CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
Arjun V. Balasingam

Project Number
S0901

Project Title
M2D2 Mechatronic Medicine Dispensing Device Engineered from Scratch and Enabled with Computer Vision for Assisted Living

Abstract

Objectives/Goals

I was motivated to work on this project, because the population of older people in the United States is increasing rapidly. As people age, they tend to develop motor skill issues, which can cause them to miss, or take incorrect doses of prescription medications.

In order to address this problem I built a device which extracts the required mix of tablets out of multiple containers at scheduled times during the day and places them in a cup for a patient to take.

Methods/Materials

I built my entire system from scratch. I used sheets of plastic, wood, and various fastening devices to create my mechanical system. I repurposed a "Lazy Susan" to build a smoothly operating base. I went through many design revisions. I used servos for actuation.

Physically my system consists of four main components: (1) a webcam, (2) a laptop computer, (3) a microcontroller, and (4) a robot arm. My software system consists of three key modules: (1) a vision system, which is built on OpenCV a public domain computer vision library. (2) a Trig Engine which computes the joint angles of my arm, and (3) a Command and Control Interface, which helps the computer, cooperate with the microcontroller to control the servos on the arm.

Results

My system ensures that it delivers precisely the right number of tablets using a two-step approach: Dip/Grab and Pick/Vision. In Dip/Grab, the robot arm reaches into a tablet container, and grabs some tablets. These tablets are then scattered on a staging area. Then, in Pick/Vision, a webcam takes an image of the scattered tablets. The computer analyzes this image using computer vision and trigonometry. The results from this analysis are then used to drive the arm to a particular scattered tablet. The arm then picks this specific tablet and drops it in the patient's bowl. Then using Pick/Vision, the arm cleans up the remaining tablets to the bottle.

Conclusions/Discussion

I invented a device, which can help patients with motor skill issues take tablets.
I integrated my system, calibrated, tested and debugged it and showed that my original goals were met.

Summary Statement

I invented a device which will benefit the growing population of older people in our nation; this has the potential to decrease the cost of healthcare

Help Received

I would like to thank my advisors Mr. Nicoletti and Dr. Kucherov for their valuable advice, and encouragement. I would like to thank my dad Dr. Pratheep Balasingam, and my mom for all of their support.

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)

Soumya Basu; Robi Bhattacharjee

Project Number

S0902

Project Title

Determining Likelihood of Computer Chip Malfunction through Probabilistic Analysis of Current Density

Abstract

Objectives/Goals

This project attempts to probabilistically determine the likelihood of a particular malfunction in a computer chip. Basically, if too many transistors in a computer chip are active at the same time (this corresponds to a high current density) then there is a chance of overheating. Therefore, this project mathematically analyses the current density in order to consequently analyze the chances of a malfunction.

Methods/Materials

To model a computer chip, we utilized a boolean grid. An active transistor was represented by a "1" in a cell, while an inactive transistor was represented by a "0". By our objective, we wish to compute the probability that there is a high density of 1's in any location in our grid.

Results

Currently, we have 3 algorithms that determine the probabilistic distribution in the one dimensional case. 1 algorithm is exact and runs on exponential time, and the other 2 are approximations that run on polynomial time. The approximations are fairly accurate for certain conditions. More results are pending.

Conclusions/Discussion

We conclude that our approximations could possibly be feasible (if generalized) in the real world. However, more testing will be required to confirm this. Future research would consist of generalizing these algorithms to higher dimension cases and further testing on the algorithms.

Summary Statement

We are determining the probability that a computer chip overheats by analyzing the current density.

Help Received

Professor Kahng helped us with the idea and provided guidance. Mr. Williams, Carrie Cao, Aaron Schild, Mrs. Newman, Mrs. Coordt and Joanne Li all gave us advice throughout the project.

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
Ian J. Bennett

Project Number
S0903

Project Title
Microbial Fuel Cell Year Four: The Effect of Thermally Enhanced Oxide Layer Growth on Power Generation in an Air-Cathode

Abstract

Objectives/Goals
My project was to determine at what temperature heat-treated aluminum anode electrodes maximize the power density from secondary treatment water in a single chamber air-cathode microbial fuel cell system at the end of 168 hours. Based on literature, I believe that heating the electrodes at 125°C will generate the most power.

