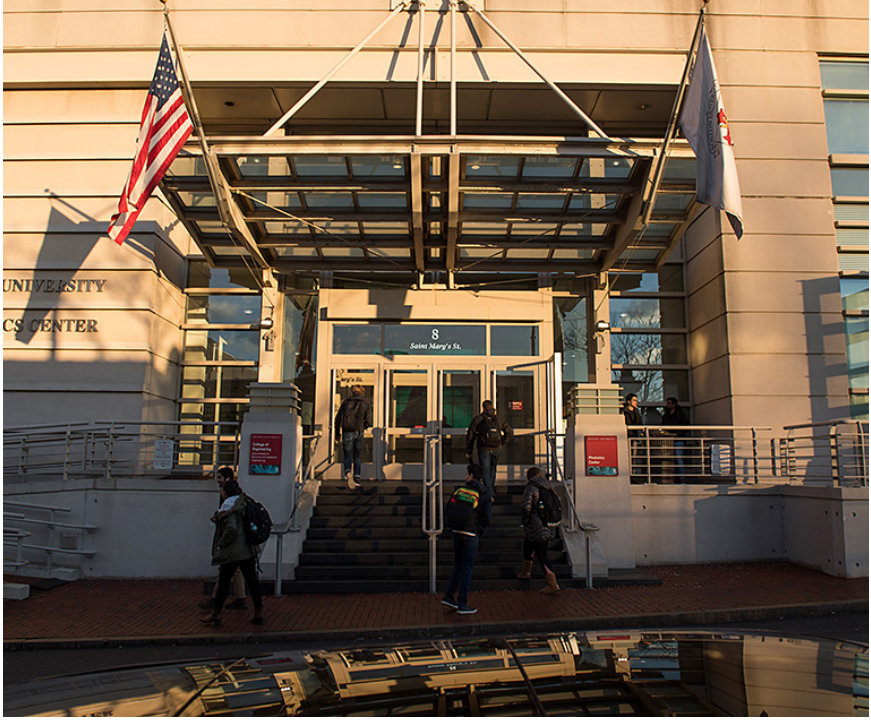

BOSTON
UNIVERSITY
2018
ECE DAY
Department of Electrical
& Computer Engineering



DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

The Boston University Department of Electrical & Computer Engineering (ECE) prepares students to be Societal Engineers for the 21st century.

The ECE academic experience is guided by respected faculty members, cutting-edge facilities, a diverse student body and an emphasis on university-wide interdisciplinary research. After establishing a strong engineering theory foundation, students enhance their understanding by developing technical skills. Seniors graduate with experience in mobile/cloud computing with security, intelligent computation and data science, image and optical science, nanotechnology and bioengineering.

This combination of practical and theoretical education ensures a breadth of experience in innovative problem solving and exploration that will prepare students for careers in industry, academia, and government.

SENIOR DESIGN

The ECE Senior Design Capstone course serves as an opportunity for students to execute the education they gained in the classroom to produce prototypes for real-world clients. Student teams serve volunteer customers drawn from industry, government, small businesses, non-profits, schools, artists, faculty, and staff. The course offers:

Technical, communication, personal, and team skills needed for successful design in electrical and computer engineering.

Knowledge of specifications and standards, information collection, design strategies, modeling, computer-aided design, optimization, system design, failure, reliability, and human factors.

Proficiency in oral and written communication of technical information.

Understanding of team dynamics and ethical issues in design.

Experience in completing a design project for a small-scale electrical or computer system.

ECE DAY AWARDS

Best ECE Senior Design Project Award

Design Excellence Award

Michael F. Ruane Award for Excellence in Senior Capstone Design

Entrepreneurial Award

TEAM 1 - CERBERUS

Joshua Stern, Dana Szapiro, Darshan Padmanabhan, Michaela Moynihan, Gianni Hallak - Client: Anthony Domenick, Christopher Eng, Alarm.com

Team one was presented with the task of making Alarm.com's home alarm system more efficient. We plan on doing this through an initiative we named Cerberus. Cerberus will build on an existing Alarm.com system, and add an NFC reader which will allow a customer to install new sensors on their own. The current process of installing new sensors into a security system involves Alarm.com having to send a technician over to the client's house to manually unlock and program a new sensor into the alarm system. Our goal is to design a mechanism that can cooperate with Alarm.com's existing home security technology to make the installation and use of their product easier for both Alarm.com and their customers.

In our approach to our client's problem, our team along with our client brainstormed different approaches. We recommended different ideas and collectively decided that the best approach to solving this problem would be to attach an Adafruit NFC reader to Alarm.com's cell module, and develop software that would allow the cell module to use the NFC reader to read in data from a tag, decode it, and send all relevant information to Alarm.com's back end. The final communication step will occur over a dedicated cellular connection set up by Alarm.com. The enclosure that we build to hold all of our system's components will have a compact design and made of a material that will not interfere with the NFC communication. Going forward, the consumer will be able to simply tap a new sensor with an NFC tag attached to the exterior of our enclosure in order to integrate a new sensor into the existing home alarm system.

By adding NFC technology in Alarm.com's security systems, this will create a new and secure way for Alarm.com's home alarm system to allow the addition of new sensors. It will require someone to be in close proximity to the cell module enclosure in order to use it and will significantly cut costs for Alarm.com, which currently needs to pay technicians to go install new sensors. Additionally, our system will feature an LED light that will flash green to indicate to the user that a sensor was successfully integrated into their home alarm system. These sensors will still be fully controlled by Alarm.com's web and phone applications, which will warn the customer if someone is trying to pair sensors into their system without their knowledge.

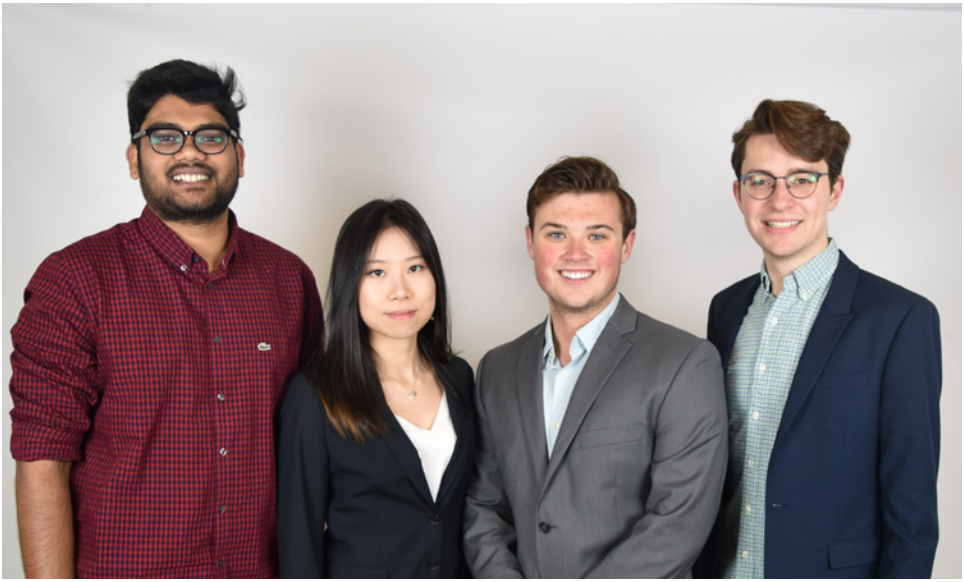
TEAM 2 - COMPOS

Reet Chowdhary, Jenna Zhu, Ben Rawstron, Qingru Xu, Rahul Jain
Client: Prof. Alan Pisano, Boston University

Every 65 seconds, an American develops Alzheimer's disease, a disease that affects over 5.7 million Americans. With the number expected to rise above 16 million by 2050, the continued care of our loved one's as they grow older is getting more and more difficult. Alzheimer's and other dementias cause the nation $259 billion annually and this figure could balloon up to $1.1 trillion in 3 decades. Even on the human scale, the impact is huge considering that 35% of caregivers for people with dementia report a decline in health due to their responsibilities. This is staggering compared to 19% for caregivers of people without dementia. (Alzheimer's Association)

A very widespread, and costly problem with caregiving for Alzheimer's patients has been keeping track of their location, more specifically ensuring against patient elopement from care facilities and homes. Family members often don't have the ability of being ever present with their loved ones, and even at larger facilities there is never enough manpower to keep track of every patient. Our team plans Compos to be our solution to this problem. Our product is an adaptive indoor locationing system composed of a network of beacons, wearable devices for the patients, a server, and a webpage. Utilizing the information about received signal strength by our wearables for signals sent by stationary beacons, we can ascertain room-scale location of a patient within a facility. If a patient ever leaves the building, a notification informs the caregiver instantly. With a key problem addressed for caregivers, Compos also aims to fulfil the needs of the patients themselves. To be of use for and help everyone, the wearable device will provide patients with the time.

