EE476 Projects

Name:

Project Requests

NAU ID:

Over the next two Fridays, you will hear from most, if not all, of the project client sponsors. From these, you will need to consider which project you would like to work on. Due October 13th at midnight (11:59pm to be exact), you will need to upload a document outlining your top 5 preferences for projects. You are also required to tell me why you want these projects, but in no more than 5 sentences total. From these requests, I will assign teams, though please understand your request is just one factor in deciding exactly which project you will be working on.

Submit your requests via BBLearn only! A link for this assignment will be opened on October 12. So start thinking about what projects you would like to participate in, but know that you cannot submit this until you have heard from all the sponsors.

Educational Platform for Communication Protocols

Objective

In this project, we develop a test platform for communication protocols to evaluate and illustrate the performance of different communication protocols under static and dynamic conditions. This module can be used for education and test purpose.

Requirements

This project is planned for a team of 3 to 5 students. Basic experience with WSN kits, Arduino or Raspberry PI board, and communication protocols is required at least for one team member. Familiarity with routing algorithms, WiFi connectivity, queuing theory and machine learning is a plus, but not required.

Technical Description

Using this platform, we will investigate the impact of communication parameters on the performance of different routing algorithms. A list of communication parameters, performance metrics, and envisioned communication protocols is provided in the following Table. The students can use their creativity to update this list and add new dimensions to the project.

We also will practice using machine learning algorithms to implement efficient communication protocols when the network status is not fully known for network nodes.

Communication parameters	Routing algorithms	Performance metrics
Network Topology	Dijkstra's Shortest Path	End-to-end delay
Link Quality	Backpressure Algorithm	Power Consumption
Noise Model	Greedy Routing	Outage probability
Coding [Turbo, LDPC, Convolutional]	Learning-based Routing	
Traffic Type [Random vs Poisson]	Probabilistic Routing	
Channel Model [AWGN, Rayleigh]		

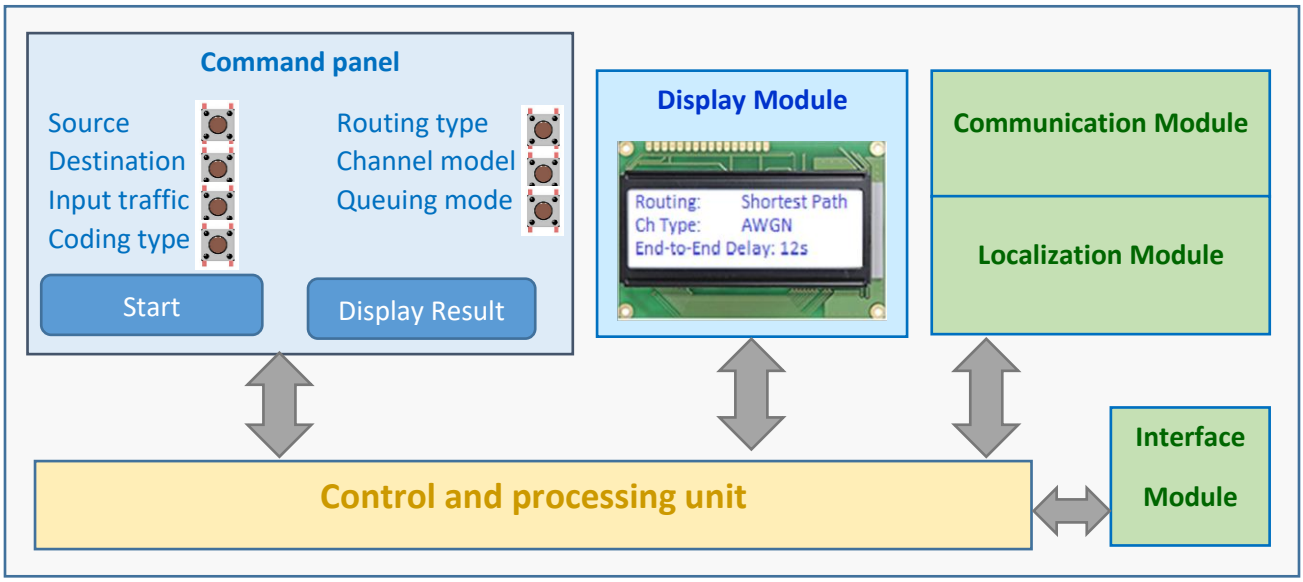
Implementation

The hardware for this project includes one central unit and multiple [about 10] network nodes.

a) **Network node:** The network nodes will be based on simple sensing/communication modules (e.g. Arduino/Raspberry PI microcontroller, XBee, TelosB Mote, …). Each network node will be equipped with some basic sensors (light, temperature) and a simple display module (several LEDs) to show the status of communication node (e.g. IDLE, Receive, Transmit, and Processing).
The network nodes will communicate with each other to send sensing information to the intended destination. The also will communicate with the central unit to receive commands and send display information. The communication protocol will be chosen by student after a careful review and exploring other options. Two important candidates include WiFi and Zigbee.

b) Control Unit

The control unit is the core of the system and hence is a more complicated board including several modules: command panel, display panel, processing and control unit, and localization module, as shown below.