Methods/Materials
Air-cathode fuel cell systems were constructed and aluminum anode electrodes were heated to 50°C, 75°C, 100°C, and 125°C for 15 minutes. The anode chambers were filled with secondary treatment water and distilled water. The nineteen MFC systems were connected to an external circuit with a 1000 U resistor and multi-meter. Millivolt and milliamp readings were recorded three times daily for 168 hours and the power density was calculated. Also, the amount of oxide layer growth and bacterial mass on the aluminum anode electrodes were measured.

Results
An electrode heated to a temperature of 100°C generated the highest power density of 25.8±0.16 mW/m2 in secondary treatment water, at 120 hours. The electrode not heat-treated and in secondary treatment water produced a power density reading of 5.8±0.02 mW/m2. The electrode heated to a temperature of 125°C generated the second highest power density of 17.8±0.11 mW/m2 in secondary treatment water, at 104 hours.

Conclusions/Discussion
The data does not support the hypothesis that heating electrodes at 125°C will generate the most power. Anodizing the surface of the electrodes at 125°C resulted in an oxide layer that may have become too thick, reducing electron flow from the bacteria to the anode. The electrode heated to 100°C had the highest power density of 25.8±0.16 mW/m2. The results show that additional research regarding heating aluminum anode electrodes may further increase power density produced by microbial fuel cells. Wastewater treatment plants could benefit greatly if an efficient, commercial scale microbial fuel cell design could be developed.

Summary Statement
Determine at what temperature heat-treated aluminum anode electrodes maximize the power density from secondary treatment water in a single chamber air-cathode microbial fuel cell system at the end of 168 hours.

Help Received
Dr. Michael Toney, Ph.D. at Stanford Linear Accelerator provided answers to my questions during the research and Dr. P.J. Utz of Stanford University Medical School provided access to lab space and equipment.

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)

Paulomi Bhattacharya

Project Number

S0904

Project Title

Optimizing the Microbial Fuel Cell-Microbial Electrolysis Cell System: A Novel Anaerobic Design for Hydrogen Generation

Abstract

Objectives/Goals

A microbial fuel cell (MFC)-microbial electrolysis cell (MEC) coupled system is a bioelectrochemical system that produces hydrogen gas as an alternative fuel. Oxygen leakage across the MFC ion exchange membrane is known to severely lower hydrogen yield. The objective of this project is to determine if an anaerobic MFC-MEC coupled system can be designed that will generate greater amounts of hydrogen gas than conventional coupled systems.

Methods/Materials

To compare voltage and hydrogen outputs, two systems were built for each trial: a conventional coupled system (the control) and the new optimized system. The new anaerobic MFC-MEC system was built by using a microbial biocathode in the MFC and an anion exchange membrane in the MEC. Double-chamber MFCs and MECs were constructed, and the source of microbes was wastewater with added organic substrates. Each half-cell was filled with dry ice that was allowed to sublimate and then with the appropriate electrolytic or wastewater solutions, eliminating O(2) gas from the system. The system was then sealed to be airtight and gastight and assembled accordingly. Voltages were measured for 15-hour periods with a multimeter. After each run, the MEC headspace was sampled with a gastight syringe. Using the known densities of H(2) and CO(2), the mass of the collected sample was compared to the mass of a pure CO(2) sample to determine the amount of H(2) produced.

Results

The conventional system produced a maximum of 0.178 V, while the optimized system produced a maximum of 0.266 V and sustained a higher voltage for a longer period of time. The conventional system produced a hydrogen yield of (0.00001 ± 1.238 # 10-4) g/ 3mL (SE at 90% confidence level, student t-dist. with n=9), while the sample from the optimized system produced a hydrogen yield of (0.00024 ± 1.238 # 10-4) g/ 3mL (SE at 90% confidence level, student t-dist. with n=9). The optimized system produced 1.5 times higher maximum voltage and 20 times higher hydrogen yield than the conventional system.