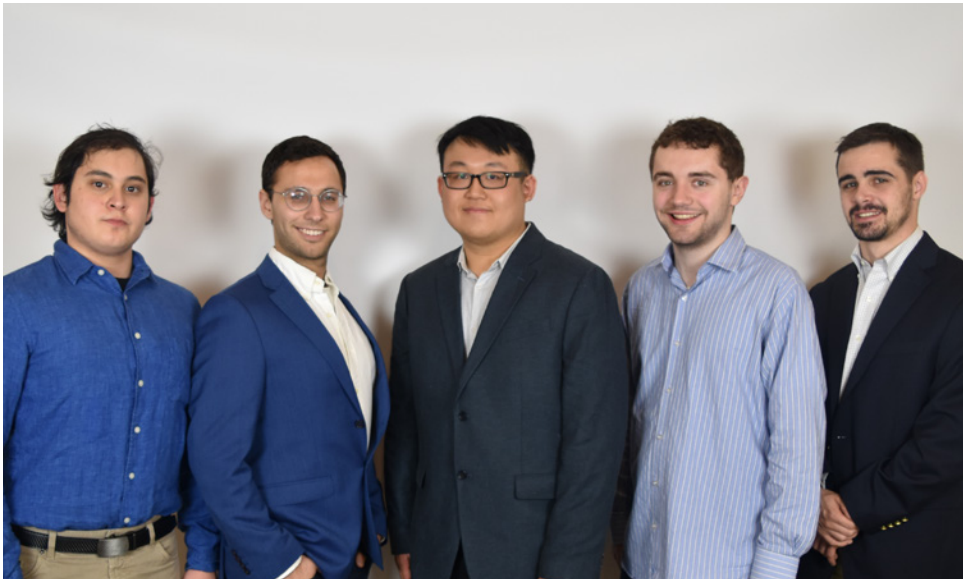
Apart from simple location services, Compos also alerts caregivers about abnormal behavior and movement patterns. This helps keep better track of patients without impeding their daily activities and so making everyone's lives easier and better.



TEAM 3 - AUTO TELESCOPE GUIDER

Rahul Cherukuri, Shuxian Zhang, Blake Hina, Dylan Herina (not pictured: Anand Sanmukhani) - Client: Prof. Alan Pisano, Boston University

With this project we aim to aid amateur astronomers by creating a device that makes it easier to keep a telescope pointed at the sun for long durations of time without the need for constant adjustment. We will design and manufacture a portable mount to fit a Televue-85 telescope that will, without any work on the part of the user find and track the Sun through the daytime sky automatically. Our team believes this can be accomplished with several sensors, including thermal imaging, an accelerometer, a magnetometer, and a photoresistor array, two high torque stepper motors, and a microcontroller unit to perform onboard processing. The design will include an iOS app which will control the mount and track usage. Our telescope mount will be the first of its kind to not require user performed calibration and should be far less expensive than competitors.



TEAM 4 - SHIFT

Boğaç Sabuncu, Daniel Oved, Eric K Chan, Joshua Manning, Nick Awtry
Client: Prof. David Starobinski, Boston University and
Jonathan Petit, Onboard Security

For most of the history of automobiles, vehicles were an entirely mechanical product, with little to no electronic systems whatsoever. However, with the onset of the technology explosion, modern cars have begun to incorporate and adopt more digital systems, a veritable marriage of the mechanical and the technological. These features have improved the vehicles overall, with manufacturers able to boast improved safety features, performance standards, and a better overall user experience with the inclusion of entertainment systems. However, there is a downside to the modernization of the vehicle, and it is the same thing that made it better originally: it has more software. With the inclusion of software and more technical aspects, the floodgates have been opened to all the weaknesses that come with these technologies, particularly exploitations and vulnerabilities in the systems themselves. It is inevitable that the more complex a system becomes, the larger the surface area for prospective vulnerabilities, which malicious actors may be able to exploit.

Presently, the automotive industry is adapting to this new safety concern, and have seeked out the assistance of those experienced in the security field. The overall mission of AutoPen is to create a user-friendly suite of procedures to perform penetration testing on a vehicle in order to detect any vulnerabilities of networks or wireless technologies that are a part of the vehicle. This year's team will focus on building upon and improving the toolkit developed in last year's project to provide a robust and complete product. We would like this toolkit to detect possible security vulnerabilities of in-vehicle networks and automation components. These features include such technologies as the Controller Area Network (CAN), wireless communication, hardware and firmware. We would like the toolkit to utilize and integrate both hardware and software components. In the wireless department, we would like to focus particularly on the radio frequency (RF) spectrum. Particularly, we would like to correlate wireless RF signals outputted by the car with wired CAN bus signals outputted internally. Finally, we want a comprehensive, user-friendly GUI for the customer to use in order to penetration test their product. We want this product to be economical, such that there is a low barrier to entry. Our goal is that anyone well-versed in vehicle security may use our product to determine whether their target vehicle is secure.

TEAM 5 - DIGITAL ENERGY BUILDING EFFICIENCY

Joonho Han, Ryan Morano, Hee Won Pak, Tatiana Diaz-Gallegos, Jessica Peters - Client: Na Cheng, Current, Powered by GE

Buildings, especially commercial buildings, consume a large amount of energy in the United States. Specifically, commercial buildings account for 19% of the total energy usage and 37% of total consumption of electricity in the United States, according to the data retrieved from the Energy Information Administration.

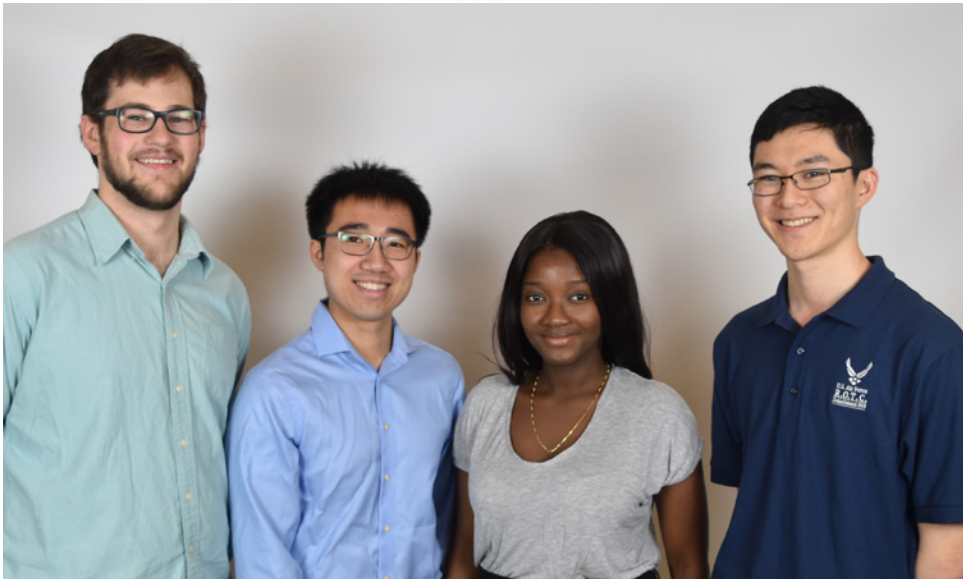
By understanding the energy consumption of commercial buildings, as well as being able to forecast future energy consumption given limited historical data about the ways in which buildings consume energy, building owners will be able to improve on the energy consumption of their buildings. Building owners have expressed their frustration in being unable to find data that goes into detail about the energy consumption of their buildings. For example, owners may only have monthly utility bills, or they may only have historical data about the energy consumption of the entire building. However, building owners could be looking for hourly energy usage information as well as energy usage data that includes more details such as the specific consumption of asset-level data such as HVAC, lighting, refrigeration, etc. Therefore, utilizing data about the building, our project will create a "digital twin" that represents the energy consumption of the building, and use that data to look at the current consumption of the building and create a prediction about the granular details of the building's energy consumption using machine learning and mathematical methodologies.

