CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Nicholas C. Batterman

Project Number

S0901

Project Title

Forehead Powered Headlamp

Abstract

Objectives/Goals

The goal of this project was to create an effortless, dependable, hands-free source of light by using body heat in order to power an LED that functions continuously at a reasonable brightness. It could be used in emergency situations where reliable back-up light is needed or any remote location where no other energy source is available.

Methods/Materials

The thermoelectric headlamp uses Peltier tiles to run without batteries, fuel, solar power, or other manual effort to power it. The Peltier headlamp relies on the Seebeck effect which produces a voltage difference when two types of semiconductors have a temperature difference between them. Sustaining a bright light for a useful period of time requires maintaining sufficient temperature differentials between the Peltier plates. This project will demonstrate that enough body heat can be efficiently transformed into electricity using Peltier tiles in order to effectively power a hands-free headlamp.

Results

Generating adequate voltage to operate a light requires stepping up the low output voltages of common Peltiers. The highest output is obtained when the Peltiers are mounted directly on the forehead. The typical output voltage of a single tile, powered from forehead heat, averaged 50 millivolts (mV). This required using a step-up converter in order to raise the voltage to at least 2 volts required to power the LED. During experimentation, substantial variation in output current, voltage, and internal resistance of the Peltiers was found. Various combinations of low internal resistance Peltiers were tested in series and parallel with the best results occurring when wired in series. The output dropped off rapidly because it was difficult to maintain a temperature difference between the two plates of the Peltiers. Several configurations of copper heatsinks and Acetone based evacuated heat pipes were tested in order to maximize the temperature differential and maintain the output for long periods of time.

Conclusions/Discussion

The results have shown that the heat of the forehead produces sufficient electricity to constantly power an LED headlamp by maintaining an adequate temperature differential. The objective towards building a usable flashlight that runs solely on the heat of the forehead was met.

Summary Statement

I created a continuously running headlamp powered by the heat of my forehead using Peltier thermoelectric generators and cooled with a heat pipe.

Help Received

Parents purchased several supplies; Neighbor lent gas torch and temperature gun; Friend lent commercial vacuum.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Kaitlyn J. Chan

Project Number
S0902

Project Title
Conversion of Pedal Power to Electricity

Abstract

Objectives/Goals
The objective of this project was to engineer a mechanical invention that successfully converted human power into electricity. Through the means of a pedal generator, the goal was to build a device economically feasible as well as user compatible. The project's wider aim was to develop a mechanism that would generate a clean source of alternative energy, a vital need to our society today.

Methods/Materials
The project consisted of two parts: the mechanical design of the stationary bicycle and the construction of the pedal generator. Materials were kept easily attainable at any hardware or electronics store. After the bicycle was made stationary by elevating the rear tire, the pedal generator was wired to a platform behind it. The bicycle tire was intended to cause rotation of the motor shaft, operationally converting the motor into an electric generator. Initially, a skateboard wheel was used to transfer rotational motion from the bicycle to the motor shaft, by force of friction. However, mechanical issues resulted in the modification of that design. Instead, a more efficient transfer of energy proved to be from directly touching the bicycle tire to the motor coupler. Current from the generator flowed through a diode to the battery. An LED was attached to confirm the generator's electrical output.

Results
The rate of charging was calculated by measuring the increase in battery voltage over cycling time. After testing various cycling speeds, the rate of 60 pedal rotations per minute was chosen to charge the battery in ten minute intervals. The rate of charging was found to be 0.65 volts per hour, equating to the battery's charging time of 4.6 hours.

Conclusions/Discussion
The electrical output for the battery turned out to be extremely small, about 0.022 kWh. For example, it would be required to pedal for 15 hours in order to power a mobile phone for one week. While I was initially disappointed by these results, my project was still a start in using mechanical inventions to generate alternative energy.

Summary Statement
I built a generated that took mechanical energy from a bike and converted it to electricity.

Help Received
I used online resources to search for generator designs.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Adam Cohen; Aaron Gerber

Project Number

S0903

Project Title

Soordi: Glasses to Hear Again

Abstract

Objectives/Goals

There are over 38 million people who are deaf in the United States alone (Harrington, 2014). Cochlear implants, which are used to treat patients who are deaf or hard of hearing, can cost up to $100,000.This is not a practical solution for most people. We designed a device called, Soordi which would be a practical, cost effective solution for these people.

Methods/Materials

Materials include a SparkFun Eletret Microphone, an Arduino Nano, a vibration mini motor, a NeoPixel LED, a 9 Volt Battery, and two 3D printed boxes. Additional materials include wires, resistors, and a capacitor. We created the code entirely by ourselves. We first started by testing our microphone. We made sure that we were getting values from the microphone. Once we were able to get values we added in the NeoPixel LED. At first we tested this by having the LED turn on when the microphone would reach a certain threshold and otherwise be in a turned off state. Once we wrote the code for the LED, then we attempted to allow it to change color based upon the sound level intensity. We tested this in the preliminary stages by emitting certain levels of sound and seeing whether or not the LED would respond accordingly based on the intensity of the sound. Lastly, we added the vibration motor and changed the code so it would vibrate based on sound levels. When testing this project we took into account trying to make deaf people more aware of their surroundings.

Results

When analyzing the data collected we saw that from 1 foot away we were very accurate with an overall accuracy level of 90%, however when moving to 5 feet it had an accuracy level or 37%. However, when only taking into the account the two quietest sounds the data collected from 5 feet away was 91% accurate. We have yet to test our Voice Recognition device in a live setting, however, in time before the CSSF competition we would like to collect data on this device as well.

Conclusions/Discussion

Based upon the data collected so far our device does solve our problem we encountered. It takes in sound as an input and outputs vibrations and a light which will allow a person who is deaf or hard of hearing to be more aware of their environment. We would like to continue collecting data and would like to improve our project. A way in which we will redesign our project include adding a more sensitive microphone and removing most of the wires and making the device wireless with bluetooth.

