CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Sunil K. Alexander

Project Number

S0901

Project Title

Fibonacci Solar Array vs. Regular Panels on a Roof

Abstract

Objectives/Goals

To measure and compare the electricity output generated by the solar panels on a rooftop to the photovoltaic cells placed on the tree branches in the Fibonacci sequence. Also to find if the process photosynthesis will help us build better solar devices.

Methods/Materials

Materials: 22 solar panels, PVC pipes, and copper wires.

Methods: I tested each system with a multimeter to find the amps and watts. I also tested the models with a propeller and lab quest reader.

Results

The Fibonacci solar array produced more energy output in amps, and RPM than the rooftop panels.

Conclusions/Discussion

The improved Fibonacci Solar Array produced more energy than the Standard roof panels. It also showed greater efficiency than the older model. This means that trees can teach us how to generate energy more efficiently.

Summary Statement

To find if trees can show us how to produce more energy.

Help Received

Guided by engineers from PSOMASFMG,

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Cody Allen; Tyler Ferris

Project Number

S0902

Project Title

Data Transmission Using Visible Light

Abstract

Objectives/Goals

The objective of this project was to see if laser communication is possible. We believe that laser communication is possible.

Methods/Materials

By incorporating hardware and software, we built a device that transmit data with a laser. Binary signals are sent from computer A to the audio output transformer through the line out of the computer, the signal is then sent to the laser where it is shot out and received by the solar cell. The solar cell sends what it captured to computer B where the signals are matched to a library and then decoded.

Results

We can send up to eighteen binary signals at 100% accuracy. Each letter has six binary signals that goes with it so eighteen binary signals is really three letters. After eighteen signals the code starts transmitting faster than it can receive so anything above eighteen signals doesn#t get recorded at 100% accuracy.

Conclusions/Discussion

Our original hypothesis, is laser communication possible, was correct, we can send up to three different letters at 100% accuracy.

Summary Statement

This project is about using visible light to transmit data.

Help Received

Cody#s mom bought equipment used for this project. Tyler#s parents gave advice on how to make this project better.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Nicholas C. Batterman

Project Number

S0903

Project Title

Heat Pipe Cooled Thermoelectric Headlamp

Abstract

Objectives/Goals

This project seeks to create a dependable headlamp for use in emergency situations and remote locations. By employing the heat of the human body, this device would be more reliable than standard battery operated lights.

Methods/Materials

I created a headlamp that uses body heat to power a light emitting diode (LED). The headlamp uses Peltier devices to produce an electrical output. Each Peltier consists of multiple semiconductors, the sides of which are heated and cooled to different temperatures. By utilizing the Seeback effect, this temperature difference induces a voltage in the device, which in turn creates a current that is used as an input to the flashlight.

Sustaining a bright light using Peltiers for a useful period of time requires maintaining a sufficient temperature difference between the plates of the Peltier. During experimentation, various heatsinks and heat pipe configurations were used to cool one side of the device.

The number of Peltiers employed in the system, wiring configuration, heatsinks, and differing heat pipe configurations were tested and optimized for the best results. The test cases were compared by calculating the total energy generated for each configuration during a 10 minute test period.

Results

The highest energy output was obtained when several Peltiers were mounted directly on the forehead. The low voltage output of the Peltiers required creating a step-up converter to power the LED. During experimentation, substantial variation in output current, voltage, and internal resistance of the Peltiers tiles was found. Fourteen different Peltiers were tested in various combinations of 1, 2, or 3 in series and parallel. The best results were obtained when the Peltiers were wired in series and were matched for lowest internal resistance and highest power output.

The output of the Peltiers dropped off rapidly because it was difficult to maintain a temperature difference between the two sides of the Peltiers. Various configurations of heatsinks were tested in order to improve performance. Several heat pipe variations were later tested in order to maximize the temperature differential and improve long-term Peltier output; an evacuated tube containing acetone transferred heat most efficiently.

Conclusions/Discussion

An LED headlamp powered by heat of the forehead was successfully constructed and ran for far over ten minutes.

Summary Statement

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

Help Received

Parents purchased supplies; Neighbor lent gas torch.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Dominic H. Catanzaro

Project Number

S0904

Project Title

Designing and Constructing Photonic Crystals at 2.4 GHz

Abstract

Objectives/Goals

Photonics crystals are repeating structures made of two materials with different indices of refraction and are useful for many applications, mostly as filters, fibers, and waveguides. My hypothesis is that photonic crystals designed for visible light can be scaled to microwave frequencies.

Methods/Materials

I built a series of photonic crystals for testing at a microwave frequency (2.4 GHz). The crystals consisted of periodic layers and columns of drywall, separated by air. To test the properties of the photonic crystal, I used a tunable 2.4 GHz source modeled after a hobbyist RADAR designed by MIT. I built an RF range using foil-lined panels to contain the energy vertically and water bottles to absorb the energy around the perimeter of the range. To measure the properties of the photonic crystal, the transmit antenna illuminated the crystal and the receive antenna measured the transmitted and reflected power. I built one and two dimensional photonic crystals.

Results

I simulated the behavior of the photonic crystals with the intent to compare with the experiment. For the one dimensional crystal I used two calculations: one using the equation for a volume hologram and the other using the thin film characteristic matrix. When fully constructed, the one dimensional photonic crystal was designed to reflect up to 80% of the microwave energy. The measured reflectivity as a function of the number of layers in the crystal matched closely to the calculations predicting the crystal#s behavior. Closed form solutions don#t exist for two dimensional photonic crystals. I used FDTD software called MEEP to simulate its behavior. The two dimensional photonic crystal was designed to guide the microwave energy in specific directions. The simulations and the experimental data showed this, although the effect was weak.

Conclusions/Discussion

My hypothesis was that photonic crystals can be scaled across frequencies. The one dimensional photonic crystal performed as expected, matching the theory and reflecting a majority of the microwave energy. I discovered while testing this crystal that inaccuracy in the assembly severely limited the reflectivity. The two dimensional photonic crystal, guided some of the energy and behaved as a photonic crystal, but did not create a complete band gap because the index contrast was too small. Thus, my hypothesis was correct: photonic crystals can be scaled to microwave frequencies.

Summary Statement

I constructed photonic crystals at 2.4 GHz by scaling designs from other spectra and then compared the resulting crystals with calculations and simulations that I performed,

Help Received

Father provided some lab equiment.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Shiloh S. Curtis

Project Number

S0905

Project Title

Enabling Situational Awareness: A Hat-Based Hands-Free Haptic Navigational Aid for the Visually Impaired

Abstract

Objectives/Goals

According to the WHO, an estimated 285 million people worldwide are blind or have low vision. Unfortunately, white canes and guide dogs, the most popular aids, don't detect face-level obstacles, are cumbersome, can be expensive, and aren't hands-free. To answer this need, the researcher designed and constructed a hat, the Haptic Navigational Aid for the Visually Impaired (H-NAV), which helps blind users detect face-level obstacles.