Our deliverable for this project will be source codes written in Python that utilizes Cassandra, a type of NoSQL Database, which will then be incorporated into Current by GE's AllSitesTM platform. This will allow for control, insight and optimization of building assets such as lighting and HVAC to allow building owners to optimize the energy consumption of their building. We will need to predict hourly energy usage using monthly usage data, and predict asset level energy usage using whole building level usage. Our approach for prediction is to utilize machine learning libraries such as TensorFlow as well as implement an algorithm incorporating methods of ratio.

TEAM 6 – BOSTON BATTERY GROUP

Teresa Jiménez Castellanos, Santiago Rilo, Agastya Bellad, Andres Vasquez, Javier Olavarría – Client: Tim Leung, Braintree Electric Light Department

Braintree Electric Light Department, a utility company in Braintree, wants to know which battery chemistry they should invest for battery storage they will potentially integrate into their grid network. Battery storage systems are very expensive, so a real in-depth analysis of various battery chemistries in a portable and cost-effective way will help them make that decision. The final deliverable is going to be a physical grid network with various battery installations with real time data acquisition such that the user can experiment and analyze the data collected. The physical model will be put into a compact container such that it can be easily moved for further testing. There are three main components in a power grid which are the generation and distribution of electricity, the loads that will utilize this electrical power, and the battery system to either charge or discharge electrical power. The power grid model will feature live characterization readings from the batteries, generation, and loads as well as a data saving via SD card to record an experiment.



TEAM 7 - LUMINOS: ENERGY SCAVENGING NIGHT-LIGHT

Benjamin Brown, Richard Fu, Janice Aduhene, Neil Fong (not pictured: Anmol Dhaliwal) Client: David Freedman, nanoView Diagnostics

The current market for indoor night-lights only allow for devices that have a built-in battery that needs to be replaced or an external power input. These restrictions limit the mobility and accessibility of the device. Our team is aiming to develop a night-light that uses solar panels and lithium ion batteries to scavenge and store energy from the ambient light within the room as its only energy source. The night-light will be motion-activated during the night to turn on the LEDs and have a knob to adjust the brightness of the LEDs.

Our night-light will allow for seamless lighting during the night without the need for an external power source or battery replacement. This feature will allow for a user-friendly device that requires no maintenance after installation.

TEAM 8 - LOW COST RIVER SENSOR

Nickholas Rodriguez, Peter Jang, Mahesh Yarasi, Daniel Mboweni, Esen Harris - Client: Wade Kimbrough, Emerson College & Dr. Pablo Suarez

The people from the West African country of Togo face heavy rains during the monsoon season. At the height of the rainy season, the Mono River has been known to frequently flood. The people, as a result, suffer from riverine flooding as the water in the river goes over the banks. These floods cause not only damage to the residential and public areas of the nearby town, but also create a swampy atmosphere that leads to a disease prone environment. In full, they are affected by the increase in spread of disease after a flooding event. This leads to malaria, diarrhea, and cholera, mainly in children. Our final deliverable will be a fully functional water height detection system that will measure the height of a river and transmit this data to the Red Cross so that they can provide humanitarian aid prior to a flooding event.The system should be able to function for a minimum of 2 months without any human interaction. The water height data must be time-stamped and delivered to our client's database, where they will store and use the data in their predictive modelling. Our system will consist of an Infrared Sensor that will be periodically measure the height of the river and compare it to a predetermined threshold that is deemed a dangerous river height. The IR sensor will send infrared rays to a reflector that is in contact with the water and indicates the river height. The reflected IR rays will be relayed back to the sensor and the voltage will be recorded. The voltage will be used to determine the height of the river at that given moment along with its corresponding distance in centimeters. The data will then be sent to the GSM module, which will transfer the water height along with a corresponding time stamp wirelessly. The Arduino is the system's microcontroller and acts as the center of control for the system. All these components will be in a waterproof case. Furthermore, the data sent from the GSM module will not only be sent to a designated member of the Togolese community but also to the Twilio API that employs a webhook to store the height along with its corresponding timestamp in a database. The front-end of the web application will display the height of the river at the time of the most recent reading. At the moment the Togolese people have a rudimentary method of determining the height of the river. They have placed a stake in the ground with colors to mark the severity of the water level. Green signifies the height is at a safe location, yellow signifies the water level is approaching a dangerous height, and red signifies a flood. Rather than remove and replace this system, we have decided to build on their current design. We will place our container at the top of the stake connected to a PVC Pipe that extends from the water proof container to the water.

TEAM 9 - HEALTHY HANDS

Michael Chang, Yanbo Ren, Cole Johnson, Jessica Alberto, Anthony Pasquariello
Client: Wade Kimbrough, Emerson College & Prof. Janusz Konrad, Boston University

Every year in Ghana, approximately 15,000 children die from diarrheal and pneumonia-related diseases. Handwashing at critical times with soap and water, such as before eating or after using the restroom, has proven to be an efficient way in reducing bacterial transmission and can save up to 1.2 million lives each year. The Engagement Lab at Emerson College, in collaboration with UNICEF Ghana, has been working diligently to interact with rural communities and ensure proper education of handwashing habits. However, in order to see if their interventions in these communities have proven helpful, the accumulation of accurate and representative data regarding proper implementation and use of reproducible handwashing stations called Tippy Taps is critical. Our multi-facet monitoring system utilizes detection sensors to process handwashing events and provide accurate collection of this data, in order to support research in shifting attitudes for public health.

TEAM 10 - HAPTIC BOX

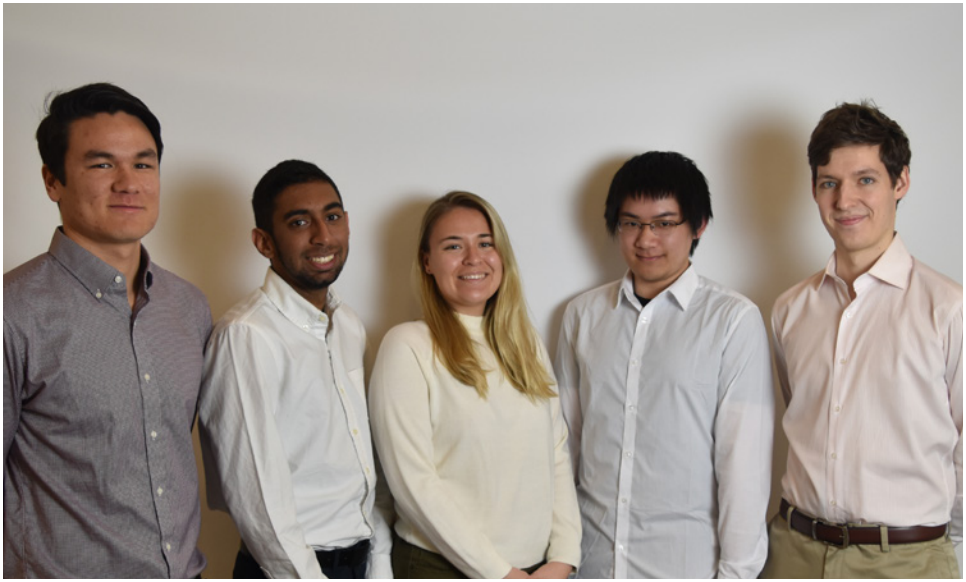
Shiming Gao, Shaina Fils-Aime, Rahmeh Fares, Peter Tang, Barry Wu
Client: Pauline Pisano, Singer and Song Writer in NYC

The purpose of the Haptic Box is to create a system that translates music to haptic feedback. Music is traditionally thought of as an auditory experience that cannot be enjoyed by those with loss of hearing. Haptic Music 2, however, aims to extend such an integral part of our society to the hearing impaired by expressing music as a physical experience. The device may be used by some to experience music of any genre for the first time or to amplify the experience of a regular music listener. The device will be able to take live and recorded audio input and transform a 1D auditory experience to a 2D haptic experience. Much like traditional headphones, it must be both silent and portable. Furthermore, the device must cover the frequency range of a full range concert piano, mapping each frequency to a haptic sensation.