Summary Statement

Soordi is a cost-effective device that allows a deaf or hard-of-hearing user to become more aware of their environment and to respond accordingly based upon this.

Help Received

We designed and built the entire project by ourselves. We had some to minimal guidance from our advisor as to where would be a good direction to move forward in.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Arya Goutam

Project Number

S0904

Project Title

ResQ: A Low Cost Wearable Device that Automatically Detects Falls and Immediately Alerts Family Members Worldwide

Abstract

Objectives/Goals

Design and prototype a low cost wearable device for senior citizens that will automatically alert family members worldwide, in the event the senior falls down and loses consciousness. It is intended to be carried in a pocket or worn around the neck.

Methods/Materials

Hardware Components: Arduino microcontroller, IMU sensor (combination of accelerometer and gyroscope), wireless Bluetooth shield and 9V battery.

Software Components: 1) Fall detection algorithm was implemented in C, to control the Arduino & IMU sensor using open source Arduino software tools. 2) Modified existing open source iOS software to develop companion iOS app using Xcode tools.

The device ResQ was created by connecting the IMU and Bluetooth Shield to the Arduino. The IMU measures the angle of the device while the senior citizen is in motion. The Arduino reads the angle values every 50 milliseconds from the IMU and converts them into angular velocities. If the angular velocity exceeds a pre-determined "falling down" threshold, the Arduino instructs the Bluetooth module to send a signal to the senior citizen's mobile phone. The phone then automatically triggers an alert Notification containing GPS location data and also calls designated family members anywhere in the world.

Results

A prototype version of ResQ and its companion mobile app were successfully designed, built and programmed. The device and algorithm have been extensively tested using a crash test dummy to simulate various senior citizen activities like walking, lying down, sitting and falling down. Angular velocity threshold has been fine-tuned to reduce false positives. ResQ's ability to automatically call emergency contacts internationally, has also been successfully tested.

Conclusions/Discussion

ResQ has been demonstrated to geriatricians, senior citizens and administrators at three local elderly care centers. The feedback received indicates that this device is clearly superior to medical alert systems available in the market today. Current products cost approximately $500 annually and many require the senior citizen to manually press a help button, which is especially hard for Alzheimers patients. Additionally, none of these services work globally. A production version of ResQ, the size of a quarter, is estimated to cost less than $20. This affordable solution has significant application for over 13 million seniors living alone in the US.

Summary Statement

I have successfully designed, built and implemented a low cost, wearable, automatic fall detection device and its companion mobile app that alerts family members worldwide in the event of a Fall.

Help Received

With guidance from my robotics teacher Mr. Schaeffer, I have worked on several Arduino projects over the past 2 years and designed & programmed my own PID algorithm for a drone I built, using an IMU sensor. This helped me design and program ResQ's fall detection algorithm, myself.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Austin Hartman; Edryd van Bruggen

Project Number

S0905

Project Title

Ultrasonic Rangefinders Aiding the Visually Impaired

Abstract

Objectives/Goals

Fractures in the elderly that result from falls are often due to impaired eyesight and are a major health problem. These falls are estimated to exceed 2 million per year in number, leading to nearly 20 billion dollars in health care costs in the United States. These falls are often simply due to uneven pavement on sidewalks or curbs. As of now, visually impaired people have few options to help them avoid such falls. It was our objective to build a simple, low cost yet effective device that could be worn by anyone and will alert them of potential hazards as they go about daily activities.

Methods/Materials

In order to alert the visually impaired about potential tripping hazards, we used two ultrasonic sensors attached to each shoe to detect objects in the wearer#s vicinity. The users were informed about these tripping hazards through small vibrating motors placed on either side of the ankles. The magnitude of the vibration informed the wearer about the relative proximity of the tripping hazard, enabling them to take evasive action. The motors and logic of the device were controlled by a microcontroller (ATtiny84) embedded on a custom etched printed circuit board.

Results

Our effective circuit design and apparatus when attached to the shoe was able to detect objects and inform the user of their approximate position. The success of the positioning system was demonstrated by a blinded test subject#s ability to navigate an obstacle course. By using an ATtiny to control the logic and motors the final product is very compact and inexpensive (approximate cost of all components is less than $10).

Conclusions/Discussion

We achieved our primary objective, namely to design, build, and implement a low cost solution to enable the visually impaired the ability to avoid potential hazards. By using this product the visually impaired can receive additional sensory input about their surroundings and mitigate the risk for potential accidents.

Summary Statement

We engineered an inexpensive device that when worn on the shoes of someone who is visually impaired can alert them to potential tripping hazards and thereby reduce the risk of fractures that result from falling

Help Received

We designed and implemented the project but received help from Dr Don Louie to make a custom etched PCB (to avoid using toxic chemicals).

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Matthew M. Hase-Liu

Project Number

S0906

Project Title

Improving the Efficiency of a Coilgun with the Use of Non-Uniform Coil Density and Current Reversal via H-Bridges

Abstract

Objectives/Goals

The coilgun is a device that launches a projectile through coils used as electromagnets. Although coilguns are quite durable, they typically only achieve efficiencies between 0.3% and 1%. A typical coilgun dumps all of the energy in a capacitor into a uniform coil, resulting in an acceleration when the projectile is in the first half of the coil and a deceleration when the projectile is in the second half. In this project, I propose three novel approaches to substantially improve the efficiency and velocity of a projectile.

Methods/Materials

I used an (open-source) Arduino controller to build my instrumentation, which included a DC current logger to log real-time coil current, a speedometer, consisting of two photogates to measure projectile velocities, and a firing control board employing solid-state relays to generate the current pulses. I bought a 50V, 120000μF capacitor as the power supply and built a charging circuit for it with a boost converter power supply that I bought. I also used PSpice (free online circuit simulator) to model RLC circuits with appropriate design parameters. I built five different types of coils, each hand-wound around styrene tubes, with varying coil densities. For the experimentation, a magnet was launched through the coils and velocities maximized with a single forward pulse. I added a reverse current pulse of the same duration when the projectile was close to the exiting end of the coil, along with varying delays placed between the two pulses to ensure the reverse current pulse was as close to the exit edge of the coil as possible. I then recorded the maximum velocities and corresponding efficiencies as functions of the delay.

