CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Hannah A. Edge

Project Number
S1001

Project Title
Development of a Low-Cost Mobile Respiratory Analysis Device Integrating FeNO Testing, Pulse-Ox and Secured Bluetooth

Abstract

Objectives/Goals
Alternative, inexpensive approach in the development and structure of a portable compact respiratory analysis device. Include FeNO, pulse-oximetry, and heart rate in addition to the spirometer functionality.

Methods/Materials
Developed prototype with a 3d-modeling software for 3d-printing/CNC, schematic and PCB programs, electronic components, Bluetooth development kit, Android SDK. Tested using a Bluetooth debugger and devices off the market to compare accuracy.

Results
The error rate of the prototype is 3% and has a variation of .14 L, complying to the American Thoracic Society's standards.

Conclusions/Discussion
The device is able to effectively and accurately record fractional exhaled Nitric Oxide, spirometric data (FEV1, FVC, PEF), and heart rate and blood oxygen levels and complies to market standards. My prototype is easy to use, cost-effective and portable.

Summary Statement
I developed a 3d-printed device that measures and analyzes respiratory function using an Android application for personal use for asthmatics and individuals with respiratory disorders.

Help Received
I researched, designed and built the prototype. I reviewed sensor data sheets and the prototype functionality with my mentor.

Name(s)

Matthew Fogel

Project Number

S1002

Project Title

3D Printing and Programming an Affordable Prosthetic Arm

Abstract

Objectives/Goals

The purpose of this project is to create a prosthetic arm that is affordable, easy to control, and easy for anybody to make themselves. The design constraints were for it to be under $100, able to fit the electrical parts inside, and similar to the shape of a real arm.

Methods/Materials

I designed a forearm on Autodesk 123D in addition to using a pre-designed 3D model of a hand. I 3D printed the parts and wired the electrical components to an Arduino. I wrote a program using a version of C++ to close each finger when a button is pressed.

Results

The prosthetic arm met the design constraints. It was able to successfully grab and hold a 12 oz water bottle, or about 3 quarters of a pound. The total cost of the materials used was about $65.

Conclusions/Discussion

This arm is an affordable alternative to currently available prosthetics.

Summary Statement

This project focuses on creating a prosthetic arm that is affordable, easy to control, and easy for anybody to make themselves.

Help Received

Used 3D printer at Loma Linda University Medical Center under the supervision of Michael Davidson, MPH, CPO

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Ethan C. Harris

Project Number
S1003

Project Title
Airprinting: Range and Interference

Abstract

Objectives/Goals
I wanted to test the range of AirPrinting and what effect distance & materials would have on the signal strength and print properties.

Methods/Materials
Tape measure, Paper & pen, Masking tape, HP Envy 4520 AirPrinter, iPhone 7, iPhone 6, iPad 1st generation, Plastic cooler, Cardboard box, Aluminum Foil, Human Body, Microwave Oven, Circuit Box, Vehicle.

Results
After my measurements and averages, I found that I was correct to assume that the inside signals were much stronger than outside. I believe this is due to the umbrella effect of the wifi and the limited interference. Since the access point is located almost perfectly in the center of the house, it spreads to even the furthest reaches of the house. I was able to successfully print everywhere within my home.

Conclusions/Discussion
As with any good research project, it seems I ended my studies with more questions than answers. One of these questions related to bandwidth. I did a range of print test with an 11kb document at different distances but I never seemed to vary significantly from an approximate print time of 38 seconds. I tried these experiments again with a larger 4mb document and the phone was unable to send it to print. With additional research time (and an endless ink cartridge budget), I would have done more tests on the ability of the phone to send larger documents over an increasingly limited bandwidth. It would be interesting to learn if the time it takes to print is logarithmic. For example, how long would a 20mb document take to print at a rate of 20mbps, versus how long it would take a 100mb document to print at a rate of 100mbps? It would be interesting to chart this on a graph. I am also curious about the impact of the IOS on the wireless signal. I was not able to find anything in my research on this topic but I was curious if this had an impact on some of my tests where the iPhone 6 seemed to out-perform the iPhone 7. Lastly, I would like to do more research on the impact of other local wireless signals. I am certain that my evening tests were impacted by our neighbors' signals as well.

Summary Statement
testing the range and items that interfere with airprinting.

Help Received
My mom took me to the store and purchased materials for me and my teacher Mr. Hunt told the whole class about this idea for the science fair, but I acted upon it.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

Alisa Y. Hathaway

Project Number

S1004

Project Title

Detection of Improvised Explosive Devices Using a Phased Array Radar System

Abstract

Objectives/Goals

Improvised Explosive Devices have injured or killed more than 40,000 people in 2013. In order to address this grave issue, the detection of IEDs is important. The scientist believes that if this project is feasible, and if the phased array radar system is effectively created, then a significant amount of lives can be saved; IEDs can be located and terminated before they destroy civilian lives.

Methods/Materials

This experiment required many different materials, divided into two major sub-systems. The materials for the first sub-system, called the "Antenna Component" included: (4) dual patch antennas, (4) front end modules, (4) SPDT RF switches, (4) phase shifters, (2) shift registers, capacitors of various sorts, one SMA Connector, (4) 6 pin and 6 socket connectors, a circuit board, and an Arduino Uno. The second sub-system, called the "Radar Function" consists of a Transmitter, consisting of a radar pulse generator, amplifier, Voltage controlled Oscillator; and a receiver, consisting of a Low noise amplifier, Mixer, and a video amplifier. A power supply, laptop computer and signal analyzer machine were utilized as well.