TEAM 11 - SECURE IOT AUTHENTICATION

Joie Liba, Iciar Ortega, Katrina Nemes, Arslan Awan, Illya Sigov
Client: Prof. David Starobinski, Boston University

Computing devices are becoming smaller, smarter, and more ubiquitous in our everyday environment. These devices include smart appliances, activity trackers, and controllable household equipment. However, typical IoT devices lack conventional user interfaces that generally come in the form of keyboards, mice, and touchscreens. This lack of interface gives rise to a fundamental question of security and the authentication process. Using a software defined radio, SDR, our general approach is to authenticate users while maintaining a privacy preserving system. More specifically, we intend to develop a RF-based authentication user system that applies an algorithm to authorize each user. A critical aspect of the project will be to design a hierarchy of authentication, such that low level credentials will allow the user access to basic smart devices like smart lighting. The final deliverable will be a hardware and software proof of concept, showcasing our ability to authenticate common smart devices.



TEAM 12 - UBRU

Zack Woo, Vinay Khemlani, Veronica Herzog, Ricky He, Alex Moyse
Client: Sebastijan Mrak, Boston University

Brurista is a redesigned espresso machine for the modern era. Currently, there are a wide variety of espresso machines, where each new iteration has its own new gadget, gizmo or gimmick. For the most part, these gimmicks are all but useless, an attempt to differentiate one machine in a sea of similar machines. However, Brurista is different. Brurista provides not only a networked backend so that every user is able to customize their own beverage and save those settings, but also to receive a similar tasting shot of espresso, regardless of the time of day or location.

To begin, the client provided the team with a Saeco super-automatic espresso machine. The team is responsible for the changes necessary to create a fully automatic espresso machine—from a new, networked control layer, a cloud backend, precise temperature and pressure control, as well as touchscreen and a user interface. The installation of a Raspberry Pi 3 with an Arduino enabled the team to drastically expand the functionality of the Saeco machine.

Upon completion, the client will receive a fully automatic espresso machine that is capable of creating user portfolios, accessing these portfolios at multiple physical machines, and caching them locally. This espresso machine will require zero user input beyond selecting their portfolio, providing the consumables and maintenance. Simply put, Brurista simplifies the espresso making process into a turnkey solution; select one's desired customized drink, make any modifications, and press start to begin the brewing process. In conclusion Brurista provides a way for users to experience their espresso just like they experience their lives; networked.

TEAM 13 - HELICOPTER ENGINE & AERIAL NAVIGATION SIMULATOR (HANS)

Nate Reddi, Jr., Mark Li, Kenneth Flores, Vivian Pazmany, Jerome Andaya

Client: Bradley Rufleth, General Electric Aviation

H.A.N.S aims to spark interest in controls systems and to attract future controls and systems engineers by providing an entertaining and educational environment in the form of a video game. Prospective hires at job and career fairs will engage with the game and learn how a helicopter FADEC operates by performing a subset of its tasks.

To achieve this, team H.A.N.S. plans to provide a platform for delivering the game via the Godot Game Engine. A transient linear model of a turboshaft engine will provide a true-to-life representation of helicopter engine status and the requirement of flight and engine control will challenge players to maintain balance as they navigate the game world.

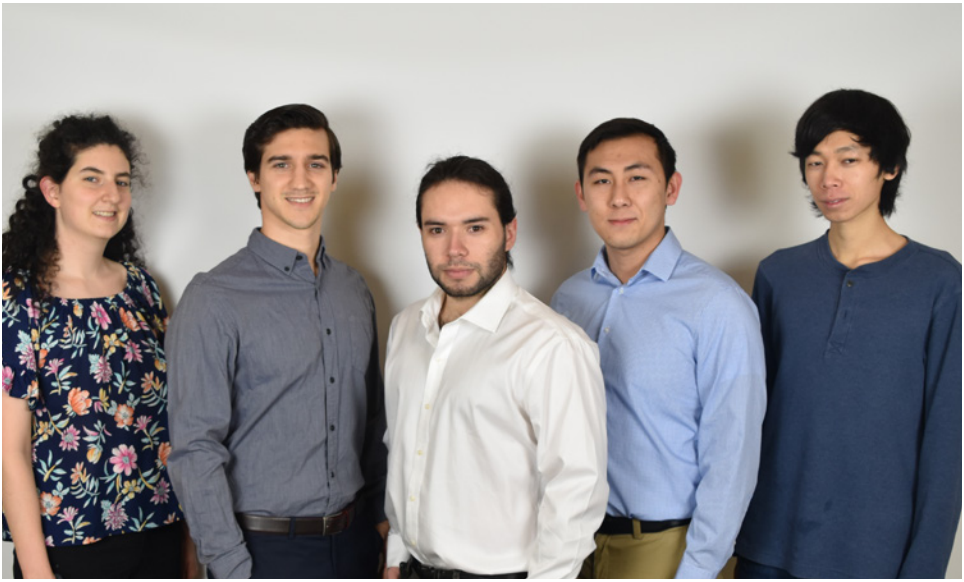
TEAM 14 - VOBOT

Steven Graham, Priya Kapadia, Shivani Bhatia, Laura Salinas, Arley Trujillo
Client: Andrey Vyshedsky, ImagiRation

Approximately 1.5% (one in sixty-eight) of children in the US are affected by Autism Spectrum Disorder (ASD). Of these children, 30-40% remain nonverbal for the rest of their lives and are placed into institutions as they cannot take care of their own needs. Children with ASD only have a short window of time for language acquisition – the first five years. That being said, it is imperative to maximize their exposure to language from a young age, thus improving their communication and speech skills. Maximizing the amount and quality of exposure is not a simple undertaking, and is a responsibility that usually falls on the child's parents. Parents often opt to enlist the talents of trained professionals for treatment, but doing so is very costly. While such assistance is helpful and can provide results, the costs mentioned may cut sessions short or deter a family from even considering the option. To further compound these issues, there is a personnel shortage of these professionals.

Our group is determined to deliver a voice controlled language therapy robot that will help assist children with their language acquisition skills. Our proposed technical approach is to modify the WowWee CHiP Robot and use it as reward platform which the child will interact with. An Android phone with our proprietary application will be used to simulate model words and to record vocalizations made by the users. The application, through the use of third party API, processes what the child has said and returns a similarity score indicating how close the child's articulation is to the word that is being practiced. Upon a successful attempt, the robot will reward the child by performing one of its pre-programmed skills, like dancing. The application will allow parents or therapists to track the results of the child as they interact and learn with the robot. The robot and application are meant to be a cost efficient supplement to speech therapy, being a tool for doctors and parents to use on the days when speech therapy through a professional is not available (such as at home sessions).

While there are devices in the market that aim to do similar language acquisition training, neither of these products offer an individualized learning curriculum, nor do they communicate effectively with the child. We hope to change this by providing a fun, friendly, adaptable, and customizable language therapy robot that will interact with the child, while also motivating them
to learn different words.

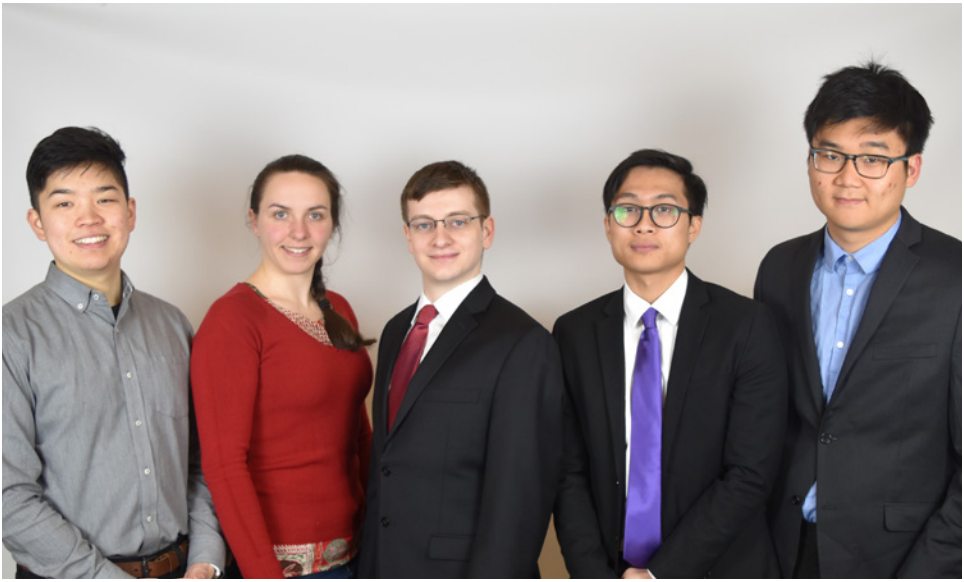


TEAM 15 - LASERTRAC

Aviva Englander, Eduardo Portet, Anton Paquin, Jeffrey Lin, Christopher Liao - Client: Prof. Thomas Little, Boston University

As the radio spectrum becomes more crowded, interference has become an increasingly urgent problem. Wireless Optical Communication (WOC) has emerged as an attractive alternative to radio communication, since it can be aimed at a specific point. Currently WOC is used between stationary objects in many cities, where the transmitter is often mounted on top of skyscrapers to ensure clear line-of-sight. However, WOC with moving targets is still being researched.