Results

In my pulsed current system, the maximum velocity of a ferrite rod is 3m/s with an efficiency of only 0.02%. However, optimizing forward and reverse current pulses with non-uniform coil density increased the velocity up to 11.92 m/s and the efficiency up to 4.711%.

Conclusions/Discussion

The results demonstrate that varying coil density, using an H-bridge to reverse current, and using a magnet as the projectile can drastically improve the performance of a coilgun. I believe this is the highest recorded efficiency of a single-stage coilgun in the literature. Potential applications of this electromagnetic propulsion technology include high-speed trains, weaponry, and launch systems, and may even replace railguns if efficiency is further improved.

Summary Statement

I demonstrated that changing coil density, using a magnet as a projectile, and reversing current could dramatically improve the efficiency of a single-stage coilgun.

Help Received

My physics teacher Dr. Roy Rocklin gave me valuable advice for my poster and presentation.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Alisa Y. Hathaway

Project Number

S0907

Project Title

A Customized Directional Antenna System to Focus WiFi Signals

Abstract

Objectives/Goals

This experiment was conducted to investigate the feasibility of utilizing a helical antenna and customized mechanism to optimize Wi-Fi strength at various locations. In the 21st century, where robust internet is a vital necessity, consumer requirements drive the need to investigate methods to enhance WiFi signal strength.

Methods/Materials

A 2.4 GHz helical antenna was constructed using physics formulas and household materials, and two pan-tilt brackets were purchased online. Two servo motors were connected to the brackets, and one of the motors was attached to a wooden base for stability. An Arduino Uno was utilized to drive the motors; it was programmed using code generated for Arduino Software. The Arduino was programmed to move +120 degrees in elevation and azimuth, depending on the location of the computer. Finally, an old WiFi router was modified to provide an internet signal to the helical antenna.

Results

Once the Helical Antenna was built, testing was possible. The Helical was measured for Return Loss in -dB using a machine called a Keysight Field Fox Microwave Analyzer. Furthermore, the Signal Analyzer was utilized to measure the far field performance of the antenna at various locations and distances. The signal strength was measure in dBm. The data showed that there was a significant increase in the power level of the Wi-Fi signal. The 15dBi output of the WiFi router was increased by the 13 dBi gain of the helical antenna, which focused the WiFi energy to a 47 degree beam. Once the antenna was functioning properly, it was integrated with the brackets and servo motors, Arduino, router, camera, and support structures. The finished #Customized Directional WI-FI Antenna System# (CDWAS) was able to be pointed directly at the target laptop computer and a focused beam of WiFi energy delivered to the user.

Conclusions/Discussion

Therefore, the hypothesis, #If a Wi-Fi router is altered to propagate beams using a customized directional antenna system aimed at specific locations, then the Wi-Fi signal strength to those locations will be enhanced.# was accepted. The CDWAS was able to focus the WiFi energy beam and point it towards the target, which resulted in an increase in the amount of signal power that a device received. In the future, it would be interesting to determine whether the design can be improved to use more than one helical antenna to allow for the tracking of more devices.

Summary Statement

The Customized Directional Wifi Antenna System was able to focus the WiFi energy beam and point it towards the target, which resulted in an increase in the amount of signal power that a device received.

Help Received

I designed, built, and performed the experiments myself.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Robert C. Henning

Project Number

S0908

Project Title

The Exchange Improving Unit: An Auditory Device for Directional Filtering: A Second-Year Study

Abstract

Objectives/Goals

Hearing aids have a fundamental limitation - when used in areas of high ambient noise such as restaurants or public buildings, they amplify background noise as much as desired sounds. This can lead to the user struggling to separate the voices they are listening to from other sounds. The goal of this project was to develop and build a device that would allow hearing aid users to select the directions that they hear from, enabling them to filter out undesirable sounds.

Methods/Materials

The approach taken was through using an array of four microphones to analyze from which direction each sound harmonic originated, and removing the sound components that fell outside of defined parameters. The processing was performed on an FPGA, with an external Atmega32u4 sending parameters set by a user interface.

Results

The device is able to effectively determine the directions of origin of sound sources and can filter out noise from all directions.

Conclusions/Discussion

The limitations of dynamic potential currently limit the quality of sound for music, but the inclusion of CIC filters and even Wavelet Transforms could make the system further optimized. This system is more ideal than shotgun-microphones and similar aids in that this device works with multiple sound sources, for a group setting, and only needs to be setup once with new configurations of speakers. A prototype, with an accurate user interface, is functioning at filtering sounds from undesirable directions.

Summary Statement

This project involved producing and testing a handheld device to actively remove ambient noise for hearing aid users using an array of microphone arrays and advanced digital signal processing on a custom circuit board.

Help Received

This project was done as part of the Clark Scholars program, where participants have access to the facilities at TTU. I brought this project after my first year of work at home to complete it, independently, in the lab of and under the mentorship of my program advisor.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Sasha Jaffarove

Project Number
S0909

Project Title
Cave Mapper

Abstract

Objectives/Goals
The objective of this project is to be able to create a 3D map of a cave or any enclosed space. With the help of electronic devices such as Raspberry Pi and LIDAR and the basic geometry, I believe I can re#create a virtual 3D map of a scanned cave.

Methods/Materials
In order to create a 3D map, I need to build a device (Cave Mapper), which is made of the following main components: Raspberry Pi(RPi), LIDAR, 2 servos and the servo controlling motorhat. I would also need a 3D mapping software to create a virtual representation of a scanned cave. The Cave Mapper will be placed in the middle of a cave and will rotate the attached LIDAR in 2 dimensions. By using LIDAR ability to measure the distance with its laser to a nearby object, I can collect 2 rotation angles and LIDAR's distance which I can place in 3D space in polar coordinates. The RPi will store collected measurements on SD card which I can then upload to another computer, which has a 3D#mapping software installed and will load and display a 3D map of a cave.