Results

The dual-patch antenna had a signal increase in 19 dB, based off of CST Microwave Studio and Antenna Magus analysis. The Phased Array RADAR was created and implemented, with detailed analysis on the usage of the VCO, Chirp Generator, and other components of the RADAR itself. The RADAR was tested with many different experiments, allowing the chirp generator to function and detect a human baseline, a human with a metal shield, and a human with a bundle of metal (emulating an IED). The results demonstrated that the RADAR was able to function and operate as intended, with the device detecting a significant change in the chirp. Through the continual trial and experimentation, the scientist was able to observe that the RADAR was able to detect IEDs.

Conclusions/Discussion

The Phased Array RADAR system was effectively designed and created, and the scientist was able to utilize the hardware for a simulated IED detection.
From this experiment, the scientist learned about the benefits of a Phased Array RADAR system, and its efficiency in terms of locating and detecting IEDs, thus offering the potential for saving many lives.

Summary Statement

This project was to detect Improvised Explosive Devices using a Phased Array Radar System, which is more efficient and cost-effective than current applications.

Help Received

Mr. Yamamoto -- question help Mr. Pandya-- lab supplies Mr. Herndon -- lab supplies Ms. Klose--teacher in charge, guidance My Parents --encouragement Rohde & Schwarz -lab equipment Mr. Elio--lab equipment

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Shek Kam; Sarah Shimizu

Project Number
S1005

Project Title
The Effect of Ultraviolet Radiation on the Signal Strength of Amateur Radio Satellite Transmissions

Abstract

Objectives/Goals
This experiment served to implement the various satellite-tracking techniques acquired through the Irvine CubeSat Program and to verify the claims by several ham-radio operators that radio signals are stronger during nighttime where there is considerably less UV interference.

Methods/Materials
Thirty satellite passes were tracked using the High Definition Software-Defined Radio (HDSDR), a Yagi arrow antenna, and a dongle at different times of the day under varying levels of UV radiation. The amount of UV radiation that the satellites were exposed to was manipulated changing the time of day in which the satellites were tracked. The waterfall displays generated from the HDSDR during each satellite capture was documented, and these displays were quantified using a number scale that ranged from 0 to 10. This scale was created based on the amount of pixel coverage for each of the colors on the waterfall displays.

Results
The signal intensity of the satellites decreased as UV presence increased, which verified the claims made by several ham-radio operators that radio signals tended to be stronger during nighttime where there is considerably less UV interference. The R-squared value for the for this data confirmed that there was a correlation between the amount of UV exposure and the signal intensity.

Conclusions/Discussion
The hypothesis was supported by the data because the signal intensity of the satellites decreased as UV exposure increased. This trend most likely resulted because greater levels of UV radiation contributed to greater levels of signal interference. The R-squared value for the trendline for this data was 0.685, which confirmed that there was a clear correlation between the amount of UV exposure and the signal intensity. These findings can be used to develop a software that could calculate a future satellite's orbit to optimize the satellite's power usage when transmitting radio signals.

Summary Statement
Thirty satellites were tracked using a software-defined radio under varying UV levels, and their waterfall displays were used to determine their signal intensities.

Help Received
Our group designed and performed the experiments ourselves. The skills that were necessary for satellite tracking were acquired through the CubeSat Program.

Name(s)

Jacob Y. Kim-Sherman

Project Number

S1006

Project Title

Optimizing Microwave Field Profile for a Quantum Sensor

Abstract

Objectives/Goals

Magnetic field sensing is a powerful technique that allows for non-invasive measurements of magnetic structure. For example, magnetic resonance imaging (MRI) allows for non-invasive imaging of internal organs. An outstanding challenge is creating sufficiently strong and homogenous radio frequency (RF) magnetic fields to control the magnetic sensor. The objective is to improve a wide field magnet sensor by designing an RF waveguide that can produce stronger and more homogeneous magnetic fields than the current omega-shaped waveguide model.

Methods/Materials

The study tested two designs of RF waveguide: an omega-shaped waveguide (existing model) and a spiral waveguide (experimental model). Within the spiral condition, spirals with 3, 5, 7, and 12 loops were simulated. The homogeneity of the magnetic field was tested using the Comsol Multiphysics software. The strength of the magnetic field of each design was tested using the Sonnet software.

Results

Comsol simulations show that square-shaped spiral inductors produced more homogeneous magnetic field than the omega-shaped waveguides; Q-factors output by the Sonnet simulations show that spiral inductors produce stronger magnetic fields than omega-shaped waveguides. Increasing the number of loops of a spiral inductor led to a stronger magnetic field.

Conclusions/Discussion

These results support the theory that an inductor with a spiral design composed of many concentric loops of wire produces a stronger and more homogeneous magnetic field than a single loop of wire. Based on the simulations, a digital mask was created, and prototypes have been fabricated using contact lithography. The performance of the different designs will be tested on the Nitrogen-Vacancy center in diamond, the magnetic field sensor.

Summary Statement

I designed an inductor for use in magnetic field sensing that improved control relative to previous models.