Conclusions/Discussion

In this design, while the anion exchange membrane in the MEC increased the hydrogen yield, the anaerobic biocathode-based MFC eliminated the key problem of oxygen leakage and provided a higher maximum voltage to sustain the optimized MEC. Data and consistent trends show that the anaerobic design was more efficient than the conventional system for producing hydrogen as a viable alternative fuel.

Summary Statement

This project developed a novel self-sustaining anaerobic microbial fuel cell (MFC)-microbial electrolysis cell (MEC) coupled system design that eliminates the external oxygen supply and produces a higher hydrogen yield than current systems

Help Received

Used school lab equipment under the guidance and supervision of mentor, Mr. Chris Spenner. Chemistry teachers Mr. Robbie Korin and Dr. Mala Raghavan answered questions that arose about solution chemistry

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)

Weston D. Braun

Project Number

S0905

Project Title

High Voltage DC to DC Conversion for Power Distribution

Abstract

Objectives/Goals

Design, build, and test a DC-DC switch-mode converter that could replace conventional iron core high voltage distribution transformers and provide more efficient DC power transfer. A switch-mode converter would provide a more flexible power grid that could be controlled remotely. This is compatible with the goals of the "smart grid" initiative.

Methods/Materials

A switch-mode converter was designed and built with the design criteria of 2000 volt input, an output of 2kW at 300 volts, and 85% efficiency. For design, the switch-mode converter was split into subsections (control circuitry, output circuitry, high frequency transformer and an IGBT switching bridge) with a separate approach to the challenges presented to each part. A design was finalized, built, and tested at various load resistances.

Results

Verification testing at 100 volts led to initial design modifications and a subsequent complete redesign of the switch-mode converter after a short circuit failure. After redesign, testing at input voltages of 1000 volts and 2000 volts with three different resistance loads produced the desired power output. Measured efficiencies ranged between 44% and 74%.

Conclusions/Discussion

The final switch-mode converter successfully converted 2000 volts DC to 300 volts DC and demonstrated the feasibility of using a series IGBT configuration for high voltage switching. While the efficiency target was not met, there is good indication that actual efficiencies were higher than measured due to excessive noise on the input current measurements. The system as designed can be easily scaled up to provide DC to DC conversion for the 7kV and 14kV distribution voltages used today.

Summary Statement

The feasibility of high voltage DC to DC conversion for power distribution was explored and a prototype system was designed, built and tested.

Help Received

My mother helped assemble the display board. Dave Fleming, P.E. supervised the high voltage testing conducted at my home lab.

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)

Richard Chavez; Obioma Onuoha; Justin Sin

Project Number

S0906

Project Title

The Microbial Fuel Cell: Is Warmer Better?

Abstract

Objectives/Goals

A microbial fuel cell is a bio-electrochemical system that creates electrical power by copying bacterial interactions found in the natural world. The bacteria within the fuel cell break down the waste that is put in, and in the process, generate electrons which are then used to create an electrical current. The objective of the experiment was to determine if a microbial fuel cell will produce more electricity if it is kept at a higher temperature.

Methods/Materials

To conduct the experiment, two identical fuel cells were constructed using a single mud sample from a local reservoir. Plastic containers were used for the anodes and cathodes, PVC pipe and agar were used to make the salt bridges, an air pump was used to supply oxygen, and copper wire and carbon cloth were used to make the electrodes. After being built, both fuel cells were tested using a multimeter and produced the same voltage. One fuel cell was then placed in a room temperature environment (approximately 20 degrees Celsius) and another was placed in a heated incubator (approximately 30 degrees Celsius). Using the multimeter, the voltages generated by both fuel cells were recorded on a regular basis for 6 weeks.

Results

The result was a significantly higher voltage of 0.30 mV coming from the heated fuel cell as opposed to a voltage of 0.13 mV coming from the room temperature fuel cell. This is an increase of about 131.00%. Also, the temperature of the fuel cell kept in the room temperature environment fluctuated more due to the fact that it was kept in an air conditioned room as opposed to an incubator. The electrical output also fluctuated more for the fuel cell that was kept in the air conditioned room, showing that there is indeed a correlation between the temperature of the fuel cell and the amount of electricity that it generates.