Results
The result of this project will be a virtual 3D map of a cave or enclosed space. The Cave Mapper will automatically measure the distance to thousands of points around the room so the 3D mapping software can use them to recreate a virtual model of the same room. Once I test the mapper on my room and get close enough 3D map, I will also test Cave Mapper on an actual cave.

Conclusions/Discussion
As I'm tuning and testing the device, I already see a potential problem # the laser measures distance incorrectly for reflective surfaces such as mirrors, laptop screens, windows, etc. I've read up about it on Wikipedia and I see that this is expected since lasers have the same reflective property as a visible light. This will definitely mess up the final 3D version of my map. I probably need to find a dry cave without any wet surfaces to interfere with the scan.

Summary Statement
My CaveMapper scans a cave and creates a virtual 3D map of that cave.

Help Received
I would like to thank Keshav and Gregory from TechLab who taught me how to use Raspberry Pi and Python coding.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Cameron C. Jones

Project Number

S0910

Project Title

Laser Etching of Graphene Oxide to Create High Energy Density Micro-Supercapacitors

Abstract

Objectives/Goals

The purpose of my project was to create high energy density graphene-based supercapacitors that are highly compact and useful for powering small electronic devices. In today's world where phones and other electronic devices are getting even thinner, electronics have to accommodate ever-smaller form factors. To solve this, capacitors need to have a very high energy density. In this project, I aimed to demonstrate that it was possible to produce very thin supercapacitors using techniques that lend themselves to mass production.

Methods/Materials

To build the supercapacitors I drop-casted a diluted aqueous solution of graphene-oxide onto a polyethylene terephthalate (PET) substrate attached to a DVD disk and let it dry. Then, I utilized a LightScribe(R) DVD drive to etch interlocking electrodes into the graphene oxide. The laser from the DVD drive boils off the oxygen atoms from the graphene-oxide film leaving a 3D-form of highly conductive graphene in its place. I was able to etch complex electrode patterns into the graphene-oxide film. I used a gelled electrolyte made from water, polyvinyl alcohol (PVA) powder, and 85% concentration phosphoric acid. This was deposited in liquid form onto the electrode array and allowed it to dry.

Results

The supercapacitor devices that I built exceeded the capacitance/volume of traditional electrolytic capacitors. My supercapacitors had capacitance/cm^3 between 50x and 560x commercial capacitors. The supercapacitors were limited to voltages of approximately 2V due to limitations of the gelled electrolyte and the insulating graphene-oxide barrier. With my devices I was able to achieve capacitance per unit volume of up to 5,900 µF/cm^3.

Conclusions/Discussion

For this project, I was able to successfully produce functional high-energy density supercapacitors using simple fabrication techniques in my garage. Due to the extremely slim form-factor of these supercapacitors, they are well suited to be used in a variety of modern electronic devices such as phones, laptops, and tablets.

Summary Statement

My project is about designing and building high energy density micro-supercapacitors from laser-etched graphene oxide.

Help Received

None, except for help in purchasing materials necessary for the project.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Hayato S. Kato

Project Number

S0911

Project Title

The Behavior of a Swarm of Simple Robots Expressing Collective Intelligence

Abstract

Objectives/Goals

The objective of this study was to design a swarm of tiny robots modeled off of ants that were able to accomplish complex tasks, despite each individual being limited in its abilities. I tested out the existence of the four main characteristics of swarm robotics in these robots: collaboration, scalability, robustness, and most of all, low cost. At the end I made the robots do a final task, which was a simulation of an ant colony searching for food in order to see whether my robots actually qualified as swarm robots with collective intelligence.

Methods/Materials

Attiyn85, LED, Phototransistor, DC motors, MOSFET, Li-ion Coin Battery. I created a palm-sized robot that was equipped with only a phototransistor, an LED, and two DC motors. I designed several different kinds of simulations such as dispersement and synchronization experiments. I tested whether the tiny robots showed signs of collective intelligence depending on whether they could complete the given task.

Results

Even though I did not directly implement any kind of work distribution program, the robots were able to evenly distribute the work of scouting for an area among themselves. The graph of task efficiency showed a linear slope, indicating these tiny robots showed decent efficiency for its simplicity. The test for robustness also showed robots being able to pass on information even if several robots malfunctioned in between. Each robot costed around $15 to make, and took about a whole day to build, achieving low cost.

Conclusions/Discussion

The tiny robots, having only two input sensors that perceived its surroundings, were capable of having communications with one another, completing the final simulation. The robots were capable of showing all four characteristics of swarm robotics, proving that my project was successful. Although these experiments were done under ideal conditions, it proves the validity of this concept of using simple robots to have them accomplish a larger task as a whole, eventually leading to future applications such as rescue robots during natural disasters.

Summary Statement

I designed a functional swarm of tiny robots using only the bare minimum parts, proving the possibilities of this type of swarm robotic system.

Help Received

From the prototyping and the actual production, the tiny robots were made completely by myself, along as conducting the experiments. I received help from my father in software development of these robots, who taught me how to program.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Venkat V. Krishnan

Project Number

S0912

Project Title

Using Optical Flow Modeling Methods and Sensor Fusion to Create a Novel Low-Cost Autonomous Emergency First Responder

Abstract

Objectives/Goals

Inefficient emergency response causes an average of 100,000 deaths per year worldwide. Autonomous flying robots have tremendous potential to enhance emergency rescue operations. Currently, flying robots are highly limited in their capabilities because they need manual control and are too large, slow, and expensive.

The objective of this engineering project is to create a low-cost, light-weight, and robust robotic drone that can autonomously navigate through hazardous environments efficiently to locate targets (e.g. source of a fire or chemical leak).