Help Received

I set up and ran simulations using software provided by the lab of Professor Ania Jayich in the UCSB Department of Physics. PhD student mentor Claire McLellan fabricated the prototypes in a cleanroom based on my design, and explained basic principles of magnetic field sensing.

Name(s)
Jonathan Ko; Abhi Upadhyay

Project Number
S1007

Project Title

Power Outlet Adapter to Autonomously Reduce Standby Power Losses Using Machine Learning

Abstract

Objectives/Goals

Standby power, the power consumed by appliances that are plugged in but not in active use, wastes an estimated 23% of residential electricity. Existing methods to reduce standby power (unplugging, powerstrips, timers, and remote-controlled outlets) are inefficient due to human negligence. Using machine learning, this project proposes an autonomous power outlet adapter for reducing standby power waste.

Methods/Materials

The adapter was built with an Arduino Uno, a current sensor, a relay module, and an outlet switch. A machine learning algorithm was trained to determine whether an appliance is on standby. The adapter was designed to disconnect an appliance when it is on standby, periodically reconnecting to "check" if the appliance needs to wake up (disconnecting again if still on standby). The adapter was tested by measuring the standby energy consumed by a speaker playing intermittent audio over four hours both with and without the adapter.

Results

The adapter saved 61.4% of standby energy with 14-second intervals between checks. Increasing the interval between checks saves more energy, but also delays wake-up time. "Checking" every 10 seconds(s), 20s, 30s, 40s, 50s, or 60s would save 34.5%, 67.2%, 78.2%, 83.6%, 86.9%, or 89.1% of the speaker's expended standby energy, respectively.

Conclusions/Discussion

The adapter design can successfully reduce standby power waste with the tradeoff of delayed wake-up time. If implemented universally, the adapter is projected to reduce household energy consumption by up to 20% (60-second checking), saving $16.9 billion in the US yearly. The estimated reduction in US carbon emissions is equivalent to that of 45 coal plants.

Summary Statement

We designed, built, and tested a power outlet adapter that effectively eliminates up to 89.1% of standby power losses by detecting whether an appliance is on standby or in active use and disconnecting or reconnecting from power accordingly.

Help Received

None. We designed, built, and tested the adapter ourselves.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

Nitya V. Kotha

Project Number

S1008

Project Title

Artificial Pancreas for Continuous High Blood Glucose Levels

Abstract

Objectives/Goals

To recreate the pancreas and its function in the body in an artificial way to mimic the delivery of insulin for continuous high glucose levels without the need to monitor levels; making an integrated pump with a conductivity sensor that will detect changes in pH and immediately act to neutralize it.

Methods/Materials

I built a closed-loop circuit that would turn on and off a pump according to pH levels sensed by a homemade conductivity sensor. I represented the process of an actual insulin pump by using an acid/base reaction. First, I normalized the pump to stop in a neutral solution. My first test was to see if the pump would turn on in the basic solution and add in the vinegar, causing the pump to turn off. I did the same test two more times but instead added increments of baking soda to the solution, representing continuous high blood glucose levels.

Results

Applying it to the real situation, the baking soda solution representing the high glucose levels and the vinegar representing the insulin shows that this basic prototype is partially successful. The first test was not very reliable as the sensor didn't detect the minor change in pH due to its logarithmic measurements. The second test, it took time for the sensor to detect the change and turn on; an average of 3 mL of vinegar pumped in every time.

Conclusions/Discussion

The experiment proved to be partially successful and did accomplish my goal although with some minor errors. By comparing my observations and results from the continuous high glucose levels test to that of the control, I understood that there are many difficulties in ensuring the accuracy of the conductivity sensor and the pump to work together. This experiment serves as one step forward in approaching the great range of diabetic issues, being a macro-scale prototype of the artificial pancreas.

Summary Statement

To understand the difficulties behind the artificial pancreas, this project will be conducted to prototype a successful artificial pancreas, focusing on continuous high blood glucose levels.

Help Received

I created the circuit design and the method of testing and was given an explanation of the circuit by the physics teacher.

Name(s)
Andrew T. Land

Project Number
S1009

Project Title
Light on the G String: Novel Optical Pickup for Electric Cello

Abstract

Objectives/Goals
The goal of this project is to develop and demonstrate an electric cello utilizing novel optical sensors directly monitoring the vibrations of each of the cello strings independently. The tone from each string can be independently processed in real-time giving unique flexibility for musical experimentation and performance on the opto-electric cello.

Methods/Materials
The prototype began as a basic beginner cello. Novel optical sensors were designed, major structural surgery performed, and custom electronics designed. The optical sensor is a dual-segment photodiode placed close to the string. This is illuminated by a laser diode, with the string casting a shadow on the sensor. The differential signal across the photodiodes is proportional to the string displacement, independently digitized and read into a computer for real-time processing.

Results
The optical sensors have been evaluated for frequency response and distortion characteristics relevant to the specific application of cello performance. Various processing options have been explored: transposing individual strings for different cello tunings; harmonically adjusting string tone; weird and wonderful distortions for novel applications. Frequency spectrum analysis of signals recorded from a high quality cello are compared with raw and processed tones from the opto-electric cello.