Methods/Materials

The hat senses obstacles using a laser distance sensor (LDS), like those on self-driving cars, mounted on top. An array of 12 vibrating motors (such as those in cell phones) inside the hatband alerts users to obstacles' presence and direction, and a slider adjusts the motors' vibration strength.

Arduino-based Version 2.1 was tested by assessing 12 sighted, blindfolded test users' ability to perform basic navigational tasks such as walking through doorways and along walls while wearing it. Based on user feedback, the hat's hardware and software were completely redesigned to accelerate assembly, improve comfort, and add features. For Version 3, the Arduino was replaced with a system of two AVR microprocessors. An ATMEGA324 on a rigid PCB under the LDS interprets LDS data and user inputs as vibrating motor commands. These are mounted on a flexible PCB inside the hatband, directly controlled by an ATTINY2313a. This system allows additional features such as a distance threshold adjustment, but the switch required a complete software rewrite, redesigning its structure and implementing basic I/O functions previously included in the Arduino libraries. Six blind users experimented with Version 3.0, providing qualitative feedback.

Results

The blindfolded users had a 90% average success rate over all tasks tested. The blind users were enthusiastic about the idea, and provided much useful feedback about the hat's user interface.

Conclusions/Discussion

To date, the H-NAV has two patents pending, U.S. 61/959,215 and U.S. 62/071,689. After revisions based on blind users' feedback, testing with a statistically significant group of vision-impaired users is the next step; several organizations for the blind have already expressed interest. The H-NAV could be produced at the low per-unit materials cost of $90-150, and has the potential to significantly improve the lives of the vision-impaired, enabling them to be safer and more independent.

Summary Statement

A hat-based navigational aid for the blind which indicates obstacle direction and distance via vibrating motors in the hat band.

Help Received

Neato Robotics donated four Laser Distance Sensors; Dr. Youssef Ismail provided technological advice; Homebrew Robotics Club advised on sensors and electronics; David Curtis supervised the project.

Name(s)
Rohan Dhesikan

Project Number
S0906

Project Title
An Apparatus for Enabling Long Flights with Drones Using Robotic Battery Replacement

Abstract

Objectives/Goals
The objective of the project is to design an automated battery replacement system for quadcopters. For package delivery, quadcopters are the future. The effectiveness of quadcopters is limited by their battery life. Currently, quadcopter batteries last about 10-12 minutes or 6-8 miles. The purpose of this project is to create an efficient yet effective method of replacing quadcopter batteries, so that they can continue flying. To do this, we set two constraints. The design constraints of the project are i) dimensions less than 5 ft. by 5 ft. by 5 ft.,ii) replace the batteries successfully, and iii) replacement in under 2 minutes. The system enables the quadcopter to land, replace its batteries, and take off with a fully charged battery. The applications are package delivery, medical delivery, aid for natural disasters, and many more.

Methods/Materials
The key elements of the project are a robotic arm, spring loaded battery contacts, and battery carriers. The robotic arm was programmed to replace batteries in three compartments, a temporary holding station, a charging station, and a quadcopter station. The robotic arm was able to pick and place batteries with a suction system. To connect and disconnect the batteries easily, spring loaded contacts were used. The batteries are placed on their carriers with the spring loaded contact at the bottom of the carrier. The carrier fits inside the compartments making contact with the receptacle at the bottom of the compartment. This allows for a simple connection by the robotic arm.

Results
The design constraints were met successfully; the batteries are replaced in an average of 47.6 seconds; also the dimensions are substantially under the constraint with measurements of 36 inches by 15 inches by 4 inches.

Conclusions/Discussion
These successfully met constraints mean that this replacement system has potential to be a mainstream solution to the problem. Although, there are a few further steps to make it a viable solution. The next steps to make the system more practical are to weather-proof the system for outdoor operation and use renewable energy sources for the charger and the robotic arm. This project could be used to create an effective package delivery system or a delivery system for medical supplies for people in need. In conclusion, with this battery-replacement system, quadcopter-based delivery could become a reality.

Summary Statement
Drones are currently limited in their effectiveness due to the short battery life, this solution using a robotic arm allows for automated replacement of batteries in drones, thus enabling longer flights.

Help Received
Mr. Peter Chester helped learn CAD software, to design prototype. Mr. Roy Osterberg helped learn programming.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
Amy Z. Dong

Project Number
S0907

Project Title
The Design of an Ultra-Lightweight Hybrid Solar-Powered Radio Controlled Aircraft

Abstract

Objectives/Goals
The objective of this project is to construct a solar harvesting system for a model airplane, and to integrate the solar harvesting system on the plane to test if there is enough energy produced from solar cells to power the airplane.

Methods/Materials
Phase one, a solar harvesting system was built by soldering four solar panels with wires. The wires are connected to the Li-Po balance charger and the airplane power system. The four solar panels were then installed on the airplane wings. Tests were conducted.

Phase two, an integrated hybrid battery and solar panel system was constructed by connecting a Li-Po battery with the Li-Po balance charger and the airplane power system. Tests were conducted on the performance of the airplane.

Results
The power generated from the solar panel system alone built in phase one was not enough to move the airplane, but noise can be heard from the running motor.

The energy generated from the integrated hybrid battery and solar panel system built in phase two was able to power the airplane. The airplane was able to run on various ground surface, take off from concrete ground and fly in the air for less than one minute each time during the test.

Conclusions/Discussion
The experiments demonstrated that an integrated hybrid battery and solar panel system has the potential to generate enough power to fly a model airplane. The primary ways to harvest more solar power for longer flying time or for bigger airplanes are to install more solar panels by increasing airplane wing span and to increase solar panel efficiencies since the efficiencies of current flexible solar panels on the market are low.

Summary Statement
The Design of an Ultra-Lightweight Hybrid Solar-Powered Radio Controlled Aircraft

Help Received
Studied engineering design fundamentals at University of California Irvine in Summer 2014.

Name(s)

Kelsi Dugas; Iryna Turchyn

Project Number

S0908

Project Title

Investigating Futuristic Ways of Frictionless Transportation: Is Quantum Levitation a Solution?