Methods/Materials

The Parrot AR Drone 2.0, a relatively low-cost platform that is compatible with inexpensive hardware, was chosen to build the flying robot. Two temperature sensors, two gas sensors, a micro-controller, and a single-board ARM-based embedded system were added to the drone to quickly process vision algorithms and sensor information in real-time. Autonomous navigation is proposed through visual image processing and monocular mapping using Lucas-Kanade optical flow modeling and sensory fusion of gas and temperature sensors to plot obstacles in an environment. The obstacle avoidance monocular mapping algorithm takes a two-dimensional image and uses it to create a three-dimensional map of the drone's environment to identify where the obstacles are located relative to the drone's position. The target location navigation algorithm monitors gas and temperature readings along with visual information to track targets.

Results

The robotic drone was successfully able to map its environment and avoid obstacles while quickly locating targets. Difficulties in obstacle avoidance computer vision algorithms to run on low-power computer were faced and solved using methods like the RANSAC model. The cost excluding the drone was under $100.

Conclusions/Discussion

This project successfully demonstrates the efficacy of electronic sensor fusion with optical flow modeling algorithms to validate a proof-of-concept prototype system that is powerful and cost-effective in autonomous sensing and navigation, with immediate applications in emergency response. Making a variety of sensors that are interchangeable will allow the system to help in different types of disasters such as storms, floods, or nuclear radiation hazard. This project has the potential to help first responders save thousands of lives annually in an emergency response situation after a natural disaster.

Summary Statement

My project is a proof-of-concept method to use sensory fusion and monocular mapping-based computer vision algorithms to create low-cost emergency rescue drones to autonomously navigate in hazardous environments after a natural disaster.

Help Received

UncannyCV, a company that creates computer vision libraries that are optimized for the ARM processor, allowed me to use their vision library for the purposes of this research.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Patrick Liu

Project Number

S0913

Project Title

Project POE: Tri-Sensor Cardiac Monitoring System

Abstract

Objectives/Goals

Problem:

Every one minute, one person dies from a heart-disease related event globally. Heart disease often strikes through myocardial infarction, or heart attack.

Objective:

Project POE aims to assist patients with heart disease through a stationary diagnostic device that is interlinked with a personalized Android app. It is the first prototype to a wearable device that detects trends before a heart attack.

Methods/Materials

Materials:

Pulse Sensor, Bluetooth HC-06 module, Arduino Uno, Olimex ECG Shield, ECG Passive Electrodes, General Purpose Op Amp (MCP601), 2 Resistors (1kΩ & 2.5MΩ), Capacitor (10nF), Nellcor(TM) Reusable SpO2 Sensors with OxiMax(TM) Technology, LCD Keypad Shield, General-Purpose PCB board, Acrylic Case Covering.

Methods:

Build, test, and fine tune each sensor circuit, add Bluetooth capability, build app, test final prototype on human subjects.

Results

From the testing of my project on human subjects, I found a gradual trend in the data as age increased; The heart rate increased as age went up (ranging from 60-82 BPM), and the oxygen saturation was consistent (98-99%). The diagnosis of the subjects was successful, outputting 100% of the subjects as "Safe and Healthy" based on their age and gender. The total price of the hardware prototype was 87$. The ECG Shield had the cleanest signal when the electrodes were attached to the left wrist, right wrist, and right ankle.

Conclusions/Discussion

Project POE successfully measures heart rate, blood oxygen saturation, and displays the electrocardiogram of the user. The heart rate and oxygen saturation is logged to an Android mobile app, where an algorithm displays the final status of heart health. The electrocardiogram is displayed on a JavaScript app, which filters the noise in the user#s environment. Project POE's capabilities and low cost override other cardiovascular diagnostic devices. Results from testing showed viable data of human subjects.

Summary Statement

I developed a hardware prototype and a mobile application which operate as a diagnostic device that measures the heart's vital data and outputs analysis.

Help Received

I developed the prototype and app myself; My father provided me with the acrylic case that covers the hardware.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Luis A. Lujano

Project Number

S0914

Project Title

Comparing Generators

Abstract

Objectives/Goals

By comparing two methods of generating electricity, the objective is to figure out which is the most efficient. As one method requires a shaking motion and the other requires a spinning motion, there are four designs that are being tested. Two designs are for the shaking method (Mark I and Mark II) and the other two are for the spinning (Mark I and Mark II). The mark II designs contain stronger magnets. Multiple formulas must also be used to gain results.

Methods/Materials

As the two methods are being compared, the shaking and spinning designs, in order to get accurate results, they will contain the same amount of copper wire, the same type of magnets and will be tested at a constant rate. There are also formulas and major components for this experiment that are essential. Some essential components are strong neodymium magnets, copper wire (32 AWG), a timer, a digital multi-meter, soldering tool and a scale. Once the designs are built, each design is tested multiple times and timed. Once the data is gained, the efficiency of the designs can be interpreted by using the formulas. Newton's second law is a major formula. By knowing how much force is being applied to receive one volt, that's what lets us know which method is more efficient.

Results

Once the shaking and spinning methods, all four designs, have been tested multiple times, the results are gained. For the shaking and spinning methods, mark I designs, the shaking method turned out to be more efficient than the spinning method because less force is being applied for one volt. The mark I, the shaking method, is best for a hand held generator. As for the Mark II designs, the spinning method turned out to be more efficient because weight also plays a huge role in generators.

Conclusions/Discussion

All the designs turned out to be successful. They were all tested multiple times, at a constant rate, for ten seconds each test. Although the shaking method produced more voltage, for every test, the spinning method is how almost every single generator is designed. It's easier to modify and because of it's mass, it turns out to be more efficient. The shaking method is best for a hand-held generator and the spinning method is best for bigger generators.

Summary Statement

For this experiment, two methods of generating electricity are being compared in order to figure out which design is more efficient.