Conclusions/Discussion
An opto-electric cello based on novel optical sensors independently monitoring each of the strings, with real-time computer audio processing, has been successfully developed. The power and flexibility of monitoring each cello string independently with these optical sensors and electronics offers a significant new range of capabilities for cello performance.

Summary Statement
An opto-electric cello based on novel optical sensors independently monitoring each of the strings, with real-time computer audio processing, has been successfully developed.

Help Received
My dad subsidized the necessary materials, helped me with the data acquisition and the poster graphics.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

Farid A. Manshaii

Project Number

S1010

Project Title

Harnessing Energy Out of Thin Air

Abstract

Objectives/Goals

The objective of this experiment is to find a cleaner source of energy which would have no harmful by-products and an efficiency rating of approximately 98.9%.

Methods/Materials

In this experiment, I required a circuit board, ceramic capacitors, electrolytic capacitors, Germanium crystal diodes, Tesla capacitors, neon sign transformer, solder, soldering iron, computer fan, gallium, indium, isopropyl alcohol, glass tubes, liquid cooling system, momentary switch, and 10-18-gauge copper wire.

Results

The experiment resulted in the accumulation and conversion of energy by utilizing Tesla capacitors and a crystal energy receiver. This resulted in a cleaner form of energy which would not have any byproducts. The crystal energy receiver I designed is capable of accumulating electromagnetic energy from 10^24 hertz to 10^5 hertz. This sanctions it to absorb solar radiation and with the avail of Tesla capacitors, it is capable to absorb a more sizably voluminous quantity at a given time. This fortifies my hypothesis and ergo has proven it right.

Conclusions/Discussion

I have concluded that when utilizing a crystal energy receiver and Tesla capacitors, I can engender an unsullied source of energy. This would sanction people to have a cleaner source of energy. With this technology, people can live in a wireless world as envisioned by Nikola Tesla.

Summary Statement

In my experiment, I was capable of modifying the design of a crystal energy receiver to harness energy throughout the entire electromagnetic spectrum and then converted the energy with Tesla capacitors so it would be safe for humans.

Help Received

I built this reactor through the inspiration of my AP Chemistry and Honors Biology teacher. I consulted them extensively in the materials required to complete the project and create an insulated chamber to hold the electromagnetic energy. I also collaborated with the Northrop Grumman FAB LAB to create a shell

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

Sina Moshfeghi

Project Number

S1011

Project Title

Intelligent Repeater for Fifth Generation (5G) Cellular Networking

Abstract

Objectives/Goals

Next generation 5G cellular networks are expected to provide orders of magnitude improvement in data rates and capacity by using higher millimeter wave frequencies. However, millimeter wave signals require a direct path between a transmitter and receiver because of much higher path loss and absorption, as compared to 4G signals. The objective of this project was to determine whether a novel beamforming repeater can be built that could amplify and actively reflect the millimeter waves to solve this problem, and to predict how an intelligent repeater would function in a physical environment.

Methods/Materials

The very first 5G repeater with narrow beams was designed and built using millimeter wave phased arrays, radio frequency modules, and two printed circuit boards. Experiments were performed where a source transmitter had its direct path to the final destination receiver blocked. The experiments used the repeater to actively reflect the signal and provide an indirect path to the destination. The end receiver was connected to a spectrum analyzer which displayed the received signal. System software simulations were also carried out through MATLAB.

Results

The experiments demonstrated that with the use of the repeater the signal transmitted by the source was received at the destination, whereas without the repeater no signal was received. Software simulations for adding repeaters to a cell area demonstrated increased coverage, higher realized capacity, and a lower price per bandwidth as compared with the small cell alternative.

Conclusions/Discussion

The experiments and simulations showed that beamforming repeaters can improve the coverage and capacity of 5G networks by amplifying and redirecting signals. Repeaters can also reduce the installation time and cost of implementing 5G networks because they eliminate the need for installation of optical fiber. Based on these conclusions, fifth generation intelligent repeaters are the least time consuming and most cost effective method of implementing 5G networks in our physical environment.

Summary Statement

In order to make the deployment of next generation cellular (5G) networks feasible, faster, and cost effective, the very first 5G repeater was designed, built, and tested.

Help Received

I designed and built the 5G repeater by myself. Sam Gharavi who is a Systems Engineer at Movandi granted me access to professional equipment and helped me understand the functions of a Radio Frequency Module.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Michelle M. Nazareth

Project Number
S1012

Project Title
ASD Alert 2: A User Friendly Wireless App to Mitigate Oncoming Autistic Episodes

Abstract

Objectives/Goals
The objective of this project was to program a mobile application that monitors biometrics of individuals with Autism Spectrum Disorder (ASD) by analyzing heart rate data, alerting caretaker, and playing music. The objective was also to make the device more practical and user friendly by using wireless technology.

Methods/Materials
This project used MIT App Inventor 2 with the Bluetooth LE library. It required a Bluetooth HR monitor and an android phone to run the application. I developed a program that automatically connects to a chosen Bluetooth monitor, reads, analyzes and graphs data, sends a text, and plays music. The user can customize information in the user interface.

Results
The app worked without issues for 11 out of 14 participants. For the participants that the app collected data on without issues, all aspects of the objective were met. The ASD Alert 2 app was able to store user inputs (child name, emergency information, heart rate sensor, music choice. and average heart rate). In addition, my app integrated user input, analyzed live heart rate data, compared to threshold, graphed the data, played and stopped music, and sent an alert in a timely manner.