Operation

Each network node is assigned with a unique number. The user defines a set of parameters, such the ID of the source node, the ID of the destination node, type of channels, coding type using the command panel. Then, the routing algorithm as well as the desired performance metric is selected. Other parameters include the statistics of input data, the number of packets to transmit, the length of queuing buffers and etc. Once all parameters are set by the user, the control unit sends these commands to network nodes. When the network nodes are properly programmed, the parameters are displayed on the display module. The information about the network is sent to a Laptop by the control unit, and the routing algorithm is executed and the best path from the source to destination is determined. This information is downloaded to the network nodes. Now, the system is ready to exchange information. Once the information exchange is completed, the resulting performance metrics are calculated by the control unit and is displayed. In some scenarios, the bets path should be altered during transmission (for instance to keep load balance in backpressure algorithm).

Learning outcome

The students will gain some information about practical board design, PCB design, communication protocols, and performance evaluations. They also will learn to program microcontrollers and communicate with MATLAB. Motivated students will learn how to develop ML algorithms to predict the network topology/status when CSI is not available to the nodes.

Client/Supervisor: A. Razi

CS486C – Senior Capstone Design in Computer Science

Project Description

Project Title: Thirty Gallon Robot Design	
Sponsor Information:	Michael Leverington, SICCS michael.leverington@nau.edu 928-523-5448

Project Overview:

Figure 1: Artist's Conception of a 30-Gallon Robot

In recent years, technology manufacturers have continued the ever-increasing trend of packing more and more computing power into ever smaller and cheaper packages; other components like accurate motors, batteries and sophisticated sensors have become cheaper and available on the consumer market as well. As a result, it has now become feasible to construct simple, relatively cheap robots with a surprising amount of sophistication. The project sponsor has been following this trend with interest, with particular focus on developing a flexible, cost-effective robotics platform to use within college level programs for educational purposes. The aim of this project is two-fold:

a) Develop a simple robot that is, in principle, capable of leading tours of the engineering building for visitors. Thus the robots will need to be able to navigate hallways, the elevator, and (perhaps calling on human assistance if locked) doorways; it will not need to be able to manage stairs. This task and all of its implications represents the core specific functional goal of the project.

b) More generally, the aim is to create a prototype that can be widely communicated, and can thus be easily implemented as "a recipe" by other schools or individuals to create their own low-cost robots.

To keep the design simple and low-cost, the project will be based on using a 30-gallon barrel as the initial structure of the robot; this is sturdy, easily-available, and provides plenty of room for components. Future refinements to the design can then focus on re-working a successful design into more compact or elegant packages. Some key aspects of this project include:

1. This is essentially a novel robotics project that can bring together students from two disciplines – Computer Science and Electrical Engineering to build a foundational product. The project will be designed to continue as a vehicle for other robotics projects that can extend this initial one with interesting additional capabilities. The potential future extensions will need a solid, reliable device that they can use and the target here is to build that unit from the ground up.

2. This robot must be reliable and robust, with the ability to move down hallways in our Engineering building without being harmed by students bumping into it and/or it bumping into students and other things. The foundational robot must have basic hazard and obstacle avoidance capabilities and some level of navigational ability to accomplish this first level challenge.

3. The difficulty building a robot such as this one from the ground up lies in correctly analyzing available technologies to figure out power system size and capacity, identifying the correct driving motors or units, implementing some fundamental turning and maneuvering abilities, and then finally synthesizing

management of the whole system. Some of this background research has already been conducted in summer 2018, but there will need to be some testing and potentially iterative research, design, and implementation to bring the unit up to the desired capabilities.

4. Upon completion of this project, the robot should be constructed from a plastic 30-gallon barrel, should be able to navigate in at least a primitive way, should be able to move around the Engineering building hallways without harming itself, and should be designed in such a way that others can either replicate the building process and/or develop extended capabilities that will allow the robot to become more autonomous in its movement and capable of taking on further challenges such as conducting tasks or providing guidance or tours to others in the building.

5. Some key features of this project will include:
    a. a detailed design specification that others could use to create their own robots
    b. information on the types of batteries, motors, and other controlling components to support others' efforts
    c. a fully assembled robot that meets the key features mentioned above
    d. ability of the robot to avoid obstacles or conditions that could cause harm to the unit
    e. ability of the robot to navigate, initially by wire or wireless control from a remote controlling system, a laptop, and/or a mobile app

6. Most robots are too small or too slow to be much more than novel toys that can run around the kitchen or office. This robot is meant to be robust enough to navigate a real-world environment such as an office or school building. With this fundamental problem solved, future students can use this robot as a vehicle to learn about improved navigation, interactions with people and parts of the building, and potentially conducting actions managed by machine learning.