Conclusions/Discussion

The results of the experiment support our hypothesis that at a higher temperature, a microbial fuel cell will produce more voltage. This information is extremely significant as if fuel cells are created on a larger scale (such as wastewater treatment plants), stationing them in a naturally warm environment (a desert, for example) will allow them to produce much more green energy.

Summary Statement

The objective of our experiment was to determine if higher temperatures would yield higher voltages in the fuel cells.

Help Received

Ms. Claire Fasching answered some questions pertaining to what research hasn't been done yet; Mr. Dirk Sikkema let us use his incubator

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
Lucrezia Donnini; Katharina Seethaler

Project Number
S0907

Project Title
Sound and Light

Abstract

Objectives/Goals
The goal of our experiment was to prove that light can transmit sound over long distances and to verify what solar panel and what laser is the best for this experiment.

Methods/Materials
Followed materials are needed: one or more lasers, one or more solar panels, an oscilloscope, a funtion generator, a sound source, an amplified speaker, an induction coil, a power supply, a microphone and alligator clips. A transmitter consisting of a laser and a sound source and a receiver consisting of an amplifier and a solar panel have to be built.

Results
The results were that the sound that came out from the amplified speaker was alway the same as we put in to the transmitter.

Conclusions/Discussion
When the laser beam is turned on, current flows through the coil and the laser is lit.The "sound vibrations" recorded on the tape are transformed into electrical vibrations. These fluctuations of the brightness of the laser beam are picked up by the solar cell and are turned into electrical pulses, which are amplified by the speaker or tape recorder and turned back into sound.

Summary Statement
The purpose of this project is to prove that light can transmit sound through long distances and to measure what solar panel and what laser are the best for this experiment.

Help Received

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
Jake H. Kuli

Project Number
S0908

Project Title
What the WiFi? 2.4 GHz WiFi Signal Attenuation and Data Transmission through Different Materials

Abstract

Objectives/Goals
The objective of my experiment is to test the loss, or "attenuation" of 2.4 GHz electromagnetic wave signal as it passes through different materials and objects in addition to testing data transfer rates through these same materials.

Methods/Materials
Testing was done by placing each material or object to be tested between one cell phone in the stainless steel shielding cylinder running the wireless tether software (the signal source); and the other cell phone running wireless network analysis software. After completing attenuation readings for all materials, I selected representative samples of materials with certain average attenuation readings to determine what the effects of signal loss are on data transfer rates. Data transfer rates were determined by moving a 4 megabyte file between one phone and a computer.

Results
In testing materials such as aluminum, galvanized steel, and other conductors, the attenuation levels were high, as expected. In testing dielectrics, however, some proved to be more transparent to electromagnetic waves than expected. For example, water was one dielectric that created more dB loss than any of the metals tested. Eight feet of water attenuated the signal to the extent that it could not be detected above the surface whatsoever. On the other hand, electromagnetic waves through concrete walls showed virtually no attenuation. With regard to data transfer, my hypothesis was incorrect. My initial estimate was that for materials that showed attenuation between 0 and -70dB, the data transfer rates would be consistent. However, it turned out that the attenuation did adversely affect the transfer rates and was somewhat proportional.

Conclusions/Discussion
The data gathered during this experiment is easily applied in a real world setting. If line-of-sight placement of antennae is not practical, materials or objects which reflect electromagnetic waves, oriented correctly, may facilitate an adequate wireless connection between devices. Knowing the effects of signal strength on data transmission rate, an architect might specify additional wireless access points to ensure adequate network speeds. Overall, the deployment of a wireless network needs to involve scientific analysis of the environment in which it is located.

Summary Statement
My project involved determining how various materials and "real world" objects affect the propagation of WiFi signal in the form of 2.4 GHz electromagnetic waves.