Conclusions/Discussion
My app met my objective because it read and analyzed heart data based on user averages. It also graphed this data to provide a visual representation. My app played music and sent out a timely alert through a SMS text. The app I built has also been an improvement from last year's edition. Because it is wireless the app provides a practical entry into the real world and can be easily carried around. In addition, the app has more user entered choices than my device last year.

Summary Statement
I created a wireless app that is able to detect autistic episodes by tracking heart rate, analyzing the data, and using user entered information.

Help Received
Ms. Cristie Kirlin from Kirby School was my project advisor. I worked with Mr. Williams to understand the basics of code in my experiment.

Name(s)
Diantha T. Ngo

Project Number
S1013

Project Title
A Biomedical Application to Smart Textiles

Abstract

Objectives/Goals
The objective of this project is to create a shirt that possesses the ability to monitor and display one's heart rate and body temperature.

Methods/Materials
Materials used were a t-shirt, electrically conductive thread, an LED light, a lithium ion battery, a pulse sensor, the LilyPad Simblee BLE, a lithium ion battery charger, and the LilyPad FTDI Basic Breakout. The LilyPad was programmed through the Arduino interface with a code that would collect heart rate, through a pulse sensor soldered to the LilyPad, and temperature, and display heart rate on an LED and temperature on a phone app. The Lilypad and LED were sewn onto the t-shirt using electrically conductive thread.

Results
I was able to successfully create a shirt that could track the heart rate and temperature of the wearer, meeting my original goal.

Conclusions/Discussion
This shirt is fully functional, simple to use, comfortable, easy to take on and off, and can potentially be marketed as a health and lifestyle product for everyday use, or has purpose in a hospital setting. The concept of smart textiles is versatile and highly useful and I wanted to use this project to showcase their various properties.

Summary Statement
My project is a shirt that possesses the ability to monitor and display the heart rate and temperature of the wearer.

Help Received
Received assistance from science teacher Mr. Jeff Adkins at Deer Valley High School in developing code for project; science project materials paid for by Deer Valley Ace Academy

Name(s)

Justin N. Quan

Project Number

S1014

Project Title

Intelligent Switch Employing Modular Sensors for Improved Power Control with a Focus on Energy Efficiency

Abstract

Objectives/Goals

Electricity is often wasted when devices plugged into outlets are on when unused. Internet of Things (IOT) smart plugs and switches try to prevent this, but they require frequent monitoring, have limited applications, and actually waste energy themselves. It is especially difficult among groups like the elderly and those with disabilities to actively switch devices on and off. My objective is to combat these issues by creating an unobtrusive and power efficient Modular Sensor Switch (MSS) that gathers data from its surroundings using sensor modules to autonomously switch the power of appliances, giving everyone, including groups like the elderly and people with disabilities, more control over their electronics.

Methods/Materials

The MSS uses the Arduino Pro Mini and an HC-06 Bluetooth module to switch a mechanical relay; I included 2 public online Arduino libraries for 2 of the sensors in my Arduino program. The 6 sensor modules that I used detect light, motion, gas, IR signals, temperature & humidity, and sound. To interface with the MSS via Bluetooth, I created an app in Android Studio, and I made the schematic in Fritzing before soldering my custom circuit. I used Autodesk Fusion 360 to design the enclosure with CAD, Cura 3 to slice it, and an Ultimaker 2 to 3D print it. To measure the MSS power use, I powered the MSS in different setups with a variable PSU at 5V and recorded the current draws. To measure the accuracy of each sensor, I induced trigger events and recorded how often the MSS recognized them.

Results

The MSS with no sensor uses 55mW, or 3.66% of the 1.5W by the Wemo Smart Plug, when the relay is open and 380mW, or 19% of the 2W by the Wemo, when the relay is closed. The average sensor accuracy is 93.4%. Each of the sensors only increased the power consumption by 0-5 mW except for the MQ-2 smoke sensor, which uses about 655 mW.

Conclusions/Discussion

Although I could use Bluetooth 4.0 or a latching relay to save even more power, I demonstrated that the MSS model still saves significantly more energy than IOT devices in a variety of applications. The MSS makes it so that people including the elderly and those with disabilities have more power control without consuming much power itself. From start to finish, I fully designed an automated switch that outperforms industry smart plugs in low energy consumption by more than 25 times in its open state while possessing a plethora of applications.

Summary Statement

I created a power efficient Modular Sensor Switch that autonomously controls AC outlets with sensor modules to afford accessible power control to people while conserving energy in numerous applications by making outdated technology "smart".

Help Received

I designed and created every component of the project -the 3D printed enclosure, the electrical board, the Arduino program, and the Android app- myself. I taught myself online how to program in Android Studio and the Arduino IDE and how to use Cura for slicing, Fritzing for schematics, and Fusion 360 for CAD.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

Ronak Roy

Project Number

S1015

Project Title

Smartphone Controlled Portable Phoropter Powered by Variable Focal Length Liquid Lens

Abstract

Objectives/Goals

A phoropter is a large, expensive device that has sets of precisely machined lenses that are used to subjectively determine which eyeglass prescription provides the clearest vision. The goal of this project was to develop a cheaper, portable device to accurately determine the degree of spherical correction for eyeglass prescriptions.