Knowledge, skills, and expertise required for this project:

- Abilities to research the best power components such as batteries, motors, and controllers
- Ability to work with a small-scale processor such as an Arduino system
- Ability to work with sensors such as ultrasonic or laser devices, and any other sensors necessary to meet the given specifications
- Ability to program at a higher level when developing obstacle clearance and navigational software

Equipment Requirements:

- Arduino processor/system and interface/IDE
- Motor controller(s)
- Battery(s) and power systems
- Driver motors, and possibly other steering motors or devices
- Thirty-gallon barrel
- Higher level computing abilities for developing and implementing obstacle avoidance and navigation

Note that equipment not free or immediately available will be purchased and/or facilitated by the sponsor

Software and other Deliverables:

- A strong as-built report detailing the design and implementation of the product in a complete, clear and professional manner. This document should provide a strong basis for future development and/or extension of the product.
- Code base posted on Github or other version control system, as well as stored on a local USB drive
- Assembled and functioning thirty-gallon robot

High-Speed Time of Flight

EE Capstone Project

Your Client

The Lee Lab at NAU is working with Sandia National Laboratory at improving their Z-pulsed power machine, aka the Z-machine (https://www.sandia.gov/z-machine/). The Z-machine is currently the largest pulsed-power machine in the world. Z-machine is used to conduct high energy density science. The machine uses up to 22 megajoules and discharges it within 100 nanoseconds, producing a peak power of ~80 trillion watts. This energy is funneled into a volume about the size of coffee can, where the magnetic fields compress it down to the size of a pen cap or smaller. This generates intense pressure and temperature that can be used to simulate extreme environments like the surface of the sun. The Z-machine is the most-advanced pulsed-power machine in the world. We are working with Sandia to understand limiting factors. A primary long-term goal for the facility is fusion research.

Our goal is to help advance Sandia's pulsed-power facilities by furthering their understanding of the processes that occur when the pulse happens. Many parts of the process are not well understood. To help understand these processes we will build a new mass spectrometer that can capture and analyze atoms or molecules that can help us understand the process. With this information, pulsed-power components can be re-designed or developed, or new materials can be used that will take pulsed-power research to the next level.

Fusion is the only long-term solution to the world's power needs. This research brings us one step closer. Additionally we will be able to better understand our sun and the universe as a whole.

Prototype Milestones

This project is unique in many ways, but at least one of these is that we will be building a complex and expensive system. Because of the complexity and the many players involved, scheduling is tight and will require work beyond that of a typical capstone project. Some components will have long lead times, which requires decisions to be made early. As such, by the end of the fall semester, the team will need to have completed simulation of extraction ion optics, core time-of-flight design integrating with mechanical design and outline for light optics.

During the months of January and February, the team will need to complete time-of-flight testing, optical design, and order remaining parts. During this time, the team will also need to develop the external control structure.

Finally, March and April will include optical testing with external control fabrication and testing, with the expectation of a finalized control system before UGrads.

There will be at least one trip to visit the Z-machine at Sandia National Laboratory in Albuquerque, and potentially 1-2 visits to companies or other institutions. The students will be expected to write their project as a design paper and submit it for publication.

Project Features

1. The final product must synchronize the timing and control for all of the system components.
2. … must produce a mass spectrum for each pulse of the master timing control.
3. … must capture and record the data from the detector for analysis.
4. … must properly account for jitter of each component and among components for the system to work as an integrated whole.
5. … must be controlled through a PC.

6. … must include proper grounding for each component and the entire system to ensure integrity of data and protection of the operator.
7. … must be properly documented for subsequent researchers/engineers to operate, repair, or upgrade the system.
8. … must account for and specify facility requirements for power for the entire system.
9. … should control several different system configurations/designs (parts of system must be compatible with existing protocols and amenable to development of future protocols where none yet exist).
10. … should allow for upgrading components (e.g., master clock, waveform generator, lasers).
11. … should deconvolute the data to produce the relevant mass spectra.
12. … ideally, would control all of the components precisely, collect the entire sample data set, and analyze it in a fully automated fashion, storing a raw data file, ASCII file with each sampled spectrum and its associated time, and a graph analyzing the series of spectra with respect to the particular parameter we are investigating.

Project Success

This project will be considered a success when it ends with a functioning system integrating electrical and mechanical components that is able to capture mass spectra for sample analysis.

Satisfaction Standards

Exemplary - The final product is so good that the client is able to start using it in April/May with the expectation of using it for the next two years.

Good - The final product works as expected, but requires manual control for some parts and/or some manual integration and analysis of disparate data files. Significant training is required for an operator to get reliable data.

Fair - The system functions, somewhat, but is not fast enough, or not able to capture sufficient data to analyze a sample. A major component may not have been correctly integrated with the entire machine.

Poor - The timing control is not reliable. Major components have not been integrated or are not reliable.

Special Team Skills

Students on this project should have a background in signal multiplexing, high speed timing and detection, data collection and deconvolution, and USB peripheral programming and control. Experience with optics or deeper understanding of chemistry will be beneficial. Given the interdisciplinary nature of the project, students on this project will work with an NAU ME Capstone team, chemists, and Sandia researchers and engineers.