Help Received
Father helped gather data

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
Keegan R. Mann

Project Number
S0909

Project Title
Stability Analysis of Control Algorithms

Abstract

Objectives/Goals
Both a robotics project and an experiment comparing the effectiveness and tuning process of different control algorithms, I investigated a system in which a robot balances on a rolling cylinder turned on its side. Control algorithms like the ones I have tested are used in everything from household heaters to high performance aircraft and are becoming ever more important as precise positioning and control is necessary in field such as robotics.

Methods/Materials
Before starting, I wrote a program in Java which simulates the system and the algorithms involved in stabilizing it. This program served as a starting point illustrating that the control algorithms work.

To run the controller code onboard the robot, I used an Arduino board based off an ATMEGA328. This microcontroller board was programed in C. It sends data to a computer which analyzes and plots the data using custom data capture software written in Java. I created a custom circuit board which contains a motor controller I designed centered around the L298 IC and the sockets for plugging in the Gyro and Accelerometer boards which are used to sense rotation. I also designed and soldered a wheel encoder circuit board.

With the robot placed on the test platform, I performed a frequency sweep and took the average angle error as a measure of stability. I also analyzed the effects of changing control constants on the performance of the robot, and analyzed the result when the robot faces a step change in its setpoint.

Results
The gyro and accelerometer didn#t output acceptable data on their own and must be combined in order to arrive at an accurate angle reading. As expected, the frequency response curve was upward sloping for higher frequencies, but it was interesting to note that the cure initially decreased. Being able to see the output of the system graphically was essential to tuning the gains in the control loop and detecting problems in software.

Conclusions/Discussion
A PID can be used to solve a wide range of control systems, but must be tuned carefully for good results. For more complex systems, a cascaded PID can be used, but the increased complexity makes the system much more difficult to debug and tune. In my case, integral windup was a serious problem. In the future, I may want to investigate methods to mitigate this such as setting limits or using a floating average.

Summary Statement
In my project, I analyzed the performance of a small robot which balances on top of a cylinder turned on its side and measured the effect of changing the controller constants.

Help Received
Father helped with wooden test platform

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
Alexander C. Nicklaus

Project Number
S0910

Project Title
The Effect of a Difference between the Ratios of Cu and Zn in Brass on the Distance It Travels when Fired from a Railgun

Abstract

Objectives/Goals
The purpose of this experiment is to determine the difference in distances of brass when it is fired from a railgun and if the difference in its distance has a trend with the ratio of copper and zinc in its mixture. A railgun is basically two long rails of a conductive metal that has electricity running down each rail. One rail has a positive charge the other a negative. When a conductive material is placed between the rails the circuit is completed. When this happens Lorenz Force is produced the piece of metal should fire down the rails.

Methods/Materials
For purposes of ease a simple railgun will be used, one which is simply two pieces of copper foil and a battery charger. The projectiles are simple cylindrical piece of zinc, copper, and two types of brass with magnets attached to the ends. First, the rails are charged with one positively charged and one negatively charged by attaching alligator clips from a battery charger to the rails. Then, the projectile is placed on the rails which should fire it down the tracks.

Results
The overall results point to an inconclusive experiment due to experimental design problems. The percent deviations were 1.95% for the control zinc, 41.29% for the control copper, 53.38% for 50:50 brass, and 48.83% for the 40:60 brass. Zinc#s average deviation is 3.16cm, copper 6.52cm, 60:40 brass 7.34cm, and 40:60 brass 5.51cm. The zinc averaged at 162.02cm, copper at 15.79, 50:50 brass at 13.75cm, and 40:60 brass at 11.26cm

Conclusions/Discussion
As shown in the data, excluding Zinc, the deviation was very high for all of the projectiles. This deviation shows that the experimental error that was present at testing was so great that the data cannot draw any firm conclusion; hence the experiment is inconclusive.