Methods/Materials

Liquid Lens and Driver IC, Arduino, Smartphone, Static Lenses, 3D Printer, Laptop with Xcode, Solidworks, and Arduino Create. A liquid lens, which changes focal length in response to an applied voltage, was used. The Arduino board was wired to the Liquid Lens Driver IC, and I programmed a C++ script that provides I2C commands to direct the applied voltage in response to wireless calls to a custom-implemented REST API. I programmed an app for the smartphone that runs the algorithm to zero in on the prescription by displaying pairs of lens powers and allowing the user to select which of the two is clearer with push-button input. The smartphone also displays a LogMAR visual acuity chart to give a point of reference for subjective clarity. An array of lenses was designed in order to project the test chart to a virtual image at optical infinity.

Results

The sample data provided the following linear regression:
(Official Prescription Power in Diopters) = 0.3235 * (Final Lens Voltage) - 17.8150
with R^2 = 0.8350 for the 26 eyes tested and compared against a refraction officially done by a phoropter.

Conclusions/Discussion

The test results yielded a relatively large R^2 value of 83.50%, meaning over 80% of the relationship between final lens voltage and the actual spherical equivalent was accounted for by the regression line. This strongly supports the hypothesis that the final lens voltage can be used to determine the spherical eyeglass prescription.

Summary Statement

I incorporated a voltage-controlled liquid lens, an Arduino, and a smartphone to create a portable, inexpensive device to effectively replace a phoropter and provide eyeglass prescriptions.

Help Received

I designed, programmed, and built the prototype myself, at home. Dr. Shira Robbins of the UCSD Shiley Eye Center helped me understand the human eye.

Name(s)
Rahul Sharma

Project Number
S1016

Project Title
Surgery Avoidance Using an Inductively Charged Pacemaker

Abstract

Objectives/Goals

The objective is a proof of concept to show if induction charging can be used on a pacemaker reliable, safe, and at what range to show if it is a better alternative than a surgical battery replacement. Another goal is to show the range the charge can go through with different materials in between to simulate the different densities inside the body.

Methods/Materials

Using a Wireless Transmitter P9038-R-EVK, I paired it up with the Wireless Power Receiver P9025AC. Then power is given to the transmitter via cable so that it can create the oscillating magnetic field. I created a pulse generating circuit from a common breadboard, wires, resistors, capacitors, and an IC-555 chip. This served as the replacement for the circuits found in a pacemaker. After sautering the breadboard and receiver together I tested the range using multiple materials in between the charge to see how it affects the range. This was to simulate the different types of materials and densities the magnetic field had to pass through.

Results

The results were successful. With Air in between, the range of the prototype was 29 millimeters. This is impressive considering the top of the line induction chargers for their phones only have a range of at most 5 mm. I found that wet newspaper has a close density to flesh and skin, and the range of the wet newspaper was 21.5mm. The results show it can be used accurately with a good range to charge the pacemaker from the exterior, and the magnetic field can pass through with little to no resistance.

Conclusions/Discussion

The goal is to create a cheap and effective wireless charging pacemaker that can eliminate the need for surgery The data showed that even with wet newspaper (similar density to muscles and skin) the range was 21.5mm. According to the CEO of Groove Mobile, "Induction Charging is hundreds of times safer than making a cell phone call" In conclusion, this device has good range, is extremely safe, and reliable, and it is clear that surgery for the elderly every 5-10 years is not the way to go. The inductively charged pacemakers will save countless of lives that could otherwise be lost in a surgical battery replacement and saves the cost of the survey. In fact, if this technology were implemented in every single pacemaker right now, then we can save up to 70 billion dollars in medical expenses.

Summary Statement

I devised a way to charge the pacemaker from the exterior using a induction charger with a range of 29mm, which will save the costs, and lives of unnecessary surgery.

Help Received

I made the project myself I just needed parental help to purchase all the electronic components.

Name(s)
Suhina Sharma

Project Number
S1017

Project Title
Low Cost Device Utilizing Mathematical Modeling of Heat Loss from the Human Body for Prevention of Hypothermia

Abstract

Objectives/Goals
The goal was to create a low cost heat loss measuring device using Arduino Uno kit that utilizes mathematical modeling of heat loss due to radiation, conduction, and convection in human body. The device assists in prevention of Hypothermia and performs proactive monitoring of lowering of human body temperatures. I was doing research on heat loss in human body and realized that there is no device that exists which can proactively monitor medical emergencies like Hypothermia.

Methods/Materials
Arduino Uno microcontroller, temperature sensor, cables, LED, and buzzer were used to build the device. Device tested on humans of different age groups under different ambient conditions with focus on elderly people. Accuracy tested with thermometer. Tests were done on healthy adults and kids in different environments and with different types of clothes to study the impact of clothing on heat loss.

Results
Multiple tests were performed with different variables to test accuracy. I took measurements of human body heat loss under different conditions. I did the tests on people with different ages with main focus on elderly people. Tests were done in conditions like home water tub, swimming pool, ocean water, and in snow conditions. This was to ensure sensors were giving accurate readings. Test results were validated using a thermometer to validate my test results.