Help Received

While I designed and purchased all the materials for my project, I had also received help from a physics teacher who taught me all the formulas needed in order to get my results.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Blake A. Martin

Project Number
S0915

Project Title
Solar: Cell vs. Mirror

Abstract

Objectives/Goals
This project was created to attempt to qualify and quantify the benefits and drawbacks of two different methods for converting solar power to electricity.

Methods/Materials
Power was measured using by:
1. Measuring current and voltage generated by a solar cell and calculating power generated over a certain amount of time, then,
2. Calculating the amount of power, created by the reflection of a parabolic mirror, required to heat a measured amount of water from an initial temperature to a final temperature over a certain amount of time.
The tests using the two setups were measured simultaneously.

Results
The results showed that the weather impacted the generation of power with the two methods. A clear day, with no wind, allow the mirror setup to create more power. A breeze and/or cloudy day allowed the solar cell to create more power.

Conclusions/Discussion
This experiment showed that the solar cell power generation was probably more consistent over time compared with the solar mirrors. If an environment was found where the wind was calm and there were few clouds, the mirrors could be more efficient than the solar cell. The one obstacle for me was to determine what costs would be for a large volume/production for each setup. I do know that the large scale power generation by mirrors is much more elaborate, including melting salt, which may reduce the variation in power generation using mirrors.

Summary Statement
I compared 2 basic solar power generation methods in an effort to determine which method was more efficient and why.

Help Received
I used store bought mirror and cells as apparatus, and used an assistant to help record the data. I had to research online how to convert water temperature change over time to power.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Anchit Narain

Project Number

S0916

Project Title

Enhancing the Rate Capability of the Ni-Co-O System Supercapacitor Electrode Using NH3 Treatment

Abstract

Objectives/Goals

The global energy crisis and climate change have become serious issues in need of innovative solutions. Supercapacitors have attracted extensive attention as promising energy storage and delivery devices due to their fast charge and discharge rate, high power density, and long cycle life. Most commercial supercapacitors EDLCs that store charge at the electrode and electrolyte interface. However, their energy densities are lower than those of pseudocapacitors, supercapacitors that store charges using reversible faradic redox reactions. Ternary oxide pseudocapacitor systems, such as Ni-Co-O, etc. have exhibited excellent capacitive behaviors, and therefore have the possibility of producing higher specific capacitances. But they still suffer from low conductivity and as a result, poor rate capability. In this study, I aim to develop a ternary oxide pseudocapacitor system using Ni-Co-LDH as a precursor treated with an NH3 atmosphere at various temperatures to improve its conductivity and rate capability.

Methods/Materials

Ni-Co-LDH precursor was synthesized using hydrothermal process. It was then treated for 1 hour with the N2 and NH3 atmospheres at 400C with an upstream temperature of 800C chemical vapor deposition (CVD). The as-treated active material was characterized by using X-Ray Diffraction (XRD) and Scanning Electron Microscope Imaging (SEM). A CHI 660D electrochemical workstation was used to test the electrochemical performance of the electrodes in a three-electrode system with Ag/AgCl reference electrode. Samples were pressed into Ni foam sheets for electrochemical testing in the electrochemical workstation. The Ni-Co-O electrode was then coupled with a graphene electrode for testing of an asymmetric system.

Results

The NH3 treated Ni-Co-O system electrode shows an enhanced rate capability with only a 14.008% loss of capacitance over the current density range of 2-20 A/g while still maintaining high specific capacitances above 500 F/g. The assembled asymmetric supercapacitor using my electrode coupled with graphene also shows high power density, good energy density, and low capacitance loss of 36.598%.

Conclusions/Discussion

The assembled Ni-Co-O system electrode shows superior rate capability and very competitive specific capacitance. These good results are mostly transferred to the assembled asymmetric system for effective real world use. However, the asymmetric system still needs more optimization.

Summary Statement

I synthesized and tested a novel Ni-Co-O ternary oxide supercapacitor electrode with superior rate capability and high capacitance. It's excellent results are transferred over to a working asymmetric system with good performance.

Help Received

Mr. Tianyi Kou from the Li Lab at UC Santa Cruz helped me use Lab equipment, plan my research, and answered my questions. Mr. Jonathan Bowns helped prepare my board and presentation.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Bennett Ngan

Project Number

S0917

Project Title

A Solar Thermoelectric Generator Utilizing a Phase Change Thermal Battery

Abstract

Objectives/Goals

Solar Thermoelectric Generators (STEGs) convert the heat generated by sunlight directly into an electrical current through the Seebeck Effect. Despite its excellent reliability as a solid-state heat converter and potential for exceeding efficiencies of 15%, scientists have not developed a functioning model for real-world applications. My engineering goal was to design and create a viable STEG by recycling the inefficient energy lost as heat and implementing a low-cost thermal battery for energy storage.

Methods/Materials

First, mirrors are angled to focus sunlight into the device. The sunlight is absorbed by a Black Body, and a container filled with Paraffin Wax is heated in the process. Heat is stored inside the wax as it enters a phase change, and is extracted by the Thermoelectric Generator during use to generate electricity. The energy lost as inefficiency is redirected by a heat sink to heat water for commercial water heating purposes. High heat retention of the device was achieved with 2" commercial polystyrene. Recorded temperatures (infrared thermometer) and known values such as R-value and specific heat were used to calculate the efficiency of the device as well as the heat retention of the battery. CAD Software (SolidWorks) was also used to model the device.

Results

Despite testing in suboptimal test environments, an efficiency of 10.58% and a cost per watt of $3.02 was determined. In addition, the phase change thermal battery was able to retain 83.35% of its energy over a 3-hour period.

Conclusions/Discussion

Because access to preferred materials was limited, the efficiency and heat retention of my final device is predicted to be much higher. Previously thought to be purely experimental and noncompetitive with other solar technologies, my device serves as a promising model for future Solar Thermoelectric Generators due to its reliability, high efficiency, and capacity for storing energy.