Summary Statement
The purpose of this experiment is to determine the if the distance a brass projectile travels when it is fired from a railgun is affected by the ratio of copper and zinc in that brass

Help Received
Rick Nicklaus: electrical engineer, provided finances, and helped with the project; Suzanne Nicklaus: edited the project; Renna Fosse, Shawnus Chen, Akira Kane: helped with the conception of the idea for the project

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)

Justin W. Rajewski

Project Number

S0911

Project Title

Utilizing Field Programmable Gate Arrays to Create an Artificial Neural Network Co-Processor

Abstract

Objectives/Goals

As artificial neural networks (ANNs) gain popularity the need for larger and faster networks has arisen. Traditionally when the network is modeled in software the parallel nature is lost as each neuron has to be calculated sequentially. To restore the parallel nature and increase speed, artificial neural networks can be modeled in hardware. The goal of this project is to determine if the speed increase of running ANNs in hardware is enough to merit the use of a co-processor.

Methods/Materials

To test this a FPGA (Field Programmable Gate Array) was used to model the network in hardware and a AVR32 was used to model the network in software. A custom PCB was made where the AVR32 and FPGA were able to communicate over SPI (Serial Peripheral Interface). Both chips ran off the same 33MHz clock for consistency. Once both networks were implemented, each one was timed.

Results

The software implementation utilized by the AVR32 requires approximately 339 clock cycles per neuron in the network while the FPGA requires approximately 12 clock cycles per layer in the network. Due to the parallelism of the FPGA as a network increases in width it requires no extra time to compute, while the software implementation does.

Conclusions/Discussion

For projects that require a large fast ANN, FPGAs provide an effective way to model the network. Large complex real-time ANNs will provide a way to create more advanced artificial intelligence in robots and help in other pattern recognition tasks such as computer vision.

Summary Statement

Using field programmable gate arrays to increase the speed on computing the output of an artificial neural network.

Help Received

FPGA part of the first schematic was reviewed by Luis Maciel, no mistakes were found.

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
Jessica A. Richeri

Project Number
S0912

Project Title
Autonomous Robotic Vehicle's Guide to Eliminate the Traffic Problem

Abstract

Objectives/Goals
By 2030 the number of cars will double, leading to more traffic jams and accidents. In the U.S., there are fewer options to add more roads or to even create more lanes. A smarter transportation system is needed and the first step is to create intelligent cars that can operate autonomously. My project implementation has three major milestones within 1 to 25 years: (1-5) The Marginal Protection System, is like a the car's virtual bubble, helping the driver be aware of where obstacles are and avoid them, (5-10) Semi-autonomous Carpool Lane, the vehicles will be able to go up to speeds of 100 mph, a couple feet away from each other, and (10-25) Fully Autonomous Car, with vehicles driving autonomously from point A to B.

Methods/Materials
I took a remote controlled car, removed the transmitter and connected an array of infra-red sensors and a LIDAR. A camera with a variable lens was used to capture the images and send to the Processing Cluster. The onboard hardware was connected to a Tablet PC. This year I installed a GPS system connected to a TTL RS232 and increased the computer power to six HP DL360 Servers Quad Core. The cluster runs Windows Server 2003 R2 and 2008 R2, to do the image processing. I added HP StorageWorks MSA1000 fibre channel share drive system to increase the handling of the captured video. I created these modules: Obstacle Detection and Avoidance, Pattern Recognition with Multistage Recognition, Behavior Generation, and Mission Planning mapped over Google Earth

Results
For my final test, I created a Mission Plan with GPS waypoints on a running track. As soon I turned it on, the car went around the track from beginning to end, time after time. To test the obstacle detection, I placed obstacles on the lanes making the car change lanes to the left or right, depending where the unobstructed lane was. When I obstructed all lanes, the car stopped before the barrier

Conclusions/Discussion
My project creates a vehicle that can drive autonomously, follow a mission planner, and recognize and avoid obstacles with a cost of only a couple thousand dollars; confirming that a cost-efficient autonomous car is not a pipe dream. After three years and over 20,000 lines of programming, I not only designed and implemented the hardware and software for this project, but also a safer and more convenient approach to modifying our ancient and broken highway system eliminating traffics jams within a realistic timeline

Summary Statement
I created a cost efficient autonomous car that can navigate from point A to point B without pre-knowledge of the environment and prevent traffic jams and accidents.

Help Received
Father recorded the videos and design for the display board. School helped with the metal components.