Specialty Equipment

Waveform generators, pulse generator, picosecond tunable lasers, and optics/waveguides; these instruments will be supplied by the project sponsor, and available for use in Dr. Lee's lab following training.

Smart Mosquito Trap

EE Capstone Project

Your Client

Mosquitos are the number one killer world wide, as they carry/transmit several diseases (viruses and other microorganisms). West Nile, found in Arizona, is a high concern in other more remote countries and areas of the world. Dr. Hepp and her research team want to catch mosquitoes, to grind them up, and to look for virus as a means of surveillance. To do this, her and her team distribute traps over a large geographic areas such as the southern US and Mexico border. These traps must be able to last for a full night and have mosquito bait to attract them. The current and standard approach is to load a trap with dry ice (not available everywhere) as a CO_2 emitter, powered by D-cell batteries that run a fan that then catches and retains the mosquito. While this method works, it has several limitations that impact the science.

One of these limitations that stands in the way is power access, the CO_2 source, and having to visit the trap daily.

Dr. Hepp would like a trap that can run at least 12 hours, that is also able to retain the mosquito should the research team not be able to return to get the mosquitos the next day. Better yet, these could be deployed for a week, utilizing ethanol or other stabilizing reagents to keep the mosquitos in good shape for the week. There are several electromechanical aspects that could change the paradigm of mosquito collection.

Maricopa County has the best sampling resources of anywhere in the world (surveillance).

This results of this project will allow the research team to do high resolution, season long surveillance in remote locations of the world, starting with Maricopa County. This may also allow us to understand where viral hotspots are, so that we can implement proactive interventions, thus decreasing human illnesses or deaths due to mosquito born viruses.

Prototype Milestones

By the end of March, a prototype that is field ready should be prepared for initial testing by Dr. Hepp and her lab. This unit will be deployed in Maricopa County in an effort to ensure that the basics of the system are functional, and to address and mosquito specific aspects that need to change before strong consideration of how the units will be scaled to greater production.

Project Features

1. The final product must trap mosquitos, retaining them after entry.
2. … must attract mosquitos to the trap.
3. … must be weather proof (including African monsoons).
4. … must have the capability to be powered and charged by solar power.
5. … must be inexpensive and scalable, using parts that can be sourced anywhere worldwide, suitcase travel able (5-10 traps in a checked bagged) and are easy to assemble by a non-electrical engineer.
6. … should be able to trap over several days, sort the mosquitos by day of capture.
7. … should be ready for sharing via a free or open source license, so that others around the world can construct and use the trap.
8. … should detect that mosquito was caught.
9. … should be able to remotely notify the Hepp Lab when a mosquito has been detected and trapped.

10. … ideally will send a picture of the mosquito to the research lab.
11. … ideally can detect what species of mosquito was caught.

Project Success
A successful project will result in a scalable and solar powered mosquito trap that can be used by Dr. Hepp and her lab in and around Arizona to collect mosquito samples in a reliable and consistent manner.

Satisfaction Standards
Exemplary - The final product is so good that the client is able to start using it in April/May, with the expectation of weekly deployments. It requires no major servicing for use.

Good - The final product works as expected, but maybe cannot be easily assembled in field settings by non-engineers. Further, it may not be something that can be easily transported in a checked or carry-on bag for use overseas.

Fair - The system functions, somewhat, but is not to a stage that it can actually be deployed for real use. This system is more of a "proof-of-concept" than a usable product.

Poor - The system really doesn't work, or maybe just parts of it work, but calling it a "proof-of-concept" would be an overstatement. The finished product is something closer to what is expected during the prototype development phase.

Special Team Skills
No special skills are required for this project beyond that of which you have learned during your undergraduate education.

Specialty Equipment
A satellite/cellular/radio modem may be required for the some of the goals and data transmission. The team will be encouraged to consider how to develop technology that can interface with any of these, as this may prove to be a constraint for the team.

Suberranean Pooper Scooper

EE Capstone Project

Your Client

Arizona is the copper state, with a strong history of copper and uranium mining. There are approximately 80,000 abandoned mines in Arizona, and 250,000 in the Southwest. Many of these are 19th century mines that bats utilize as homes. Bats are highly successful mammals that have significant impact on the ecosystem, eating pest insects but also carrying diseases. Some of these diseases can jump to humans or livestock. Catching bats to test for diseases is tough, and typically requires five people, a net, and an entire night of effort. The bats move in and out of the mines nightly, dropping feces and urine in and around the mines. Fecal and urine samples can be used to test for diseases, but still require human retrieval.

The current method of collect involves send someone into the mine, to physically collect a sample, scooping the poop from the under the roost. Not all mines are safe though, especially the uranium mines. Further, the researchers are put at risk by rattlesnakes, skunks, or even bears who are also utilizing the mine for shelter.

There is a clear and strong need for a non-human way to collect these samples, such as a robotic platform.

With a fecal sampling robotic platform, the research team could quickly and cheaply figure out where the diseases are in the environment and therefor mitigate the chances of those jumping to humans. While this test platform is intended for use in Arizona, it could eventually be used in other locations as well.