Abstract

Objectives/Goals

Even a few decades, the possibility of frictionless vehicles seemed impossible, but today the new invention of floating maglev trains is more common all around the world. By constructing a symmetrical car model out of styrofoam, and supercooling it with liquid nitrogen (LN2), we predicted that the object will undergo levitation and suspension for 2 minutes, and will be able to carry approximately 15-20 grams, while traveling a total of 16 meters. In addition, our levitator will be able to be suspend for 1.5 minutes. In order to test our hypothesis, we created a neodymium magnet track and a small automobile model to float on a small superconductor cooled with liquid nitrogen and to record different variables: speed, carrying weight capacity, distance traveled, etc.

Methods/Materials

Neodymium (NdFeB) block magnets (150) attached to a stainless steel strip - creating a neodymium track. Levitator (YBCO superconductor with thermal insulation) is supercooled/soaked in liquid nitrogen with help of a Dewar, thermal gloves, ladle, plastic tweezers, and metal tongs. For additional experimentation we used a timer, sphere weights, a camera, styrofoam containers, and base structure we designed to demonstrate suspension and quantum locking of the levitator.

Results

By conducting four different experiments, we were able to prove our hypothesis and test the various factors of the levitator, such as its weight carrying capacity, speed, traveling distance per certain amount of time, ability to experience suspension, and the levitation time length.The superconductor was able to levitate for a highest average of 2:08.2 after being soaked in LN2 for 10 seconds. For second experiment, although the superconductor levitator was suspended for only 1:57.8, it was able to carry an average of 31.17 grams. During suspension, the time levitation averaged out to 1:17.91. On the horizontal track, the levitator traveled an average of 1545.2 cm/min. Using proportions, we conducted that a superconductor average-sized car can travel 156.96 km/hour.

Conclusions/Discussion

While experiencing frictionless levitation, we explored the idea of creating a superconductor levitating vehicle. Thanks to it properties of zero electrical resistance and the expulsion of the magnetic field, the superconductor can be considered as the world's next efficient solution of incredibly fast frictionless transportation and reducing the emissions of CO(2).

Summary Statement

Experiencing frictionless motion in both levitation and suspension while levitating a superconductor levitator above maglev neodymium track and stainless steel base structure.

Help Received

Materials ordered from Amir Saraf (Physics from Tel Aviv University, Israel); liquid nitrogen from Air Gas Company; levitation/suspension base structure - created by Andrew Turchyn; supervision of Karen Reynosa during experimentation.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Hannah A. Edge

Project Number

S0909

Project Title

3D-Printed Bluetooth Android-Based Spirometer with HIPAA-Compliant Secured Cloud Data Storage

Abstract

Objectives/Goals

Asthmatic and COPD patients need portable digital spirometers because they are optimal tools in determining their lung capacity and detecting changes in lung function in a more accessible manner. This results in a better evaluation and treatment of earlier exacerbations and reduces ER visits and healthcare costs. It also involves and encourages patients to take an active role in monitoring their symptoms.

Methods/Materials

Creo ProEngineer; ProJet 3510 HD; VisiJet M3 Crystal ; EAGLE; SmartDraw; Eclipse (Java); Android SDK; 2 circuitboards ;Circuitboard components: ; 1 red LED light; 1 green LED light; MPXV7002DP air pressure sensor; CC2541 Bluetooth module; 2 NPN transistors; 17 fixed resistors; 1 toggle switch; 10 nonpolar capacitors; 1 button; 3 AAA batteries; WQS-8888 Spirometer/Calibrator; Google Cloud Service.

Conclusions/Discussion

The spirometer prototype had an approximate 4% error rate and variation of .14 L, complying with the American Thoracic Society#s standards. It demonstrates a cost-effective, portable, durable, user-friendly solution by resolving the issue of having costly desktop spirometers.

Summary Statement

This project identifies an inexpensive approach in the development and structure of a portable, compact spirometer; merging new technology such as 3D printing, Bluetooth, Android & Cloud for the gathering and determination of lung function.

Help Received

Schematic diagram reviewed and corrected by Mr. Cai, suggestions on Cloud provided by Professor Breaux of Carnegie Mellon

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
Robert C. Henning

Project Number
S0910

Project Title
The Exchange Improving Unit: An Auditory Device for Directional Filtering

Abstract

Objectives/Goals
There is a fundamental limitation inherent in standard hearing aid devices- due to the fact that they amplify all ambient noise, use in noisy environments is both irritating and isolating. The purpose of this project was to develop a device that would enable users to actively filter signals, directionally, to be more comfortable with more situations.

Methods/Materials
This was developed by beamforming the harmonic components of the signal received from four microphones and rejecting components that originated from undesirable directions. The real-time processing was performed by an FPGA calculating phase shifts through an FFT and attenuating frequencies based on a localization and parameter-analysis algorithm that was refined through testing.

Results
The results indicate that this system is a viable solution to assist hearing aid users for conversational, meeting, and other spoken sources. The restrictions in the dynamic potential currently limit the quality of music and similar sounds, especially in increasingly louder environments.

Conclusions/Discussion
The benefits of this system over others, such as shotgun-microphone based aids is that this device can work with multiple voices, as in a group setting, and only needs to be set-up once in a new configuration of sources. Although this device still has extensive refinement needed for future production, the essential technological components were proven to function at ideal levels.

Summary Statement
This project helps hearing aid users by removing sound from undesirable directions in noisy, public environments.

Help Received
Emailed a local professor while learning basic concepts; all research was done independently and at home.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
Anish G. Krishnan

Project Number
S0911

Project Title
Sniffing Shepherd: A Noninvasive Low-Cost Electronic Nose Breath Analyzer to Detect the Deadliest Cancer

Abstract

Objectives/Goals

With lung cancer being the leading cancer killer in both men and women in the United States and worldwide, it has become crucial to develop a screening and diagnostic tool for early detection. Lung cancer causes more deaths in the U.S. than the next three most common cancers combined; colon, breast, and pancreatic, and has been the most common cancer in the world for several decades. The current screening methods for lung cancer not only is expensive, but also invasive. Studies have shown that patients with lung cancer produce a unique signature of volatile organic compounds in their breath when they exhale. One such signature is the presence of acetone and toluene in the ratio of 15:1. The objective of this innovation was to design and develop a noninvasive and cost effective system to detect lung cancer, using an electronic nose equipped with volatile organic compound (VOC) sensors to sense acetone and toluene present in the breath of the patient with lung cancer.

Methods/Materials

An electronic circuit was built using an Arduino kit with VOC sensors to detect acetone and toluene. The prototype was designed with 2 types of gas sensors with different sensitivity characteristics. The first sensor (sensor 1) has high sensitivity to acetone and the second sensor (sensor 2) was equally sensitive to acetone and toluene. Sensor 1 was calibrated using known concentrations of acetone. Sensor 2 was calibrated with known concentrations of acetone and toluene using ratios of 10:1, 15:1 and 20:1. The experiment was repeated with various concentrations of acetone ranging from 50 ppm to 500 ppm.