Summary Statement

I designed and built a viable Solar Thermoelectric Generator prototype by recycling wasted heat energy and integrating a phase change thermal battery.

Help Received

Mr. Charles Williams and Mr. Kenji Mitchell assessed the validity of my results. SolidWorks was given access by Mr. Charles Williams and was introduced by Chloe Liau, a fellow student.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Cade Pretorius

Project Number

S0918

Project Title

Digital Stethoscope to Assist Detection of Irregular Heartbeats

Abstract

Objectives/Goals

According to The Heart Foundation, the number one cause of death in the United States is Heart Disease. Doctors around the world use stethoscopes for the diagnosis of various heart conditions. Unfortunately, according to a recent Washington Post article, "both internal medicine and family practice trainees had a disturbingly low identification rate for 12 important and commonly encountered cardiac events." The goal of my project is to create a digital stethoscope to help detect irregular heartbeats. Future models could include artificial neural networks to differentiate between specific conditions.

Methods/Materials

I used a Sparkfun Fio v3 (Arduino based) microcontroller with an electret microphone connected to a standard stethoscope, all housed inside of a project enclosure and linked via USB to a PC running code for processing data. Test models relied on an Arduino Uno and a breadboard microphone amplifier circuit.

Results

The stethoscope linked to the microcontroller successfully captures and displays heartbeat data, including the possibility of an irregular heartbeat. Incoming data is converted into 1's and 0's, which is compared to an ideal sample that is created dynamically.

Conclusions/Discussion

I accomplished what I set out to do in my objective. I have created a digital stethoscope that can help to detect irregular heartbeats. My project provides information that can help doctors to detect a possible irregular heartbeat.

Summary Statement

My digital stethoscope can effectively detect potential irregular heartbeats, and could assist in diagnosis.

Help Received

My dad helped me with programming aspects. Mr. Mays of Santa Rosa Academy gave electronics advice. Mr. Slaughter helped as a sound engineer.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Atul Raghunathan

Project Number

S0919

Project Title

Recovering and Recycling Excess Thermal Energy to Improve the Net Efficiency of Common Lighting Sources

Abstract

Objectives/Goals

Even the most efficient consumer light form, the LED, converts between 5-40% of its energy input into heat. Everyday household LED bulbs have large radial heatsinks to remove and dissipate this heat. This project aims to utilize this wasted heat by collecting it, converting it into electrical energy, and recycling that energy to partially power the LED bulb. With a combination of inexpensive thermoelectric generators, capacitors, and transistors, I intend to capture at least 60 milliwatts and successfully recycle it to power a Cree Xlamp CXA 1304.

Methods/Materials

I created my apparatus from four small Peltier CPU coolers used as thermoelectric generators. With a NiMh Battery and a 3 Ohm resistor, I was able to provide the manufacturer specified current to the four LEDs. I charted the output every 5 seconds for 10 minutes to view the trend of the power being produced by the generators. A function was also generated to predict future data. Four iterations in design yielded a consistent output.

To recycle the power, I use an LTC3108 boost Converter to convert the output of the four thermoelectric generators to a usable 8-12 volts. This is then used to charge a capacitor, which breaks the circuit powering the LED with a depletion mode N-Channel MOSFET through a voltage regulating P-Channel enhancement mode MOSFET. The LED switches to the power output of the capacitor for a fraction of a second. The design of this component was perfected in five iterations.

Results

The thermoelectric generator was able to produce 132 milliwatts at first, but that declined and stabilized at 109 milliwatts. With data from the second prototype, the LED was 80-90 degrees cooler with use of the thermoelectric generator; it reduced the temperature on an average from 210 degrees to 120 degrees Fahrenheit.

Conclusions/Discussion

This mechanism effectively recycles power to the LED in a closed loop system. This LED bulb can increase the efficiency of LED lighting and reduce the amount of heat dissipated. Therefore, air conditioning costs can be lowered and smaller heatsinks can be used due to cooler ambient air. As the LED also runs at a cooler temperature, the lifespan of the LED can be increased by up to ten years. If instituted in the average American home, such bulbs can save between 129 and 322 kilowatts of power. With a consistent 109 milliwatts, the engineering goal was achieved and surpassed.

Summary Statement

I converted the waste heat produced by an LED bulb into electricity, and recycled it to partially power the same LED bulb.

Help Received

My physics teacher explained to me the principles behind a MOSFET. I designed and built the apparatus myself.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Anish Seshadri

Project Number

S0920

Project Title

Wearable Diagnostic Point of Care Instrument for AGE Correlated Degenerative Diseases Using Smartphone Technology

Abstract

Objectives/Goals

The goal of the project is to construct a novel, point of care biomedical device using smartphone technology that can reliably and economically determine pentosidine concentration in a patient#s skin and provide a risk assessment. This device consists of two parts: component one and component two. Component one is a spectrophotometer constructed primarily from an unmodified iPhone 4S and an emission light source made up of an ultraviolet light source with a short band-pass filter. The absorption of light by skin results in the formation of excited molecules, which then return to the ground state and emit their energy in the form of light. Thus, emission of UVA wavelengths causes auto-fluorescent excitation in pentosidine, a biomarker and protein component of Advanced Glycation End (AGE) Products.

Methods/Materials

LED light bulb, Iphone 4S, short bandpass filter.

Results

Twenty tests were conducted per subject consecutively using the WDIDD. The raw data collected from the WDIDD is in the form of RGB pixel values that are then dynamically transferred to Excel#s graphic utility. Data from each corresponding data point from each of 20 tests was averaged to give a final data set that had cancelled out a majority of the random values. Specific data modeling methods were used in order to analyze and process the massive bulk of data that were on the order of tens of thousands of data points per participant. WDIDD#s merit was evaluated for three criteria: reproducibility, validity and statistical significance of results compared to pentosidine#s behaviors which increases in concentration linearly with age, and is extremely high in patients with AGE related degenerative diseases.