Prototype Milestones

This project has no additional milestones outside of those required by the class.

Project Features

1. The final product must be able to remotely controlled, with video to the driver outside the mine.
2. … must retrieve fecal samples that are not visible from the entrance.
3. … it must be possible to retrieve the collection unit/device.
4. … it must be possible to retrieve the unit without a human going in after it.
5. … must not cross contaminate samples from the same mine.
6. … must be easy to sterilize between uses.
7. … should be able to navigate over non-level surfaces, steps for example.
8. … should be easy to sterilize between sites in the field.
9. … should not make use of bright cameras or loud motors, so as to not disturb the animals.
10. … should be operational by a single individual.
11. … ideally can take multiple samples, all sterile relative to each other, within the same site.
12. … ideally can geotag (distance from entrance of the mine) each sample.
13. … ideally can record climate data such as temperature, ph, and moisture of sample area.

Project Success

A successful project is one where the system can reliably and repeatably can collect a sample at least 100 feet deep into a mine/lava tube. This product will be one that Dr. Fofanov and his lab use on a regular basis following completion of the capstone sequence. A successful project will

also be marked by the complete design plans and details sufficient that the system can be shared via an open or free license so that others can replicate the system worldwide.

Satisfaction Standards

Exemplary - All project features are in place and fully functional. The product can collect samples in rough terrain beyond the visual range.

Good - The final product works as expected, but maybe cannot collect samples outside of the visual range. All "musts" are in place and functional.

Fair - The system functions, somewhat, but is not to a stage that it can actually be deployed for real use. This system is more of a "proof-of-concept" than a usable product.

Poor - The system really doesn't work, or maybe just parts of it work, but calling it a "proof-of-concept" would be an overstatement. The finished product is something closer to what is expected during the prototype development phase.

Special Team Skills

No special skills are required for this project beyond that of which you have learned during your undergraduate education.

Specialty Equipment

This project does not require any special equipment.

Reduction of CO2 from Primary Source Project

As of 2010, there are more than one billion cars on the road on this planet. That is a lot of harmful CO2 emissions. More recently, electric and gas/electric hybrid cars on the road have become more numerous, and that helps a little, but that still leaves hundreds of millions of cars still on the road providing further risk to our environment. I have an idea to drastically reduce, if not eliminate all harmful emissions from our vehicles: an internal combustion engine exhaust filter.

The theory behind the car exhaust filter is that we can use high voltage to create the jolt necessary to break up the CO2 coming from any standard internal combustion engine into C and O2. This process could also work with the NO2 molecule as well. This device would then have a system to catch break up the CO2 using the broken-up carbon (like an electrostatic air ionizer) and then deposit that into a catch basin or container to be disposed of at an appropriate location. In the end, this device could provide applications beyond automobiles.

I have some found previous studies done that would help in this venture. One is a study that was done by the Delft University of Technology located in the Netherlands called, “The Mitigation of CO2 by Chemical Conversion: Plausible Chemical Reactions and Promising Products,” by Xu Xiaoding and J.A. Moulijn. This experiment proved that CO2 could be broken down using less energy required as long as there were higher temperatures. The other was a study done by the University of Michigan on Carbon Capture in vehicles, called, “Carbon Capture in Vehicles: A Review of General Support, Available Mechanisms, and Consumer-Acceptance Issues,” by John M. Sullivan and Michael Sivak. This one talked about some concepts including some of the ones that I would use. Both of these studies could provide the necessary data to be able to prove my concept on paper and then through proof-of-concept experiments.

The goal at the end of school year would to be for the team to be able to provide proof of concept experiments or conclusions based off those experiments for me to move forward. Hopefully by the end of December the team will have gathered enough research and necessary equipment to begin said experiments. I have provided two resources listed above and also have results from a prior related project available. Multiple completed proof of concept experiments would be considered an outstanding project result. Successful experiments are obviously ideal, but a completed proof-of-concept experiment drawing viability conclusions would be the minimal goal for the completion of this project.

I’m looking for students ideally with an understanding of physics and chemistry. As well as the possibility of chemical engineering. Students should have an understanding of how chemistry and physics work together. Though for some of the proof-of-concept experiments, a good understanding of electrical engineering would suffice as well as being able to prove that the idea would work on paper (chemical formulas, math formulas, etc.).

This project may require some special equipment. This might include a Van de Graaf generator, Jacob's ladder generator, UV lamp or other UV light, CO2 detector, some CO2 cannisters (or a small amount from a car's or other internal combustion engine's exhaust pipe). A box (clear container to hold said CO2) and other equipment. This also might include a CO detector as well and an Ozone detector, a dielectric that dissipates heat, as well as other electrical, hardware and other components and parts. This can be determined at a later date once the experiments are proposed and the details of which are known at that time.