Results

The resistance values for sensor 1 and sensor 2 (0.2916 and 0.2512) corresponded to a ratio of acetone: toluene of 15:1, which is one of the unique signatures of VOCs present in the breath of patients with lung cancer. To investigate the accuracy of the prototype and validate the calibration curves, blind testing was conducted. The acetone concentrations obtained from the prototype showed a strong correlation of 0.93.

Conclusions/Discussion

This project successfully designed a noninvasive and cost efficient prototype of a breath analyzer, to screen and detect lung cancer. This novel approach can potentially save many lives by early detection. This work is also an important initial step in screening and diagnosing lung cancer, thereby revolutionizing medical diagnostics and pioneering future research.

Summary Statement

Design and development of a noninvasive and cost effective system to detect lung cancer, using an electronic nose breath analyzer equipped with volatile organic compound sensors.

Help Received

Lab equipment used at Monta Vista High School under the supervision of my teacher Mrs. Renee Fallon.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Harrison M. Ku

Project Number

S0912

Project Title

Using Mechanical Models to Determine the Maximum Amount of Energy Gathered from the Human Footstep

Abstract

Objectives/Goals

The objective of this project was to determine which types of electricity-generating mechanisms at which parts of the foot would generate the greatest amount of electricity. Three different positions were tested against three different locations to attempt to find the best possible combination.

Methods/Materials

For this project, a re-wired hand-crank flashlight was used as a generator. A large water bottle was also used as a mass, and a mass scale was used to calibrate that mass. A voltmeter was also utilized to measure the amount of electricity generated.

Results

Having a normal lever system at the heel strike, a pad-type mechanism at the ball strike, and a inverted lever system at the forefoot strike proved to be the combination that produced the most energy (electrical potential).

Conclusions/Discussion

Current technologies that utilize the forces of a footstep to generate electricity focus on the heel strike. In comparison, my experiment shows that more than three times as much electricity can be generated if forces from the entire footstep are captured with the correct mechanisms. Applications in this field are enormous: current technologies are shown to be able to charge an iPhone in only 6 hours, and my design only improves this process. Some research I hope to conduct in the future includes utilizing my model to build a completely functional prototype, or testing my model further using computer simulations.

Summary Statement

My project experiments on the forces of a footstep to determine which footstep energy-harnessing design will produce the most electricity.

Help Received

Parents helped to buy materials.

Name(s)
Erik N. Lamp

Project Number
S0913

Project Title
DC/DC Hybrid Converter for High Power Energy Harvesting

Abstract

Objectives/Goals
The objective of this experiment was to demonstrate the successful design and construction of a DC/DC hybrid converter for the purpose of high power energy harvesting through powering a standard DC/DC converter with a conventional energy harvester.

Methods/Materials
The performance of a LT1619 DC/DC converter was compared to a custom-designed DC/DC hybrid converter by setting the output voltage of each to 5.33 volts and determining which had the lower activation voltage (without a load on the output). This indicated that a DC/DC hybrid converter is possible. For an additional test, two different power MOSFETs were used in both DC/DC converters. The first MOSFET had a gate threshold of 1.9 volts. The second MOSFET had a lower gate threshold voltage of 0.8 volts. The MOSFETs were compared to see which gave the two DC/DC converters the lowest activation voltage.

Results
The data collected, showed that an output voltage of 5.33 volt, without a load, was achieved with an input voltage of 0.85 volts, compared to the 3.06 volt input from the standard DC/DC converter. By using a conventional energy harvester to power the power MOSFET of the standard DC/DC converter, the input voltage required to output 5.33 volts, decreased by an estimated 72.2%.

Conclusions/Discussion
A DC/DC hybrid converter is possible by powering the power MOSFET of one DC/DC converter with the output of another. By using a conventional energy harvester, the standard DC/DC converter was activated at a lower activation voltage than it would without it. Achieving a lower activation voltage also means a lower input voltage. With this new technic for DC/DC converters, new possibilities of energy harvesting can be explored. This includes enabling solar panels to function in the shade and maximizing the storage capacity of a supercapacitor.

Summary Statement
In this research project, the idea of a DC/DC hybrid converter for a high power energy harvester, in the use of solar cells and energy storage, was explored.

Help Received
My father funded my project and mentored me through basic electronics. In addition, a couple of my teachers proofread my research paper.

Name(s)

David Legg; Britny Patterson

Project Number

S0914

Project Title

Coil Conundrum

Abstract

Objectives/Goals

This project aims to investigate the relationship between projectile mass and projectile kinetic energy after firing in small-scale coil guns.

Methods/Materials

A single-stage coil gun was assembled, and a device to measure projectile velocity was constructed using two pairs of LED's and photo-dependent resistors. Four projectiles of different masses were made by cutting different lengths of a steel rod, and each was fired ten times through the device. The velocities were electronically recorded, and their respective kinetic energies were calculated. Finally, a two-tailed student's t test was used to determine statistical significance of the data.

Results

The data indicate that projectile mass has no statistically significant effect on the kinetic energy imparted. However, random error may be masking underlying trends in the data.

Conclusions/Discussion

This implies that scale of a coil gun should be based on other factors. Another benefit of this project was the practical knowledge gained in controlling the discharge of capacitors and in the capabilities of the system. This insight was important when continuing to Phase II, a multiple-stage coil gun, fired precisely by an electronic microcontroller. Also, random error present in this experiment was further minimized in Phase II.

Summary Statement

This project attempted to optimize the mass of a coil gun's steel projectile.

Help Received

Partner participated in entire project. Father helped with some soldering and woodwork.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Janet M. Liu

Project Number

S0915

Project Title

F=-kv? The EM Parachute

Abstract

Objectives/Goals

To explore the parallel nature between eddy current and 'parachute' brake system, I performed experiment to show that magnetic braking force due to eddy current is proportional to the velocity of the falling magnet F=-kv in the conducting tube. The k constant and terminal velocity depend on the properties of the magnet and electrical resistance of the tube.

Methods/Materials

I derived a formula to compute the terminal velocity and the time for a magnet to fall through a conducting tube. My formula shows that the time is inversely proportional to the electrical resistance of the tube and also depends on the property of the magnet.

I performed experiments by dropping different magnets (neodymium disc vs. Plug) through conducting tubes of different electrical resistance (Copper: Cu vs. Aluminum: Al) but of same length and measuring the time it took to completely fall through each tube. Based on my formula, I can show that the ratio of fall time for a neodymium disc to fall through Cu tube and Al tube shall be the same as that of neodymium Plug. I can also show that the ratio of fall time for a neodymium disc and a neodymium Plug to fall through Cu tube shall be the same as that of Al tube. I call this time ratio method.