The goal of our project is to maintain two-way WOC with an Unmanned Aerial Vehicle (UAV). In order to accomplish this goal, the problem of tracking a moving object must be solved. We intend to use the laser used for communication to track the UAV. While both WOC and laser tracking are well researched, there is little prior work focused on accomplishing both communication and tracking with one laser device. Potential applications for our project include providing internet access to disaster areas, drone racing, and air traffic control.

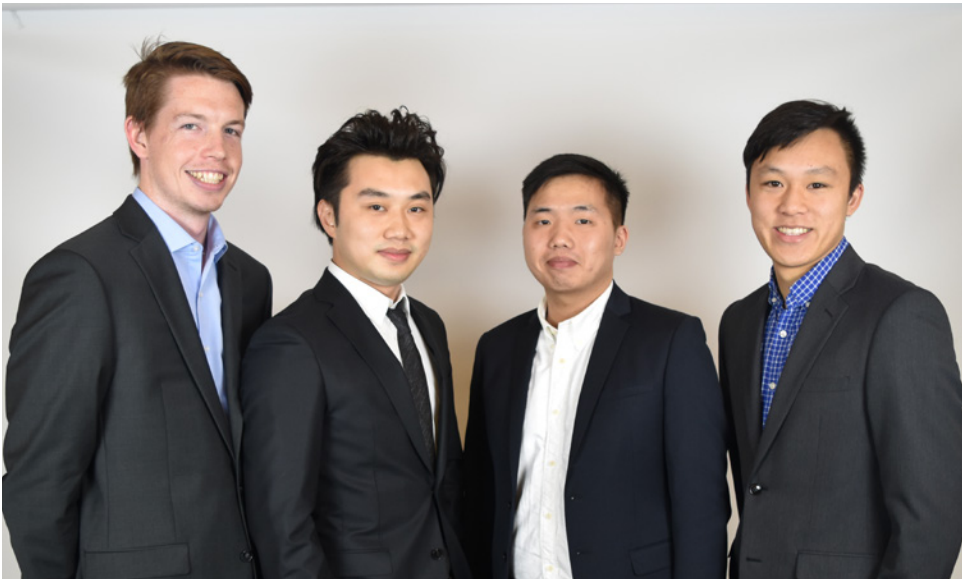


TEAM 16 - ACTILOCATE

Dong Hyun Kim, Hannah Gibson, Adam Surette, Tu Timmy Hoang, William Chen - Client: Prof. Janusz Konrad, Boston University & Prof. Prakash Ishwar, Boston University

Internet-enabled devices are increasingly surrounding our life, from smartphones to home assistants such as Amazon Echo. Professors Konrad and Ishwar of Boston University's ECE Department are exploring the possibility of a smart lighting system that can detect and localize objects or people in a room in a privacy-preserving manner. This technology has potential for integration into the concept of a "smart home", where active localization can provide benefits such as energy efficiency and optimized lighting that could integrate into other smart lighting technologies, such as visible light networking ("Li-Fi").

Currently, the professors have produced a proof-of-concept model on a small-scale testbed. However, they have encountered challenges regarding scalability to a full-sized room. Most notably, modulated light needs to be produced with enough intensity to be reflected off surfaces and detected by sensors regardless of ambient light conditions. This project focuses on providing infrastructure enabling testing of active localization on a larger scale. To do so, our team will deliver a set of hardware components that are improvements on parts used in the small testbed. The final deliverable will consist of an array of modulating LEDs that are synchronized and integrated with sensors, controlled by a single-board computer that also receives sensor data. This data can then be processed offline for localization detection.



TEAM 17 - INTELARACING

Steven Maloney, Huabin Liu, Zhixuan Mo, Andrew Hoang
Client: Dylan Domenico, Baja at Boston University

Vehicle telemetry is a process in which data from a target vehicle is reported back to a remote station for processing/monitoring. Each year, the BU Baja team builds a vehicle to compete in Baja SAE, a collegiate design competition that includes a dirt-track endurance race. Live vehicle data is vital to successful performance in the race, as the pit crew and driver must have information to make strategic race decisions. In previous competitions, the team has suffered from lack of an effective vehicle telemetry system – last year's setup had a slow refresh rate, only reported vehicle speed, engine temperature and location, and did not present the data to the pit crew in a readable format.

To help the Baja team perform better in competition, our team will replace the existing system with a more effective one that will use readily available sensors affixed to various parts of the car to gather data. The sensors will connect to an on-board microcontroller, which in turn will aggregate data and transmit it over an on-board radio. The transmitted data will be handled by a radio receiver attached to a Baja team member's laptop computer. We will provide a software package that allows the team to view the incoming data live as well as query and archive historical data for analysis later.

While there are many off-the-shelf vehicle telemetry systems available, very few are designed for Baja SAE: the vast majority of products hook into CAN buses and are therefore only useful for automotive vehicles, as the Baja car does not have a CAN bus. In addition, our solution is a completely self-contained, plug-and-play system. The car's gasoline engine cannot support electrical peripherals, meaning that our design must carry its own battery pack. Most importantly, our solution cannot depend on an external wireless network (i.e. cellular SMS or data) because the competition is held on a remote dirt track. We look forward to overcoming these challenges in cooperation with BU Baja.

TEAM 18 - SMART LENDING LOCKER

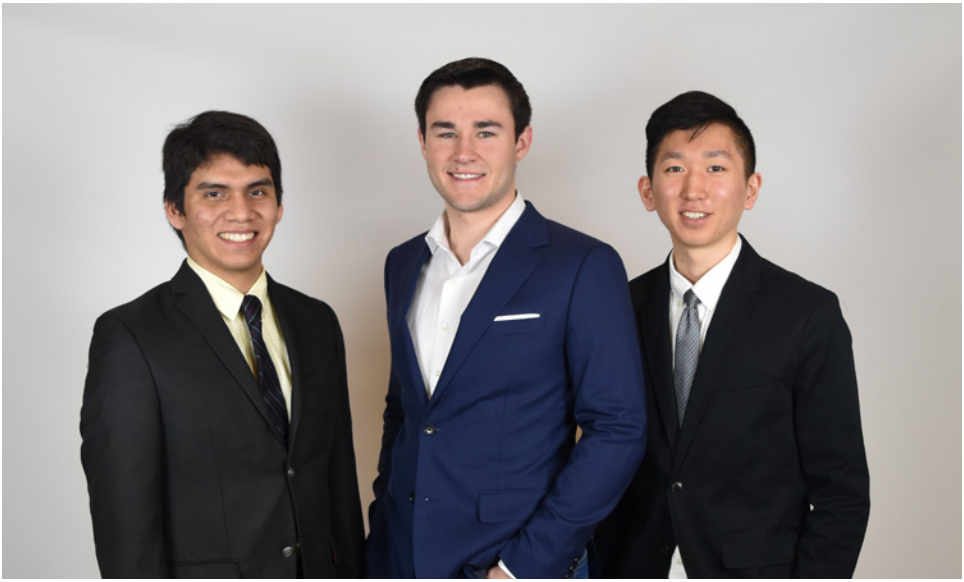
Will Norman, Zheng (Isabelle) Yang, Samit (Jade) Dhangwattanotai, Joseph Ward, Erostin Lushka - Client: Gavin Gray, Oomf Inc.