Conclusions/Discussion
The device measured skin temperature as well ambient temperature in different weather conditions and calculated heat loss from human body in those conditions. I also created a threshold limit of 94 °F for skin temperature and the device alerted for anything under this limit. Device also alerted when heat loss from body was high. It met my design goals as it notified before the body temperature dropped to critical level and hence prevented triggering of Hypothermia. The device can be calibrated so that it can alert differently as per requirements.
I plan to extend the capabilities of device in future research work. I would like to make this device work using blue tooth technology so that you do not need any wires and the device works like a waist band. I also plan to build a mobile application that can be integrated with this device. One would get alerts along with other details on mobile application that can be used to prevent fatal events proactively.

Summary Statement
I created a low cost heat loss measuring device that utilizes mathematical modeling of heat loss due to radiation, conduction, and convection in human body that can help in prevention of fatal conditions like Hypothermia.

Help Received
I created and programmed the device myself. I researched on internet by watching videos and joining programming forums. My science teacher reviewed my findings.

Name(s)

Guo (Andrew) N. Sue

Project Number

S1018

Project Title

Drunk Driving Prevention Key (DDPKey)

Abstract

Objectives/Goals

The objective of this project is to create a key accessory that will hopefully reduce the incidents of drunk driving by preventing the key to be inserted into the ignition of the car when the alcohol level in the breath of the user is too high.

Methods/Materials

The main components of the device consist of an alcohol gas sensor to sense the alcohol level in the surrounding air, a programmable IC chip to control all the components, a plastic sleeve that covers the blade of a key to prevent the key to be inserted into the ignition, and a solenoid to block and prevent the sleeve from moving. The concept behind this device is when the alcohol sensor detects a high level of alcohol, it tells the IC to stop the solenoid from retracting so that the sleeve cannot move, and therefore the key cannot be plugged into the the ignition of the car. If the alcohol level is at a normal level, then the solenoid is allowed to be retracted so the plastic sleeve covering the key blade will be able to move, letting the key able to be inserted in the ignition of the car.

Results

It had been tested with multiple types of liquor, including red wine, white wine, rice wine, and beer to see the reactivity of the device toward different types of liquor. It works best with the liquor that has the highest concentration of alcohol, but its performance with other types liquor is good enough for the objective.

Conclusions/Discussion

Using a alcohol sensor, a solenoid, a plastic sleeve, a programmable IC chip and a software script for the IC, a device is created that forces users to blow into this device in order to insert their car keys into the ignition. Therefore, many drunk drivers can be stopped before they attempt to start their car, reducing incidents of drunk driving.

Summary Statement

This project describes the creation and design of a key accessory that helps reduce the incidents of drunk driving.

Help Received

I did not receive any professional help. I searched the internet for inspiration to solutions when I encounter a problem and my parents helped with purchasing parts and provided some feedback.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

Johnny Wang; Lizhi Yang

Project Number

S1019

Project Title

Flexible Capacitive Graphene-Based Touch Panel with USB HID Support

Abstract

Objectives/Goals

Our project goal is to design a flexible capacitive touch panel for traditional displays by taking the advantages of graphene properties.

Methods/Materials

The graphene conductive sheet is developed using multi-layer graphene, which is produced from pure graphite by meshing graphite flakes onto the surface of a plastic film and reducing the graphite to few layers of graphene. We employ four sensors at each corner of the touchscreen, where we take the ratios of the capacitance values from each sensor as parameters and convert them to mouse coordinates using a mathematical model. We used the Arduino framework and Mathematica to develop our coordinate calculation system written in C++. The coordinates are then communicated to the host computer via USB HID protocol.

Results

The touch sensor yields high success rate when detecting the presence and movement of a finger. The device can detect the presence of a human finger with a 99% success rate. When a finger translates on the screen, the sensors detect its moving direction and speed with an average accuracy of 90%. The mouse coordinates are then computed with those data and transmitted to the host computer. The device takes less than 5 seconds to boot and automatically calibrate the touchscreen. Additionally, the delay is consistently below 10ms.

Conclusions/Discussion

This project showed the potential of graphene as a more robust, environmentally-friendly, and cost-efficient material for replacing conventional technological devices such as the capacitive touchscreen. Further experiments will optimize the graphene production technique and investigate the cause of instability in the capacitance readings.

Summary Statement

We designed a graphene capacitive touch panel for all USB HID supporting devices.

Help Received

We designed, built, and performed the experiments ourselves, with some guidance from our school mentor.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

Thomas A. Wheelock

Project Number

S1020

Project Title

Could Seismometers Be Used as a Security System?

Abstract

Objectives/Goals

The objective of this project was to determine whether a seismometer could be used as a form of security system. By doing this project, I hoped to achieve the knowledge of what is needed to build a seismometer, as well as what it would take to turn it into a security system.

Methods/Materials

A casing, a soldering iron, some scrap wires, and a Piezo Element were used to make the seismometer. A free program Wave Pad was used to record the data.

Results

With the data that was collected from the seismometer, it can be mildly, or very sensitive. The seismometer was able to pick up just about anything from doors opening and closing, to the slightest ground movements produced by people walking.

Conclusions/Discussion

The data from the seismometer proves that it could very well be used as a form of security system. The sensitivity is adjustable within the capsule, which makes it fit to the owner's needs. Compared to a seismometer, or other security systems that could be bought online, this is a much cheaper alternative, as most of the components to the seismometer could be found around the house, and if not, then could be bought at a local hardware store.