I also measured the time it took for a magnet to completely fall through two tubes by stacking one tube on top of another in alternate orders (Cu stack on top of Al vs. Al on top of Cu) . Based on formula, the time for a magnet to fall through Cu+Al is the same as that of Al+Cu tube. I call this time sum method.

Results

I used my experimental data to compute time ratio and time sum. Time ratio method shows that the time ratio is the same. Time time sum method shows that time sum is very close to the same.

Conclusions/Discussion

My hypothesis is correct that the force to brake a falling magnet in a conducting tube follows the F=-kv law. Both K and terminal velocity depend on properties of magnet and the resistance of the tube. Throughout this experiment, I learned about the elegance of brake system that naturally adjust their braking force to suit the object speed. I hope to extend F=-kv to biology. I would like to design brake for light vehicles, such as skateboards that would engage upon detecting an increase in the rider's heart rate to prevent accidents and make sports safer.

Summary Statement

Verify that F=-kv is true for eddy current based EM braking system.

Help Received

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Nilay B. Mehta

Project Number

S0916

Project Title

Using Electromyographic Technology and Voice Control to Create a Cost-Effective Prosthetic Arm

Abstract

Objectives/Goals

My project#s goal was to create a prosthetic hand that rivals mid-priced prosthetics in both price and functionality. The original objective was to embed muscle control but I eventually added voice control because it added a tremendous amount of value for the price. The target price range is $250-300.

Methods/Materials

My most important materials were the Arduino board, servo motors, the 3d printer, sEMG electrodes, bluetooth module, two prong microphone and the rest were mainly used to assemble the hand. With the software side of the project, I split up the different components for EMG(for muscle control) and voice control. In order to maximize my efficiency, I split up the project into several smaller projects and combined each segment one by one. I first worked with the EMG side and determined that a conditional statement between three variables gave the most accurate results. The next module I needed to develop was the voice control. I went through several iterations for both hardware and software, but I concluded that that a VR shield provided the best results for the price.

Results

In its current state, I have to say that as a prosthetic, it would be relatively large and unwieldy for an amputee. This is mainly because the forearm houses the five servos and there is little space for anything else. As a result, some of the batteries and the Arduino must lie outside the original arm#s specifications. So currently, I would recommend it as a viable prosthetic, but not in its current state. More work would have to go into the design side of the project in order for it to be a worthy replacement.

Conclusions/Discussion

Overall, I do think my project is successful in terms of functionality but the usability aspect needs work. In order for it to be more usable, the user would have to use smaller microprocessor. In my current setup, there are too many parts outside the forearm that it is cumbersome to use. Moving forward, I would like to create an entirely new arm where I would use smaller motors embedded within the hand. This would free up the forearm to add the internal components with a lot of space left over. This space can be used to accommodate a wider variety of amputees because my current hand requires that the entire forearm of the user is missing. Regardless, my work has created a new foundation for cost-effective prosthetic hands that will hopefully change the lives of current and future amputees.

Summary Statement

For my project, I created a prosthetic hand (that used muscle control and voice control) with the purpose of minimizing the cost.

Help Received

Gavin Periera, an orthopedic professor at UC Davis helped me with information on amputation procedures, current prosthetic, etc; the staff at the Long Beach public library allowed me to use their 3D printers.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
George D. Morgan

Project Number
S0917

Project Title
A Multi-Architectural Approach to the Development of Embedded Hardware: A Second Year Study

Abstract

Objectives/Goals
Last year#s research explored a multi-architectural approach to the development of embedded hardware. While a small portion of the study was dedicated to the fabrication of a software framework to accompany the device itself, many related topics were not thoroughly covered and left many questions unanswered. This study attempts to fill in those gaps and pick up where last year#s left off, starting with the hardware that was designed.

Methods/Materials
While robust in core design, the first hardware prototype developed lacked supporting circuity for adequate voltage regulation, straightforward reprogramming, and expandability. These issues were addressed with the arrival of the second prototype. With new hardware that was easier to work with and debug, a software infrastructure was laboriously crafted. Designed for compatibility across the x86, AVR, and ARM architectures, a universal communications protocol, a filesystem, device drivers, firmware, and a toolchain were meticulously woven together to form an integrated platform that has since become known as Flipper: Carbon Edition.

Results
In conclusion, the hardware fabricated in last year#s project was updated by having a printed circuit board professionally manufactured. The software architecture proposed in last year#s research was realized to it#s fullest potential. Firmware was developed for the device, alongside operating system software for the main processor. Both codebases incorporated the data infrastructure needed to create a dynamic and expandable communications protocol that enables functions to be invoked inter-architecturally. Using two data transmission functions invoked using the proposed architecture, data can be transmitted from a host to the device and a function executed giving the user the illusion that both entities share the same RAM address space.

Conclusions/Discussion
The endeavors of this research were a huge success, and their implications in extending the proposed use-cases of last year#s research are more real than ever. The fabrication done to improve the design and expand the software backend make this multi-architectural approach to the development of embedded hardware a more consumer product than it was last year, preparing it for launch and review by the public.

Summary Statement
I set out to design a development board that would make hardware and software development available to the public so that anyone can learn how to program and make every-day objects come to life.

Help Received
None. All of the work done on this project was my own.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Neil Movva

Project Number

S0918

Project Title

(In)security Everywhere: Machine Learning Assisted Deep Power Analysis Fundamentally Defeats Software Cryptography

Abstract

Objectives/Goals

Classical computers must use power to perform calculations, and this fundamental fact leaves them vulnerable. Since all data is bound to physical electric charge, a computer#s different inputs and operations leave distinct power signatures, resulting in patterns that can be described and predicted by a Hamming weight model. By monitoring a system's power consumption over time with an oscilloscope, patterns in its power use may be identified and used to infer the contents of #secure# data inside the processor. We present a novel, complete system to automatically monitor a target system and procedurally retrieve randomly generated encryption keys, defeating some of the most common cryptography systems in use today.

Methods/Materials

The use of machine learning (scikit-learn) and other modern compute amenities (simulated annealing) gives our solution unprecedented adaptability and efficiency in defeating security; we limit ourselves to the most basic equipment (50 MHz oscilloscope bandwidth) to demonstrate technique efficiency and the extent of threat potential.

Results

On a 16 MHz AVR microcontroller, we defeat AES-128 security in an average time of 152 seconds. We also demonstrate near-linear time scaling with software complexity, ie. keylengths are directly proportional to solution time. Alternately, increased hardware complexity quickly increases solution time, without a strongly discernible relationship.