In short, this is an idea that is needs testing. The possibilities are endless with the elimination of CO2 locally before it even becomes part of our atmosphere. If successful, the reduction of CO2 emissions on the road could be just the start of the worldwide benefits of this project, but I need your help. I believe that by proving the science on paper, coming up with theoretical ideas and then conducting testing of concepts, this can be turned into a reality. I look forward to working with Dr. Winfree and your students and the group that accepts and decides to take on this interesting challenge. If you need to contact me at all, my phone number is (650) 380-2330. You can also reach me via e-mail at jlr53@nau.edu or jeffnau@sbcglobal.net. Thank you very much in your assistance with this project.

DOE Collegiate Wind Competition 2019 (CWC19)
EE/ME Capstone Project
(This document is written for the EE students)

The Problem

Taking from the 2019 Rule and Regulations Document for the Competition:

"*According to the U.S. Department of Energy's (DOE's) Wind Vision report, wind energy could supply 10% of the nation's electricity needs by 2020, 20% by 2030, and 35% by 2035. As more wind energy is incorporated into the United States' power generation mix, qualified workers are needed to fill related jobs at all levels.*

To help facilitate this process, DOE and the National Renewable Energy Laboratory (NREL) created the Collegiate Wind Competition in 2014…The competition directly aligns with DOE's overall goals: to create and sustain American leadership in the transition to a global clean energy economy. Its vision is a strong and prosperous America powered by clean, affordable and secure energy. Specifically, the competition's objective is to prepare students from multiple disciplines to enter the wind energy workforce by providing real-world technology experience. Positions in the workforce that require development include researchers, scientists, engineers, educators, project managers, business and sales forces, and many others. Wind-energy-specific advanced degrees are not required for many of these jobs, but having wind-related experience is considered to be highly valuable.

Each year the competition identifies a new challenge and set of activities to address real world research questions, thus demonstrating skills students will need working in the wind or wider energy industry. The Collegiate Wind Competition 2019 challenge is to:

Research, design, and enhance a turbine for a grid scenario with a high contribution of renewables and be able to operate in an islanded mode.

Specifically, competition participants will need to create:

- *An effective mechanical, electrical, and aerodynamic wind turbine and load design that is safe and reliable for testing in an on-site wind tunnel.*
- *An electrical control system that can maintain a constant voltage into a competition-provided variable-resistance load during the durability portion of the turbine testing, utilizing a competition-provided storage element to balance source and load energy.*
- *A cost of energy analysis for the site plan developed in 2018.*

The competition does not prescribe a power system market or wind regime."

This year's CWC will travel to the National Wind Technologies Center (NWTC) at the DOE National Renewable Energy Laboratory (NREL) in Boulder, CO for testing in the DOE's wind tunnels at the end of the spring 2019 semester. Teams are expected to iterate on the previous year's design or to come up with something new. It is expected that this resultant product will be taken to competition by the students and to compete against other universities. Once the competition is over, the design may go on display at the Department of Energy's DC office if a winning design. Regardless of the outcome of the competition, the system will be used for educational purposes to teach the next generation about wind energy in the state of Arizona.

Your Client
Since the admission to the competition was awarded through a competitive proposal process where only 12 universities were admitted, there are a few clients for this project. Karin Wadsack was the Principle Investigator (PI) and David Willy was the Co-Principle Investigator (CO-PI) for the successful proposal for the 2018 competition. All 12 teams have been invited back for the 2019 competition – which is a "light" version of the every-two-year competition. During the last few years, Dr. Venkata Yaramasu has advised the Electrical Engineering students and will continue this role for 2019 competition with help from David Willy – who will be advising the Mechanical Engineering students. Karin Wadsack will help from an administrative level only this year in support of Dr. Yaramasu and David Willy.

For ease of management, fundraising, and NAU logistics for travelling during the academic year, this project will be managed through the new Energy Club at NAU (official website coming soon…): https://nau.campuslabs.com/engage/organization/energyclub

EE Project Milestones*
Late November – Prototypes in software of electrical topology and controls
Mid-January – Final designs in software of electrical design and controls
Mid-February – First Functioning Prototype Complete and bench-tested
Mid-March – Redesign (if needed) and initial wind tunnel testing of full system (ME & EE)
Mid-April – Final inspection for competition and UGRADS
* Collaboration with ME team will be needed to meet these milestones

Project Features
1. The project design must abide by all rules and regulations outlined in the DOE CWC rules document (See DOE CWC R&R document for details).

Project Success
The design and team must be able to compete in all aspects of the competition. This means a functioning turbine in advance of the competition date that has the potential to acquire points in each of the categories outlined in the competition rules.

Mechanical Test Turbine Team (5 ME students) – Design, build, test, and iterate on a small wind turbine to be tested in the wind tunnel at the NWTC in the spring. This sub-team will focus primarily on the ME subsystems but will need to integrate their design with the EE sub-team design. **(This team has already been filled)**

Electrical Test Turbine Team (two teams of 4-5 EE students each) – Design, build, test, and iterate on a small wind turbine to be tested in the wind tunnel at the NWTC in the spring. This sub-team will focus primarily on the EE subsystems but will need to integrate their design with the ME sub-team design. This design may sub-divide even smaller depending on how they organize to sovle the problem. (Team not filled yet)

Siting Team (2-3 students) – Design a complete wind power plant within 100 miles of NAU in software (DNV GL WIndfarmer, AWS Openwind, and/or NREL System Advisory Model). This is an analytical project (paper project) that will require wind resource assessment, land use and environmental considerations, turbine selection, overall site selection, turbine micro-sitting, and investigations into other aspects of a power plant such as utility power purchase agreements and the public. (Team not filled yet, could be ME or EE students)

Funding comment
The proposal for the 2018 competition was extended for the 2019 competition to help cover travel and hotel arrangements at the competition of the students and advisors for each of the teams. Funding for the design will come from capstone fees and/or fundraising efforts.