Summary Statement

I built a very cheap seismometer and used it as a home security system.

Help Received

I designed and built the seismometer myself after hours of research on Piezo elements on the internet.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

Edward Yang

Project Number

S1021

Project Title

An Innovative Approach to Addressing the Needs of the Visually Impaired

Abstract

Objectives/Goals

The objective of this study is to design a system that the visually impaired can use to warn them of any object nearby that is above or below the knee and thus preventing them from colliding with the obstacle.

Methods/Materials

Microcomputer(Raspberry Pi3), Laser Distance Meter, Cane, Ultrasonic Distance Sensor, Vibration Motors, Stepper Motor

Programmed and wired the components together. Then, the system was optimized by adjusting the components.

Results

The system was able to accurately measure the distance away of an object with a percent error of 3.75% after testing with various objects set at exactly 40 cm away. It was able to vibrate the vibration motors when the obstacle was too close above or below the knee.

Conclusions/Discussion

This system will be able to give more advanced warning signals to the user about obstacles around him above or below the knee and thus allow the user to bypass the obstacle safely.

Summary Statement

I created a system that could warn the visually impaired of any obstacle around him above or below the knee.

Help Received

None. I designed, built, and performed the experiments myself.

Name(s)

Michael L. Yuan

Project Number

S1022

Project Title

PID Controlled Ball Balancing System

Abstract

Objectives/Goals

The purpose of this project is to create a precise control system for applications in microscopy, microsurgery, and robotics. Currently in this area (field), cost and precision are things that could be improved. This system is used as a general approach to demonstrate accuracy while maintaining a lower cost (making it more accessible). The goal is to design and implement an automated system that can balance a ball (at a desired location) on a platform. The product (result) will be evaluated based on accuracy (how well it can balance the ball), speed (how fast can it return the ball to the desired position), and cost.

Methods/Materials

I started to tackle this project by coming up with a (structural) design through online research and finding a structure (model) that would fit the design requirements (able to perform the necessary functions). This model allowed me to start gathering the components needed for the system to operate. The Arduino Mega 2560, a programmable microcontroller that is used to control the other components, is the core of this system. Other notable components include Micro Servo motors (allows movement) and a resistive touch screen (provides data). After testing and getting familiar with these components, I put everything together to form one cohesive system. This lead to the development of the (my own) software (including the PID control algorithm) that would be driving the rest of the system. Following the integration of software and hardware, I began tuning the PID control algorithm through manual calibration.

Results

The current, fully functional, system can balance a ball under eight seconds and with an accuracy of ±1.5 cm. The total cost of this system is around $90.

Conclusions/Discussion

This project successfully achieved the original goal of creating an automated control system. It demonstrated that a precise system could be created while still considering the cost factor. Throughout the process, I learned a lot about the engineering process, the diversity of the Arduino platform, the PID control algorithm (how to implement and tune it), and about the different components. The results are general, and the backend system is very versatile, having a sundry of applications.

Summary Statement

A system that can automatically balance a ball (to a desired location) on a platform using a PID control algorithm.

Help Received

Most of the project (software and hardware) was done by myself. I discussed and worked together with my parents and teachers when I had questions.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Michelle Y. Zhu

Project Number
S1023

Project Title

A Novel, Portable Device to Improve Brain Recovery after Traumatic Head Injury, Cardiac Arrest, etc.

Abstract

Objectives/Goals

This project aims to create a revolutionary and innovative device to induce therapeutic hypothermia, the controlled cooling of the brain to 32 deg C-34 deg C, for the prevention of irreversible brain damage after traumatic brain injury and cardiac arrest, as with current methods and devices. In detail, this project aims to cut operation cost of current devices by 100 times, size by 20 times, weight by 10 times, and increase continuous operation time by 200 times. Such innovations are important because out-of-hospital traumatic events demand portable, noninvasive and reliable solutions.

Methods/Materials

A physical pocket-sized prototype of the device uses an improved intranasal catheter to cool the nasal cavity, and in turn, the brain. The device has a closed-loop control system with sensing accessories as well as a microcontroller for autonomous control and timed monitoring of cooling elements and patient brain temperature readings in real-time. A model brain comprising of an amount of water calculated to be equivalent to a human brain, based on average human brain characteristics, was used during testing. Model temperature data were collected with a variable thermistor.

Results

The device was able to control output temperatures and maintain model brain temperatures at stable hypothermic temperatures of 34 deg C over three intervals, during which the control system maintained temperatures within ±0.1 deg C of the goal temperature. By utilizing the Peltier effect and the specialized nasal catheter, the resulting device weighs less than 1kg and costs less than $50 USD.

Conclusions/Discussion

Operation tests demonstrate the device's ability to induce and maintain hypothermia over extended operation periods. Due to its feedback control capability along with smaller size, lighter weight, higher energy efficiency, and longer operation time between recharges, this device has many advantages over current technologies.

Summary Statement

I designed, built and tested an inexpensive, portable, reliable and functioning brain-cooling device to prevent brain damage after traumatic brain injury and cardiac arrest.

Help Received

I designed, built and tested the device myself. My high school teacher Ms. Fallon provided support, supervised my experiments, and reviewed my results. Professor Newcomb (University of Maryland, College Park) provided me with advice on my control system and theory.