Conclusions/Discussion

We discuss the impact of this vulnerability, especially in context of the trend towards ubiquitous embedded processing; finally, we detail potential countermeasures for the techniques presented.

Summary Statement

Modern computers leak sensitive information in their power consumption "signatures;" careful monitoring and analysis of this data with modern machine learning frameworks enables rapid, adaptive defeat of computer security measures.

Help Received

Independent Development

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Rajiv Movva

Project Number

S0919

Project Title

A Novel Use of RC Circuits to Build a Low-Cost and Non-Invasive Respiratory Monitor

Abstract

Objectives/Goals

The field of biotechnology is advancing quickly today - new devices that fit new use cases are developed all the time, but some firmly established medical tools are being left behind. In this project we apply modern technology to advance breathing monitoring, which is vital in hospitals and humans alike, especially for those 18 million Americans who suffer from sleep apnea and whose lives depend on accurate respiratory monitoring. In particular our goal is to apply capacitive sensing to build a cheap, touchless monitor that will bring utility to many.

Methods/Materials

Two charged conductive plates form a capacitor - an electrical component that stores energy in an electric field. Since humans are good conductors, a capacitor following the parallel plate model is formed between a conductive plate and a human. In our setup we have a plate under a human's chest - since capacitance can be modeled geometrically using the equation $C = E*A/d$, where E is a constant, A is the plate area, and d is the distance, we know that capacitance varies as the human's chest geometry varies. So we correlate changes in capacitance of the human-plate system to breaths. To measure capacitance we use a resistor-capacitor circuit and calculate C by applying properties of the RC time constant. However, there is lots of noise in our capacitance vs. time signal. Thus we use a fast fourier transform to break down the signal to its constituent waveforms and then apply a distance clustering algorithm to identify the frequency band which corresponds to breathing. If there is no activity where expected, our system raises an alert.

Results

We tested our device for accuracy (3000 breaths at 20 bpm) and fault detection time (30 tests) in four sleeping conditions: prone, supine, side, and half plate cover. A plethysmography belt, which works by translating abdomen displacement to breaths, was our benchmark monitor. Our worst use case of half plate cover had 72% accuracy and 13.7s fault detection time on average.

Conclusions/Discussion

Our breathing monitor achieved the goals we designed it for - our worst fault detection time of 13.7 seconds still leaves ample time before hypoxic damage, and our monitor is low-cost and zero-contact. Our next steps would be to bring our device to clinical testing and optimize for more realistic sleeping conditions using other pattern recognition algorithms. Our design was successful as a proof-of-concept.

Summary Statement

In this project, we built a completely touchless and cheap breathing monitor, targeted to be used in diagnosis of sleep disorders and for monitoring of sleep apnea patients.

Help Received

My project mentor, Mr. Spenner, gave useful advice; Brother helped me learn about circuits and provided science fair tips; Father provided presentation advice; Mother helped build my board.

Name(s)

Gustavo Padilla

Project Number

S0920

Project Title

RFID Theremin: Music with No Limits

Abstract

Objectives/Goals

The goal for my project was to create a device/musical minstrument that is able to play any instrumental sound and can be played without any physical contact through the use of electronic tone generation coming from a theremin and the use of RFID technology in order to play intrumental sounds.

Methods/Materials

RFID Transponders
RFID Reader
Theremin
Speaker
Computer
USB to Micro USB Cable

Results

As far as my results go my theremin prototype can reach frequencies as low as 130 Hz to as high as 1,1661 Hz. When calibrated at 6 inches away from the antenna, the low C of 130.8Hz should be audible. Each note after that will incriminate in periods of 0.5 inches. For example, the note D of 146.8Hz will be found 5.5 inches away from the antenna. After this octave and the high C of 261.6, the increments for each note will become smaller as the distance from the antenna shortens, coming down to increments of a quarter of an inch for the next octave and approximately an eighth of an inch for the octave after that. As for the RFID tags, I have them coded for a full chromatic octave from a low C to a high C with varying hertz depending on the instrumental sounds that they are programmed to play. They make a total of 13 chromatic notes for each instrument. The RFID tags are able to play any sound as long as I have the sound files in the same directory as the program itself. I currently have sound files of a violin, piano, cello, guitar, and bells. I also have piano accompaniment sound files that I can play automatically with the swype of a tag.

Conclusions/Discussion

My device is in fact able to play any instrumental sound or sound in general using RFID technology as long as the sound files are in the computer directory. The same program that is used to call the sounds with the swype of a RFID tag can be recycled and the new sounds can simply be substituted into the program. Both the theremin and RFID technolgy can be used simultaneuosly to play a song. For anyone with no musical background, that cannot read music, or a person with a physical or mental disibilty; they will be able to play any intrumental sound with a simple swipe of your hand through mid air.

Summary Statement

I designed a musical instrument that is able to play any instrumental sound that I want aswell as be able to omit a wide range of elctronic tone generation with a simple wave of your hand through mid air; an instrument for the disabled.

Help Received

Tech guy at school helped me wire board for the theremin. Emailed a science buddies expert that helped me with my program.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Manjit Ruprem

Project Number

S0921

Project Title

Frequency-Distance Analysis of Two- and Four-Coil Based Wireless Power Transfer Systems under Resonance

Abstract

Objectives/Goals

In my previous research, I studied the scientific theory and technical design of Wireless Power Transfer (WPT) Systems. In WPT, efficiency is achieved through impedance matching. The purpose of this project is to demonstrate a frequency-distance analysis of WPT under resonance. In resonant systems, several configurations are possible. The goal was to consider two dedicated configurations: (a) two-coil based WPT, and (b) four-coil based WPT with two sub-configurations (step-up/step-down and step-down/step-up). In order to meet the objective in designing the transmitter and receiver resonators, the guiding question is #what innovative design methods are feasible to achieve at least 50% power transfer within 5% of the resonant frequency and at a minimum distance of 10% of transmitter coil diameter?#

Methods/Materials

Following appropriate technical design methods and procedure, I developed the desired configurations and tested the hypotheses that (a) the electrical parameters of the transmitting and receiving coils determine the design criteria to attain the required power level, (b) under resonance, maximum power transfer occurs, and (c) more power at the transmitting coil results in more received power. Inductance and capacitance of the Tx and Rx coils played a role in WPT design. Keeping C constant, the Ls of the Tx and Rx coils were calculated (using AWG, axial length, and radius) to determine the natural frequency so that resonance will occur to attain the required power level.