For questions, please see David Willy in rm324c or david.willy@nau.edu

Please see this year's rules:
https://www.energy.gov/sites/prod/files/2018/08/f54/cwc_2019_rules_and_requirements_manual_20180809.pdf

DOE CWC website:
https://www.energy.gov/eere/collegiatewindcompetition/collegiate-wind-competition

Bio-Inspired Design to Improve Energy Efficiency

Northern Arizona University (NAU) is inefficient with its energy consumption. Many systems have been implemented throughout NAU to combat this problem. However, most of these systems are being placed in newly developed areas of campus (i.e. The solar panels on Student Academic Services building). The systems within the older sections of campus need to be redesigned to improve energy efficiency.

Scope of Work:

The scope of this project is to use aspects of nature to design, build, and validate a system that will improve the overall energy efficiency of NAU's campus. The project should focus on an electro-mechanical system, which can be an innovative design or a complete redesign. With buildings being the number one consumer of energy within Universities, it is advised a system within NAU's older buildings (i.e. Old Main, SBS, SBS west, Adele, etc.) be the focus of the project. However, systems contained not in a building are acceptable.

When completed in the Spring of 2019, the project should incorporate:

- A prototype demonstrating and validating the design's functions
- A description or guide on how the design is to be properly used
- The aspects of nature used to inspire the design
- The design's energy efficiency and how it compares to the pre-existing system
- Evidence supporting the payout timeline of the project
- Why an innovative design was chosen, or why a redesign was chosen
- All calculations, codes, and manufacturing processes used
- Any research to provide evidence of the project being reasonable and feasible
- Any health and safety risks associated with the project/design
- Any future work (if needed)
- Any additional work assigned by the clients and customers (i.e. Professors, NAU, NAU buildings/departments, students, ect.)

Desired Engineering Major: Mechanical (3-4 students) and Electrical (1-2 students)

Sponsorship:

Northern Arizona University should fund most of this project. Whether the funding comes directly from the University or the department/building for whom the project is being completed. As part of this CAP stone project, the team involved is responsible for reaching out to these departments and the University. If additional funding is needed or desired, the team must inquire about outside resources. Finally, if funding cannot be provided or found, then the team may address the project in an analytical manner. However, it is the team's responsibility to speak with their supervising professor for any requirements they need to add or drop.

An Active Prosthetic Device

EE/ME Capstone Project

The Problem

Everyday, you take your sense of touch for granted. Your sense of touch is critical to how you interact with the world. Imagine for a moment that you have lost your hand. Maybe from an accident, maybe from an infection, or maybe even as a congenital condition. For persons with prosthetics, touch becomes a complex issue. Those with amputations are often eligible for prosthetic devices. However, for a variety of reasons such as cost and technology, these devices are rarely actively driven and almost never provide the user with a direct sense of touch. This project will seek to address the limitations of existing prosthetic technologies, by leveraging rapid prototyping technologies such as 3D printed materials and inexpensive embedded architectures, and will result in an inexpensive, customizable, actively controlled, and haptic enabled prosthetic for children in the Northern Arizona (NAZ) area who have a below the elbow amputation. It is expected then that this resultant product will be utilized by children in NAZ, changing how they interact with the world around them.

Your Client

Dr. Kyle N. Winfree (kyle.winfree@nau.edu), director of the Wearable Informatics Lab, NAU Go Baby Go, and EE Capstone program coordinator, will serve as the introductory client. A family in the NAZ area will be identified as the recipient family. This family will become the client starting in mid October.

Prototype Milestones

Aspects of haptic feedback, intentional control, and low weight actuation are all expected to be challenges related to this project. A successful project will have prototyped solutions to these problems by late November. By February, a prototype or set of prototypes is expected to be available to the family for testing different aspects of the final product. By mid April, it is expected that this project will have a fully functional prosthetic ready for regular use by the recipient family.

Project Features

1. The prosthetic is scalable in size, allowing for customization at fabrication for users.
2. … is light enough to actually be used on a daily basis.
3. … is electromechanical controlled.
4. … can sense aspects of touch.
5. … is able to relay aspects to touch to the user via a haptic interface.
6. … is rechargeable, and lasts for at least 8 hours of regular use.
7. … can be further customized by the user (hardware).
8. … can be further customized by the user (software operations).
9. … can identify user intention, predicting and acting on when the user would activate it.
10. … future users or engineerings are able to download all design files, replicating the device.