To automate the process of school faculty lending out smart devices, this team will design and build a smart lending locker with the capability to house up to 10 laptops for campus students to get temporary access to laptops. The goal of this project is to address the ongoing issues that have always been present in higher education lending systems. To track the use of laptops, the group will develop a smart lending locker system that will allow locker itself to report inventory status to the client's platform through a cellular connection. Access to the locker can be managed through mobile application that can communicate via cloud services and process authentication on user's phone. Pictures will be taken by an external camera module incorporated into the locker frame whenever a laptop transaction occurred. This smart lending locker can be the most effective one in comparison to other lending lockers in the market with a more manageable size and simpler user operation.

TEAM 19 - OUDSTICK

Jasper Schilling, Noah Abbott, Baraa Koshak, Charlie Salazar
Client: Bodoor AlHaddad, Ranam

Oud is a traditional arabic instrument that is a staple in Arabic music. Yet, very few developments have been made to the instrument throughout the years. It is big, fragile, hard to tune and hard to create music with, in terms of recording and editing. Our product, the OudStick, is a small oud to jam with on the go. It is, in fact, the first oud MIDI (Musical Instrument Digital Interface) controller that is auto-tuned, handles pitch bend, small and wireless. The OudStick is easy to carry, auto tuned and easy to make music with, since MIDI is a universal language of music production and editing. It will use a hexaphonic pickup to sense the amplitude of the strings, which determines the output volume of each. On the other end, six modified membrane potentiometers will sense the finger position along each set of strings, adjusting the pitch of the output per strummed string. A raspberry pi reads this data, and sends the MIDI information through a locally created MIDI bluetooth connection, where the notes may be played by any and all MIDI-enabled music editing software. The end result is a device that feels like an oud, strums like an oud, and sounds like an oud, but eliminates the frustrations of playing the real thing.



TEAM 20 - SMART LOO

Brandon Ng, Ben Corn, Sarah Araujo, Arturo Asmal, Bonnie To
Client: Andrea L. Vullo, Current powered by GE

Technology is helping commercial buildings achieve increasing levels of efficiency through advances in internet-connecting services such as smart lighting, HVAC control, and intelligent monitoring solutions. As the industry continues to produce compelling advances in energy saving solutions for commercial properties, restrooms are currently an underrepresented area in the marketplace with great opportunities for improvement. Commercial restrooms are often maintained and monitored through scheduled maintenance checks where custodial engineers perform routine maintenance and cleaning. Employees perform best when they have a schedule; however, this doesn't mean these schedules are efficient. Modern day restroom maintenance is a great example of how inefficient schedules can lead to supply waste and facility downtime.

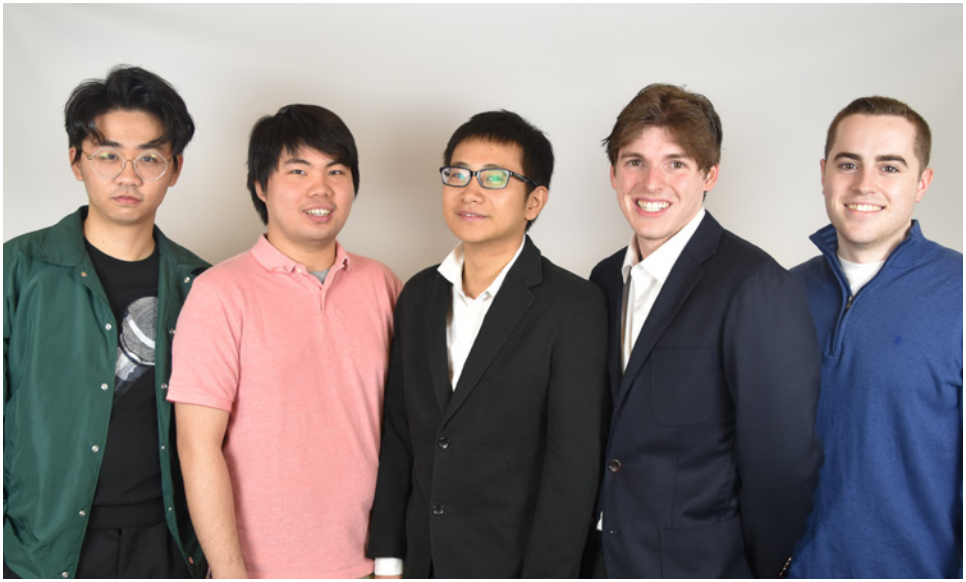
Depending on usage of a restroom, supplies may run out before being serviced, or are replaced before they are fully utilized, leading to unnecessary waste, harming the environment, and costing the company money. Since these maintenance schedules are based on time rather than service demands, hours may pass before a maintenance worker makes it to a restroom that is in need of immediate servicing. To solve these inefficiencies, we propose a system of wireless sensors to monitor real-time supply levels of restroom supplies to produce data-driven optimized schedules, leading to reduced waste from premature replacement and improved customer experiences.

Restrooms equipped with a network of Loo powered sensors continually monitor supply levels and predict when maintenance will be required for a particular area of the restroom. Because Loo is continually analyzing usage patterns, Loo will always be learning and adapting. An optimized maintenance schedule produced by Loo will let facilities know when a utility must be replaced, ensuring restrooms that need attention are serviced first and reducing the amount of time a product sits without replacement. Additionally, issues requiring emergency maintenance, such as flooding, trigger a push notification to facilities staff via text message to let the staff know exactly where an issue is occurring the moment it happens. A Loo powered restroom provides a cost-effective, long-term solution to the current inefficiencies associated with restroom maintenance, improving customer experiences while reducing costs and environmental impacts derived from supply waste.

TEAM 21 – WILLCHAIR

Rijish Ganguly, Zhuohao Yang, Ali AlSalamah, Paul Ngouchet, Chengshi Zhang - Client: Prof. Osama Alshaykh, Boston University

Many wheelchair users face difficulties opening doors and operating elevators. The goal of this project is to build a smart wheelchair with a depth-sensing camera, a tablet running a user interface, and a robotic arm that opens the doors and operates elevator buttons at the user's will. The system will use image processing techniques to find the doorknob and open the door using the robotic arm, so that the user would no longer need to reach for the door. The system needs to operate under different weather conditions, independent of a Wi-Fi connection, and function without an AC power source for at least a day.



TEAM 22 - SOLARBYTES

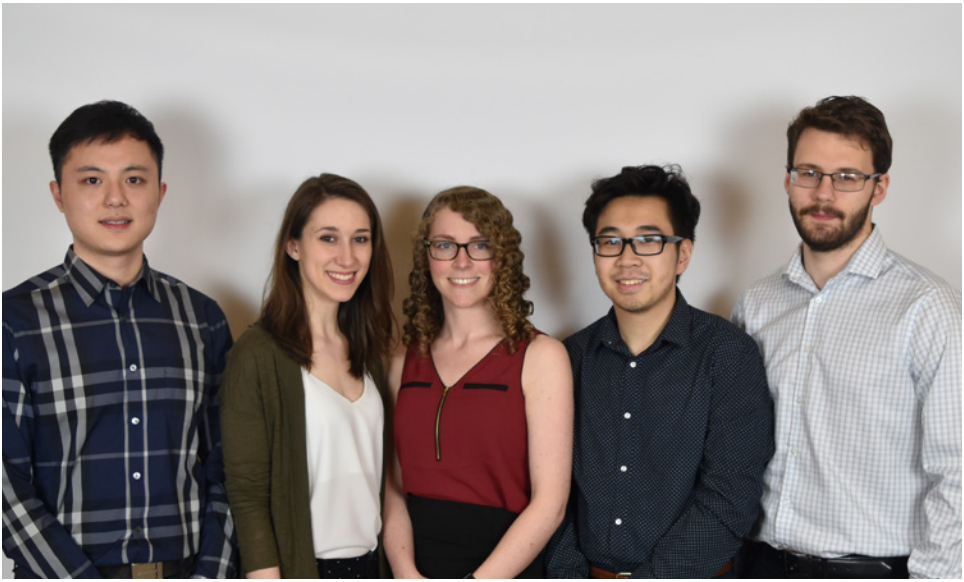
Zhuoren Ma, Jonathan Zhao, Zhengyu Zhao, Graham Silva, Joshua Surette

Client: Prof. Mark Horenstein, Ryan Eriksen & Cristian Morales, Boston University

Currently, Solar Cells at many of the major solar farms are cleaned using gallons of water. This current method is incredibly wasteful and is also very costly. Currently, there is a technology called an Electrodynamic Screen which creates an electric field to repel dust and other particles off of the solar cell. However, this technology has yet to be proven to be as effective as water cleaning methods. This necessitates the construction of a testing device to see how the performance of the solar cell is affected both before and after EDS usage. However, given the remote nature of these farms, it is important to be sure tests can be conducted remotely by labs and that data can be stored remotely as well for access. Along with this, given that WiFi may not always be present, it is important that tests can be automatically conducted and that data can be stored locally by default for workers to access and determine the effectiveness of these EDS cleaning devices.