Results

In two-coil configuration, resonance occurred at 6.0kHz (designed at 5.0kHz). The max. received power was 1.457W at 6.0kHz at 5 cm (25% coil dia.). Received power was above 50% of I/P power between 4.3-7.5kHz (53% of the resonant freq.). In the four-coil configuration resonance occurred at the calculated freq. of 100kHz. The max. received power for step-up/step-down was 11.1W at 100kHz at 12cm (60% coil dia.). Received power was above 50% of I/P power between 96-103kHz (7% of the resonant freq.). The max. received power for step-down/step-up was 10.72W at 100kHz at 5cm (25% coil dia.). Received power was above 50% of I/P power between 95-104kHz (9% resonant freq.). The new results agree with the hypotheses.

Conclusions/Discussion

Among four-coil configurations, step-up/step-down is more efficient. Future work will include design of a charging circuit with a focus on exceeding the minimum power loss.

Summary Statement

Considering efficiency of Wireless Power Transfer Systems, two- and four-coil based configurations were demonstrated through frequency-distance analysis.

Help Received

Used lab equipment at California State Univ., Fresno (Industrial Technology). No professional guidance was received.; Brother helped in plotting the 3-D curve using MATLAB; Parents helped in printing the board

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)
Conrad W. Safranek

Project Number
S0922

Project Title
Compass Belt: Utilizing Neuroplasticity and Digital Signal Processing to Improve Self-Navigation

Abstract

Objectives/Goals
When people lose their ability to competently navigate their environments, quality of life can quickly erode. In severe cases, such as Alzheimer#s disease or blindness, loss of independence or institutionalization can ensue. This project#s aim is to create a non-intrusive device for under 100 dollars that is durable and easy to use. Through neuroplasticity, the device would enable the user to gain a better sense of direction, eventually interpreting the subtle vibrational stimuli autonomically.

Methods/Materials
I designed a prototype belt that gives users a sense of spatial orientation: a #compass belt,# consisting of eight motors spaced evenly around the user#s waist, indicating north through selective vibrations. After considering other options, such as a hat, I decided on a belt as it is more practical, easily concealed, and remains level. Throughout the design process, I worked to balance size, cost, durability, and functionality.

Results
A 3-axis compass, gyroscope, and accelerometer are used to collect data from the environment. This data is interpreted and manipulated by the Arduino Pro Micro. In turn, the Arduino#s I/O pins turn on and off the eight transistors, thus allowing for the north-most vibrational motor to be powered. A pouch on the back left of the belt houses the electronics that selectively control the eight motors, indicating to the user which direction is north. The cost of the components came to 94 dollars. The next step is user trials.

Conclusions/Discussion
This non-intrusive technology has great potential to improve the lives of individuals who struggle with navigation. As the brain adapts to the new form of neurological stimuli from the compass belt, the user will learn to intuitively and autonomically interpret the data from the belt, and thus gain a natural sense of direction and orientation in space. In conclusion, I have successfully constructed the compass belt prototype under budget, with all design criteria met.

Summary Statement
Bridging the fields of neuroplasticity and digital signal processing, this project aids people with orientation difficulties; by learning to interpret vibrational stimuli from a compass belt, users can gain an autonomic spatial awareness.

Help Received
Erik Meike (classmate), provided help with code and circuit design; Meera Santhanam (classmate), collaborated during initial design stages; Andrew M. Saxe (mentor, PhD candidate Stanford), provided guidance in my exploration of neuroscience and neuroplasticity.

Name(s)

Vasily A. Tremsin

Project Number

S0923

Project Title

Can I See It if I Cannot Hear It? Real-Time Visualization of Incoming Sound for People with Hearing Disabilities

Abstract

Objectives/Goals

According to World Health Organization, over 360 million people have disabling hearing loss, and the situation is expected to get worse with the younger generation due to exposure to loud music. The purpose of this project is to develop a device that will help people to sense the sound that they are unable to hear in cases when hearing aids or implants are ineffective, enhancing their quality of life.

Methods/Materials

Sound is registered by four unidirectional microphones. These signals are amplified and digitized by an Arduino microcontroller board. Then the amplitudes of the microphones are used to calculate the direction of incoming sound. An omnidirectional microphone and the frequency analyzer provide information on the pitch and amplitude of incoming sound. If the incoming sound is one of the pre-determined sounds (e.g. a car horn), then it is detected by comparison to a calibrated spectrum template of that sound. All results are visualized to the user in real time by an LED circle.

Results

Several algorithms for the calculation of sound direction were tested, and the "ratio of 2 pairs" method proved to be the most accurate. Analysis of "special sound" detection methods revealed that both the measured and pre-calibrated sound spectra have to be normalized in order to eliminate the dependence on the amplitude. The analysis and visualization of incoming sound is performed in less than 0.1 sec.

Conclusions/Discussion

The measured sound characteristics are converted to visual information shown on a 16-LED circle in real-time. The direction of incoming sound is shown by a corresponding LED on a circle, with the color and brightness of the light representing the pitch and amplitude. "Special sounds" are shown by specific patterns on the LED circle. This lightweight and low-power device can enhance the perception of incoming sound for people with hearing disabilities or ear obstruction.

Summary Statement

To help people with hearing disabilities, I developed a device which visualizes incoming sound to the user in real-time.

Help Received

My father helped me with circuit diagrams and checked my soldering.

Name(s)

Maya Varma

Project Number

S0924

Project Title

A Wireless Smartphone-Based System for Diagnosis of Pulmonary Illnesses

Abstract

Objectives/Goals

The prevalence of respiratory illnesses such as Asthma and COPD has been growing rapidly across the world, with more than 900 million currently afflicted. The spirometry equipment used in hospitals for pulmonary function testing costs thousands of dollars, which is beyond the means of health care facilities in many countries. In this project, my objective is to design a low-cost smartphone-based pulmonary function analyzer that can be used to measure lung function and diagnose various respiratory illnesses without the assistance of a trained healthcare professional.

Methods/Materials

My system consists of three parts: (i) the spirometer shell, (ii) the pressure sensor and electronics, and (iii) the software application. The mechanical part of my system consists of a 3D-printed spirometer shell. The instantaneous flow rate during breathing is measured by a pressure sensor as air passes through a fine stainless steel wire mesh in the shell. The pressure sensor output is monitored by a microcontroller, which transmits the information over a Bluetooth 4.0 link. The measurement data is received by an Android app running on a smartphone or tablet, which analyzes the data and displays it graphically. The app computes various quantitative metrics on the lung performance and compares them to their predicted values based on the user's age, gender, etc. Based on these comparisons, the app determines the probabilities of the results matching the characteristics of five different respiratory diseases: COPD, Asthma, Emphysema, Chronic Bronchitis and Restrictive Lung Disease.