Project Success

A successful project will result in a 3D printed arm that can be fabricated with all electronics using readily available and inexpensive parts. It must be sizable to different recipients. This prosthetic will sense aspects of touch, such as force or temperature, and relay that information to the user.

Satisfaction Standards

Exemplary - The prosthetic design is ready for prime time, to be shared around the world.

Good - This model works, as described and required, but is a one-off custom device.

Fair - There are parts of the system that work independently, but not together and is not a usable product for the recipient.

Poor - While it might look good, nothing or nearly nothing works.

Special Team Skills

This project is a joint EE and ME project, where each will have a team of 3-5 students, enrolled in their own capstone class and responsible for respective class deadlines and deliverables. However, these teams will work with each other to advance this project beyond that of which either discipline could likely achieve alone. The EE team will be generally responsible for logic control, sensing, and electrical actuation. The ME team will be generally responsible for physical design and fabrication, sensor integration, and electromechanical actuation.

This is a cross-disciplinary project, and will require cross-disciplinary communication.

Specialty Equipment

The two teams will be encouraged to make use of rapid prototyping tools such as a 3D printer. Otherwise, no specialty equipment is required.

GoBabyGo Wild Thing!

Sponsor Information:

Dr. Cole Galloway
Physical Therapist
GoBabyGo Founder

Project Description:

GoBabyGo is an international movement to empower children with disabilities to take control of their world. Children with limited mobility often do not receive the much needed exposure to socialization to appropriately cognitively develop. Existing research shows that enabling young children with self control of their own environment can have meaningful impacts on the long term outcomes given such impairments as cerebral palsy or muscular dystrophy. The GoBabyGo (GBG) project at the University of Delaware has developed a set of DIY cars for families with children with mobility restrictions. These cars have been designed on commercially available ride on toy car platforms (like Power Wheels) and have been deployed world wide by the GBG team. These cars have shown to be a cost-effective means of enabling young children to move and interact with their peers. These cars, though very effective, has missed the mark for older and more able children.

The goal of this project will be to build a gaming system on top of a real world mobile platform. Rather than playing virtual tag, your project should support real world tag, but for children with movement disabilities (this is just one example). This will require two modified Wild Things.

You will work with Dr. Cole Galloway via regular phone or FaceTime conference calls. You may also work with Fisher Price, as they have expressed interest in this project.

Key features of a successful project will be:

- electronic control of the Wild Thing from the brains of the project's output system.
- ability of the system to detect interaction with another Wild Thing, supporting game functions.
- interface with a mobile phone or a notebook computer so that different games can be designed and loaded into the system and synchronized across two or more Wild Things.

This project will be tested by local children with

the assistance of Dr. Winfree.

Needed Skills, and Expertise:

Software design.
Serial Communication.
Arduino (or similar) Programming.
Human-Computer Interface Design.
Mechanical fabrication skills, to adapt the existing device to fit children with special needs.
Enthusiasm to work with special needs children.

Equipment Requirements:

The Mobility Platform (supplied, though most all electronics on board will need to be replaced).

Deliverables:

Regular progress reports.
Semi-Weekly meetings with demonstrations of project status.
Documentation.

Image Source:

https://target.scene7.com/is/image/Target/52188701_Alt01?wid=520&hei=520&fmt=pjpeg

Augmented Powered Mobility

Sponsor Information:

Krista Branch, PT, PCS, ATP
Physical Therapist
Pediatric Certified Specialist
Assistive Technology Professional

Project Description:

You've probably heard of GoBabyGo, and the amazing benefits early mobility provide to young children. I work in a school setting with a variety of students who have never experienced independent mobility, but they are too big for the standard GoBabyGo cars. I would like to work with a team to develop an augmented power mobility unit which can be used by preschool-high school-aged student's with significant motor impairments. Ideally, the unit would be able to capture information regarding activation and force. In addition, I would like to eventually pair this data with other information to determine how the ability to experience independent mobility impacts the student's overall development..

The goal of this project will be to design and develop the electronics and software to run on an existing mobility platform (details TBD) in order to enabled force feedback training and data collection for therapist assessment.

Key features of a successful project will be:

- automatic establishment of a wireless network between the platform and a host PC.
- user adjustable parameters of force feedback, object avoidance, and data collection metrics.
- user configurable inputs, including but not limited to, a force feedback joystick, standard powered wheel chair joystick, and other head control input switches.
- a user PC side GUI for setting of parameters and assessment of driving skills

This project is expected to be deployed for use in the Flagstaff Unified School District. Early testing may involve real users in conjunction with Krista Branch (PT).

Needed Skills, and Expertise:

Software design
Serial Communication
Arduino Programming
Human-Computer Interface Design
Processing (or similar UI)
Some mechanical fabrication skills

Equipment Requirements:	The Mobility Platform (supplied, though most all electronics on board will need to be replaced).
Deliverables:	Regular progress reports. Semi-Weekly meetings with demonstrations of project status. Documentation for end users and developers, especially written such that other PTs would be able to put into practice your designs with the aid of a skilled technician.