Conclusions/Discussion

The Wearable Diagnostic Instrument for AGE Correlated Degenerative Diseases (WDIDD) was created to provide a method for identifying patients at risk of or already ailed by diabetes or other degenerative diseases related to AGE build-up.

Summary Statement

The Wearable Diagnostic Instrument for AGE Correlated Degenerative Diseases was proven both functional and valid in measuring levels of pentosidine and predicting risk assessment for AGE correlated degenerative diseases.

Help Received

I did the research and designed and built the device myself including the software and experimentation.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Anshul Singh

Project Number

S0921

Project Title

Prototyping a Quadrotor Collision Avoidance System Using Ultrasonic Rangefinding with NodeJS and Arduino Platforms

Abstract

Objectives/Goals

Make a collision avoidance system and algorithm that overrides user input to maneuver a quadrotor away from potential threats. Maneuver the drone in a variety of test cases to test effectiveness.

Methods/Materials

Laptop with the Arduino IDE and a NodeJS compiler. Unmodified, the AR Drone 2.0 used in the experiment is controlled through a smartphone app. In order to prototype a collision avoidance system, the controls of the drone had to be manipulated. An Arduino Mega 2560 with a physical joystick and buttons was connected to NodeJS through a serialport. Node communicated user commands to the drone through an API, and an avoidance system mounted on the drone delivered data to the Mega 2560. Whenever threats were detected, user control was overriden. The program architecture and any software was a novel creation. The system was tested in 80 different test cases.

Results

The drone was run through eighty presentations of obstacles. The drone successfully avoided sixty eight out of eighty cases and failed to avoid twelve cases. The Arduino Mini mounted on top of the drone was sending incorrect signals at times, which can be attributed to the ultrasonic rangefinder. These cases occured mostly in presentations of objects quickly to the drone, or when the object was too small.

Conclusions/Discussion

The tests went relatively well but the twelve times that the drone didn't avoid the presented objects was partially to blame on the sensor and the angle of the drone itself. The angle of attack at which the drone takes movement at can affect the angles at which the sensor can detect obstacles. The rangefinder also did not detect small objects very well. In order to maximize performance, a LIDAR sensor and a gimbal should be used in the future. A wider field of view would also maximize performance in the system.

Summary Statement

I created a collision avoidance system that overrode user control whenever objects posed a threat to a drone using ultrasonic rangefinding, NodeJS, and Arduino.

Help Received

I created the entire architecture and software myself, after watching a variety of tutorials on programming and debugging.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Ana Daisy Torres; Arien Alexandra Valencia

Project Number

S0922

Project Title

How Does Light Intensity Affect the Resistance of a Photoresistor?

Abstract

Objectives/Goals

This project examines how photo resistors work and examines new applications for them. It investigates the relationship between light intensity and the resistance of a photo resistor.

Methods/Materials

The materials needed for this experiment are: photocell, incandescent light bulb (4W, 15W, 25W, 40W, and 60W), multi meter, laptop, paper, and pencil.

Our procedure starts with setting up the experiment based on the following diagram:

Results

By taking the line of the best fit, one can conclude that light intensity (measured in LUX) is inversely proportional to electrical resistance (KΩ). When light intensity increases the electrical resistance of the photocell decreases. We only tested light intensity values between 20 to 850 LUX. We assume that this linear relationship will continue if we expand our light intensity scale. Hence, we demonstrated that our hypothesis was correct. QED.

Conclusions/Discussion

We then found the LUX (light intensity) of each light bulb and graphed our data. On this graph LUX is the independent variable and the photocell#s electrical resistance is the dependent variable:

Summary Statement

As concluded in our project the more the light intensity is the less the resistance it has and vise versa.

Help Received

Mr.Incze, Mrs.Wilkonson and AHS robotics club

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Vasily A. Tremsin

Project Number

S0923

Project Title

Am I Protected from that UV Sunlight? Personal Devices for Prevention and Preliminary Detection of Skin Cancer

Abstract

Objectives/Goals

My main objective was to create a set of affordable devices that will allow people to monitor the efficiency of sunscreen protection in real-time and aid visually disabled individuals to detect the first symptoms of skin cancer. These devices can potentially decrease the number of incidents of the deadly disease and save human lives.

Methods/Materials

The main components of this project are an Arduino microcontroller board and software tools, UV photodiode, RGB sensor, and LCD screen, speaker, and vibrators for real-time representation of measured results. The present intensity of UV radiation and sunscreen efficiency are measured by a UV photodiode, which is insensitive to visible light. Sunscreen efficiency is determined by UV reflection properties of specific areas of skin. The preliminary detection of skin cancer is performed through spectral analysis of the measured skin region. All results are represented to the user in real-time in multiple ways: visual, acoustic, and haptic. This makes the devices useful to visually disabled and colorblind people.

Results

It was found that UV reflectivity of skin with sunscreen is only 42% compared to the bare skin reflectivity. The degradation of sunscreen protection can be predicted as a function of time for a constant environemnt. In reality, a perfectly constant environment does not exist, and therefore real-time monitoring capabilities of my device may be very helpful for sunblock users. The device for preliminary cancer detection proved to be very sensitive to even the slightest skin discolorations and gave effective warnings when tested on photographs of skin cancer patients.

Conclusions/Discussion

I developed a set of compact and low-cost devices for skin cancer prevention and preliminary detection. These devices can be most useful for visually impaired and colorblind people. One device can let the user estimate the time when sunscreen needs to be reapplied in a particular environment. Another device can scan human skin and warn the user for suspicious abnormalities. The results are provided to the user in real-time in multiple ways to suit the needs of users with various disabilities.

Summary Statement

I created a set of affordable devices for real-time monitoring of sunscreen protection and preliminary diagnostic of skin cancer, suitable for visually impaired people

Help Received

My advisers helped me to find background information and the suitable sensors, as well as helped me to find the appropriate amplifier circuit diagrams.