Results

I have successfully developed a prototype of the pulmonary function analyzer with the Android app and completed extensive testing of the system using the ASL 5000 breathing simulator from IngMar Medical. I used the ASL 5000 to simulate the breathing patterns symptomatic of various diseases precisely and used my system to measure the flow rates and make inferences. The results show that my system was able to detect and classify the five different respiratory diseases accurately. The total cost of parts of my design is under $35.

Conclusions/Discussion

My low-cost pulmonary function analyzer has the potential to revolutionize healthcare, especially in poor countries. The modular and open-source design of my system makes it an attractive platform for the development of new software applications to diagnose and manage respiratory illnesses.

Summary Statement

I have designed a low-cost open-source smartphone-based pulmonary function analyzer that can be used to measure lung function and diagnose five common respiratory illnesses, including COPD and asthma.

Help Received

I used funding from the Cogito program at Johns Hopkins University to purchase parts for the project. Prof. Ali Yousuf answered my many questions on spirometry. Mr. Michael Blaisdell provided access to the ASL 5000 for testing my system.

Name(s)

Austin S. Veseliza

Project Number

S0925

Project Title

Touch to Talk: Wearable Tech Glove to Enable Speech Impaired Persons to Communicate with Strangers in Public

Abstract

Objectives/Goals

Sign language is an effective alternative to speech for individuals who are speech impaired but still have full motor control. However, few people outside of the speech-impaired community understand any variety of sign language, leading to frustrating communication barriers between those who can#t speak and those who can. Previously proposed solutions to replace typing messages out on a cell phone have typically required prior setup between the two conversation partners. Those solutions, while useful in more private situations, are not viable between strangers in a public setting. The goal of this project was to create a device that allowed a speech-impaired person to communicate fluidly in public with strangers who do not know sign language.

Methods/Materials

Multiple iterations of functional prototypes were built by augmenting the Peregrine gaming glove, a device intended to log hand movements and send the corresponding keystrokes to a PC. Using the stainless steel strips woven into the fingers of the Peregrine as a base, a microcontroller and LCD were installed on the back of the glove, allowing the device to directly interpret and display hand movements as custom characters, words, and grammatical syntax.

Results

The glove acts as a keyboard, allowing users to type out messages by touching their thumb and palm to points along their fingers. The messages that are typed are then displayed in real-time on a screen housed on the back of the glove.

Conclusions/Discussion

This project#s goal is to make a device useful and beneficial to the speech-impaired. User trials are currently underway to improve the design and better align the function to the users# needs. Future research will be done to bring the glove from a theoretical model to a commercially available product.

Summary Statement

The goal of this project was to create a device that allowed a speech-impaired person to communicate fluidly in public with strangers who do not know sign language.

Help Received

Received advice from my mentors: Brent Baier, Steve Mogensen, Bruce Schechter, Dr. Marilyn Buzolich, Rich Redelfs, Kim Saxe, Tim Saxe, Jen Selby, and George Jemmott.

CALIFORNIA STATE SCIENCE FAIR
2015 PROJECT SUMMARY

Name(s)

Vanessa Wang

Project Number

S0926

Project Title

Little Insect Project (Inspired by DARPA LittleDog Project)

Abstract

Objectives/Goals

The LittleDog project was part of the DARPA Learning Locomotion program, which involved using a quadruped robot, LittleDog (constructed by Boston Dynamics), to walk through different terrains. The LittleDog is a college level project; the robot is costly, and the algorithm/programming to control the LittleDog is complex.

The objective of this engineering project was to find an affordable (less than 100 dollars) and simple way to build a robot that would be able to walk through different terrains nearly as well as the LittleDog.

Methods/Materials

In this project, a robotic insect was made from off-the-shelf micro-controller and commonly available materials. The robot had to be programmed differently to walk through a gap, several stairs, and a section of rough land.

Results

The robot was able to walk through all the terrains without major problems such as tripping and unbalancing. The hardest parts of the project were making the leg sensors (used to detect the ground contact and programming the robot to walk through the rough terrain. Push-pull switches were originally planned to be used as sensors placed at the bottom of the legs. However, the robot was not heavy enough to push the switches so custom-made switches were made. Because the rough terrain was bumpy, the robot could not balance well at first. Programming to adjust the legs based on angle difference between the legs allowed the robot to be more balanced and stable.

Conclusions/Discussion

From doing this project, students will be able to learn robotics and programming and fully utilize commonly available materials to make robots that can perform near professional-grade functions.

Summary Statement

This project uses an affordable (less than $100) and simple way to build a robot that would be able to walk through different terrains nearly as well as the LittleDog.

Help Received

Dad helped buy materials

Name(s)

Alexander Woodside

Project Number

S0927

Project Title

Creating an Accurate Temperature Sensor Incorporating a Thermistor and Arduino Uno

Abstract

Objectives/Goals

The goal of my project was to create a reliable temperature sensor incorporating a 10K ohm thermistor and an Arduino Uno.

Methods/Materials

My project used an Arduino Uno and a thermistor to read temperature. The thermistor was incorporated in a voltage driving circuit (VDC) to make reading the resistance of the thermistor easier. A wire was connected to the VDC and runs to the Arduino. This was my input on the Arduino. My output was a liquid crystal display (LCD) attached to an Arduino Shield. I then programmed the Arduino to interpret the data from the thermistor. I used the Steinhart-Hart equation to change thermistor resistance into temperature. The Arduino displayed the temperature on the LCD after converting it into Celsius.

Results

The main problem in my results was converting voltage values (0-1023) to resistance in ohms. This caused me to have three programs, each with a different conversion method. Program 1 had some early success with 66% accuracy at a tolerance of 0 degrees. This did not continue with 0% accuracy results in trials 2 and 3. Program 2 had fluctuated results varying from 16% to 75% accuracy at 0 degrees of tolerance. Program 3 was the only program at 100% accuracy with 0 degrees of tolerance. Unfortunately this did not hold with the next trial having 0% accuracy. Program 2 had the most consistent accurate results with a tolerance of +/-0.1 degrees.

Conclusions/Discussion

In conclusion, my results do not support my hypothesis. I could not make an accurate temperature sensor with an Arduino Uno and 10K ohm thermistor. My main problem was converting voltage input into resistance of the thermistor. My best method used the analog to digital converter (ADC) which was (1023/V-1)R. This was inaccurate because the ADC on the Arduino is only 10 bit(2^10=1024). I believe that if a 14 or 16 bit ADC converter is attached to the Arduino Uno, correct values could be found with a thermistor.

Summary Statement

My objective was to create a reliable accurate temperature sensor that utilizes a thermistor and Arduino Uno.

Help Received

My family supported and encouraged me throughout the project. Jim Bock, a SJOE robotics instructor, gave advice on programming and circuity.