Our final deliverable in response to this problem is then to build a remotely accessible Solar Cell Autotester system that gathers data about EDS performance in environments with/without remote access. This major brain of our application will be a Raspberry Pi, which will serve as our IoT gateway into our testing hardware. We have a SQL database hosted on our Pi to persist local storage as well. We are also hosting the web server on the Pi, and make the Pi accessible to other networked devices using ngrok, which acts as a reverse proxy to the open web to allow for access on the open internet. Along with these remote access deliverables, we must design a PCB that will be able to last reliably for 2 weeks without dying, and must be able to interface 8 solar cells to gather the current from these cells both before and after EDS activation, which serves as a proxy for performance. Finally, we must be able to interface this current measurement to our Pi using an ADC, specifically the MCP3008, which will connect our PCB tests to the digital world for our user to interpret. In order to be sure that our system is safe in harsh desert environments where temperatures can range from -2 to 52 °C, accompanied by 250 mm rainfall/year and wind speeds upwards of 300 km/h, we must also design a case to enclose our circuitry. This case must be insulative and lightweight for a user (ie: 5-10kg) since it must be easy to transport. As such, it will be made of wood, insulating foam and heat wrap. The case will also be triangular to be sure that solar cells can be attached and staggered in such a way that EDS activation will not drop dust on another cell.

Given current testing systems used in the field, this remote accessibility is our major advantage in comparison to other systems. As long as the farm has WiFi, we will be able to turn on our testing system through our web app connected to our Pi. However, even in the case where we don't have WiFi, we have default interval tests already encoded on board, and also have the ability for local storage by default which means that we will need to user interference. Along with this, our system enclosing shape, in contrast to the square prisms currently used, will be able to interface with more cells since we have 2 viable surfaces to attach cells rather than just the top surface of our square prism. Finally, we will utilize our software to be sure the Pi is operating in low power mode unless we have active requests, making our system very efficient to be sure local workers do not need to change out power supplies frequently.



TEAM 23 – STREET STATUS MONITOR SYSTEM

Tiancheng (Andrew) Liu, Erin Murphy, Kaitlin Walsh, Khai Phan, John Delaney – Client: Prof. Greg Blonder, Boston University

The City of Boston has handled many winters, and is no stranger to storm clean up; however, they have found their methods are not the most cost efficient. Boston sees the value of collecting data remotely to monitor the exact conditions of the streets. With this information, they will be able to better dispatch plows or salting trucks according to their exact needs. Currently, there is no means of collecting this data.

Our solution will solve their problems by providing a monitoring system that will collect live snow and ice levels from the streets of Boston. We will provide a small set of our devices that will be attached, universally, to any light post around the city. These instances will be networked together and the data will be aggregated, analyzed, and displayed on our intuitive software suite. With this accurate and up to date information, Boston will be able to better allocate winter spending, issue weather advisories, and keep the streets safe.

TEAM 24 – UPR LEVEL SECURITY

Brock Guzman, Brandon Webster, Eugenia Almandoz, Juan Peralta, Namir Fawaz - Client: Sergo Sagareli, PE, PMP Secretary, CIGRE WG B3.47

UPR Level Security was formed to design a utility patrol robot to more effectively monitor substations. Electric companies, such as Con Edison, are looking for a product like this to detect unauthorized personnel in the station and detect anomalies in the equipment that could potentially have disastrous results if left unchecked. One way to achieve this goal is by placing a utility patrol robot in the substation to monitor it daily. A utility patrol robot is preferable to deploying human security personnel because it can operate more often and is a safer solution than sending a human into the substation.

In order to provide Con Edison with a solution to this problem, UPR Level Security will be providing them with one fully functional patrol robot and the software needed to operate it, to be used as a prototype. The software includes a web application to interact with the robot, algorithms necessary for autonomous navigation, and software for image recognition. To solve the problem at hand we will be using a combination of object detection and localization to autonomously navigate the robot around the substation. The robot will be mounted with ultrasonic sensors, and both a camera and thermal camera. The ultrasonic sensors will be used to detect objects, the thermal camera will be used to detect hotspots, animals and humans and the camera will be used to read gauges and stream live video. Using a Raspberry Pi connected to WiFi we will be storing information with a server hosted using AWS and communicating that to the user through a web application to alert the user of any anomalies the robot detects. Through the web application a user will also be able to remotely control the robot manually to do specific tasks. When comparing our product to similar electrical substation robots found on the market, an innovative feature our product provides is security. In addition to detecting faults in the equipment our robot looks for unauthorized personnel in the station as well as animals who should not be there.

TEAM 25 - PROJECT LARNX

Christina Howard, Kestutis Subaciu, Napassorn Lerdsudwichai
Client: Gintas Krisciunas, Boston University

Dysphagia is a condition in which a patient loses the ability to swallow properly due to muscular or nerve damage in the hypopharynx. This results in a subsequent buildup of food residue in the patient's throat, and can directly lead to complications through choking or infection. Ultimately, dysphagia is the cause of 60,000 deaths annually in the U.S. alone. One of the reasons the death rate for dysphagia remains high is due to challenges in properly assessing and diagnosing dysphagia severity. Current methods of diagnosis are subjective, and there exists no measurable way to assess the severity of residue accumulation in the throat. This leads to misdiagnosis and miscommunication between physicians regarding the severity of a patient's condition, and such inaccuracies can result in preventable deaths.

Our final deliverable is to provide a software application that physicians will use to acquire objective, quantifiable metrics regarding the severity of dysphagia in a patient. These metrics will be the volume of residue in the throat, and the surface area coverage of residue in the throat. Providing those objective metrics will allow physicians to no longer rely on subjective diagnosis. Our proposed technical approach is to use a 3D stereoscopic endoscope to image the patient's hypopharynx during a diagnostic procedure. We develop 3D video processing algorithms that render the volume of the throat, including any residues that are imaged, and we use these 3D processing algorithms to calculate the volume and surface area of the throat.

In conclusion of our application, we will have developed a novel method of measuring the severity of dysphagia as enabled by stereoscopic imaging and 3D volume rendering algorithms. This method can directly complement current diagnostic standards, ultimately serving to improve the accuracy of diagnosis and reduce the rate of misdiagnosis. Should our metric of measuring dysphagia severity prove robust, a completely new standard of diagnosis is likely to emerge.

THESIS STUDENT JOHN ABERNATHY

Advisor Prof. Martin Herbordt, Boston University

The objective of this thesis is to design and implement a field programmable gate array (FPGA) cluster to accelerate the calculation of the range-limited force required for the simulation of molecular dynamics (MD). Molecular dynamics is method of simulation that allows researchers, such as biochemists, to model interactions between small molecules such as proteins at an atomic level. Specifically MD allows researchers to model fast(ms timescale) biological processes that cannot be viewed through traditional observation methods such as microscopy. However, to achieve this resolution significant amounts of computing power are required. There are two main computing architectures used in MD simulations: general-purpose processors (e.g. GPUs, CPUs) and ASICs (AntonII). However, these architectures have their limitations, performance and cost respectively. By using FPGAs for MD simulation a compromise between the cost of ASICs and the performance limitations of general-purpose processors can be achieved.

Presently, there is not a FPGA cluster implementation for the purpose of MD simulations. Specifically, this thesis concerns the acceleration of the range-limited component of molecular dynamics as this operation requires ~90% of floating point operations (FLOPs) required in MD. The main challenge in implementing such as system is the need to maintain a linear increase in performance with regards to the number of additional processing elements (PE) or strong scaling. Strong scaling is difficult to achieve because the communication overhead increases as additional PEs are added to the system. Consequently, the main objective of this thesis will be concerned with limiting inter-node communication between FPGAs to maintain strong scaling.

Thesis students from left to right: Joseph Greene, Richard McAllister, Sonam Ghosh

THESIS STUDENT SONAM GHOSH

Prof. Alexander Sergienko, Boston University

Quantum Computing offers the benefit of being more efficient and significantly faster than classical computing for the simulation of a complex physical system. The purpose of this thesis is to demonstrate the utilization of simple quantum simulations to model the behavior of a complex physical system such as a molecular system which in our case will be a benzene molecule(C_6H_6). The benzene molecule will be modeled optically through an arrangement of directionally-unbiased optical multiports biased with photons delivered via laser. The Hamiltonian which governs the energy dynamics of the system will be mathematically determined along with its corresponding eigenvalues and eigenstates which will be then compared to the Hamiltonian of an actual benzene molecule; this will be done through both software simulation and optical measurements. In addition to this, the analysis of Quantum Random Walks over the entire system will provide information on the transmission probabilities of photons and their likelihood to be found at a site. The comparisons made between the software simulations and optical measurements will be within a specific error threshold (to be determined) to assess for efficacy.

THESIS STUDENT JOSEPH GREENE

Advisor Prof. Selim Ünlü, Boston University

There is an unprecedented need in the medical sector for a universally accepted instrument able to test for antibiotic resistance in bacteria populations. As the CDC reports, wide-spread use of antibiotics has created a proverbial double edged sword, simultaneously saving countless lives while also breeding generations of antibiotic resilient 'superbugs'. In America alone, antibiotic resistant bacteria (ARB) afflict tens of thousands each year, and that number is only predicted to rise.

Modern hospitals rely on the use of Antibiotic Susceptibility Tests (AST) to identify proportion of a bacterial population contain ARB. The two most popular ASTs are diffusion disks and genetic sequencers. While these two technologies are effective, they may not be the most efficient means to detect ARB. Diffusion disks take several days and yield semi qualitative results, while genetic sequencers are significantly quicker but expensive ($40k-$365k). This limits their feasibility as 'universal solutions'.

In this Senior Thesis, I worked with Boston University's Professor Ünlü to optimize their biosensing platform, the Interferometric Reflectance Imaging Sensor (IRIS) to provide a cheap, rapid, effective AST. Currently, IRIS identifies mutant genes in bacteria DNA indicating antibiotic resistance using an in-liquid environment and gold nanolabels. However, current experiments require that a user manually prepares the target sample, designs a microfluidic layout, adjusts the microfluidics during the experiment, collects data and processes results. Medical personnel do not have the time to receive training for all these steps so my instrument, the Automated, Microfluidic-IRIS (AM-IRIS), has an integrated microfluidic setup and GUI to control every parameter with minimal user interaction. In addition, AM-IRIS uses external beanshell files to run predetermined experiments, which will run the microfluidics, collect data and process results automatically. AM-IRIS costs approximately $20k and recent IRIS experiments were able to identify low concentrations of target genes (~10 femtomolar) in a 4-hour incubation, inferring that AM-IRIS will have equal or better sensitivity.

THESIS STUDENT RICHARD MCALLISTER

Advisor Prof. Thomas Little, Boston University

As the Internet of Things continues to expand, many applications such as robot navigation and in-home assistance need accurate indoor positioning systems. However, current systems such as GPS, used outdoors, don't work nearly as well indoors due to signal attenuation and multipath propagation and reflection. Many different technologies have been proposed or developed to solve this problem, including WiFi, Bluetooth, RFID, and optical beacons (Rahaim,1). The goal of this project is to combine WiFi-based indoor positioning with visible light positioning to try and achieve greater accuracy than what either method can achieve on its own. In addition to the hybrid system, each subsystem will be available on Github too and can be used separately for a total of three deliverables.

Comparing the two systems, visible light positioning or VLP is very accurate and relatively inexpensive by using existing infrastructure already found in every indoor environment. The algorithm estimates distance from each light source using the received signal strength (RSS) from it and then uses multilateration to estimate position of the receiver. VLP does have some serious drawbacks though and cannot be used in certain situations such as in dark rooms, and is less effective in other situations such as hallways. The VLP software is written as a GNU Radio out-of-tree module hosted on Github. Like VLP, the Wifi component uses the received signal strengths from transmitters but unlike VLP, WiFi fingerprinting uses a polling system rather than a mathematical channel model. Instead of calculating position from the RSS directly, it generates 'fingerprints:' a list of RSS values of each available network matched to a physical location or 'cell.' These fingerprints are stored to a SQLITE database, and afterwards, the software searches it for the RSSI values it measures. While less accurate than VLP, it is even less expensive and even more ubiquitous. In addition, the method is less sensitive to tilt and signal occlusion as VLP is. The software is entirely written in Python and uses Linux system utilities such as iwlist.

The hybrid framework will also be written in Python. Using the subprocess module in the os library, a Python script can execute and run GNU Radio. Simultaneously, a separate thread polls the WiFi networks for RSSI values and then compares them to previously saved fingerprints. Like the other systems, the hybrid framework will be hosted on Github for anyone to install. Since VLP requires GNU Radio and the WiFi fingerprinting system uses Unix calls, this project will be limited to Linux and other Unix-based operating systems.

SENIOR DESIGN FACULTY

ALAN PISANO Associate Professor of the Practice

Dr. Alan Pisano received a Ph.D. in electrical engineering from Northeastern University in 1974. He retired from General Electric in January 2010 after a 39 year career there in both Power Systems and most recently Aircraft Engines. There, he was responsible for numerous advanced controls technology programs and held a variety of managerial positions including Manager of Turboshaft/ Turboprop Controls and Manager of Advanced Controls Technology and Planning. After retiring from GE as a Department Staff Engineer, he was appointed to the full-time faculty in the ECE Department at Boston University as Associate Professor of the Practice. He is currently the lead professor and course coordinator of the capstone Senior Design course in ECE and also regularly teaches courses in control systems and electric energy.

OSAMA ALSHAYKH Lecturer & Asst. Research Professor

Dr. Alshaykh is CEO of NxTec. He was CTO of Packetvideo corporation, Scientist at Rockwell and Visiting Researcher at UC, Berkeley. Osama received a Ph.D in Electrical and Computer Engineering from Georgia Institute of Technology in 1996. Osama received Fulbright Scholarship and served as associate editor for IEEE Transactions on Circuits and Systems, Video Technology. He served as a consultant, board member and advisor for several companies and groups.

MICHAEL HIRSCH Adjunct Professor

Dr. Hirsch is President of SciVision, Inc.. He consults and advises companies and institutions in remote sensing systems, rapidly going from ideation to Series A, market or deployment. He fuses real-time heterogeneous networks of GPS, radar and optical sensors, breaking through legacy spatiotemporal sensing limits.

TEACHING ASSISTANTS

ZELIN MA

Zelin is a second year PhD student working on fiber optics, in the group of Prof. Ramanchandran.

SEBASTIJAN MRAK

Sebastijan received a M.Sc in Electrical Engineering from University of Ljubljana in 2016. Currently, he works with prof. Joshua Semeter as a Ph.D candidate on radio remote sensing and GPS imaging of the Earth's ionosphere.

KIDANE KEBEDE

SHUTO OSAWA

Shuto Osawa is a second year PhD student working with Prof. Sergienko. His research is on an experimental quantum walk.

THANK YOU, CLIENTS

Thanks to all who suggested problems, encouraged their student team and challenged the seniors with their real-word engineering needs.

THANK YOU, ALUMNI JUDGES

Special thanks to ECE Alumni, who took time from their schedule to be with us today.

THANK YOU, ECE & ENG STAFF

ECE Staff worked countless hours to support the year-round needs of the senior design projects, and to coordinate the culmination event, ECE day.

THANK YOU, STUDENTS

Finally, thanks to all the seniors—who did the work over the approximately 240 days since they first arrived in EC463.

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