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)

Austin K. Russell

Project Number

S0913

Project Title

The Minicomputer/Projector: An All-In-One Mobile Solution for an Interactive "Touch Screen" Interface on Any Surface

Abstract

Objectives/Goals

This experiment was conducted for the purpose of answering the following question: Can a computer be combined with a projector and infrared cameras to create a pocket-sized device capable of providing an interactive computer interface on any surface?

Methods/Materials

A Pico-ITX embedded motherboard was combined with an RGB laser based pocket projector. Dual infrared texture-mapped depth imaging sensors and an accelerometer were integrated to allow for object tracking and auto-calibration. Microsoft Windows 7 OS was installed. Software was written and hardware was modified to network components and enable inter-communication. The device was powered via a modified 5V AC/DC power adapter or eight 1.2v AA NiMH batteries. RCA connectors were used as a power transfer medium.

Results

The device was successful in responded in real-time to physical user input and computationally intensive applications. The prototype unit effectively communicated with the necessary components and a useful product was produced.

Conclusions/Discussion

The computer/projector design was successful as a practical solution for a cost effective, energy efficient mobile device. By creating a small portable unit with large screen size capability, users are no longer restricted to a fixed "Smart board" location. This concept would benefit numerous industries as well as have potential educational and military applications due to its small size and effectiveness on multiple surfaces. Ultimately my goal is to enhance the device capabilities to track objects beyond the X and Y axis, and incorporate the Z axis.

Summary Statement

A computer was combined with a projector to create a pocket sized solution that projects an interactive touch screen interface onto any surface.

Help Received

No Help.

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
Alexander J. Sercel

Project Number
S0914

Project Title
The Hunt for Red October: Fact or Fiction? An Experimental Validation of Magnetohydrodynamic Propulsion

Abstract

Objectives/Goals
The purpose of this experiment was to test the analytical MHD propulsion theory. The theory states that thrust will increase linearly with current and magnetic field strength and therefore inversely with increased ohmic resistance of the working fluid and linearly with voltage.

Methods/Materials
To test the theory, I built an MHD propulsion system using rare earth magnets and a series of batteries, and I prepared a bath of saturated salt water in which to run my propulsion system. To predict thrust, I measured the magnitude of the magnetic field, the resistance of the water, the chamber dimensions, and the applied voltage. Then I measured the thrust using a video camera tracking jet velocity by following jet bubbles as they moved past a ruler and then calculated thrust with the fluid momentum equation. I employed the MHD equations and used spreadsheets to analyze the data and compare the expected and measured thrust values.

Results
The relationship between the voltage driving the engine and the thrust produced is linear and is highly correlated. The theoretical model was perfectly linear and followed the experimental values at low voltages, but at higher voltages, the experimental values were greater.

Conclusions/Discussion
I found the expected and measured thrust values to be significantly similar and measured thrust trending closely to prediction. The relationship between voltage and thrust produced is statistically significant, allowing me to perform inference on the population of all MHD systems. These results confirm the appropriateness of using classic MHD theory to model MHD propulsion system performance.

Summary Statement
This study modeled MHD theory and attempted to provide evidence to either validate or discredit the theoretical model by comparing it to an experimental trial.

Help Received
My father tutored me in electrical and MHD theory and my mother helped as a lab assistant while I constructed my apparatus and assisted me with display construction.

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
Stewart H. Wirick

Project Number
S0915

Project Title
Can a Smart Phone Be Charged by Radio Waves?

Abstract

Objectives/Goals
I always wondered if there was a better way to charge a mobile device than by plugging it into a wall socket, and if there was any way to harvest stray radio waves that would otherwise fly off into space. The purpose of my experiment is to find whether a smart phone battery can be charged by a radio antenna by stray RF, and if so, how much time would be required to charge from 0% to full battery capacity.

Methods/Materials
Materials: .5 Watt 915 MHz transmitter with power supply, 915 MHz "Powercast" P2110 Development Kit, Satellite TV dish, 10 ft copper wire, 915 MHz patch antenna, 915 MHz omni directional antenna, 10 volt Multimeter, 20 foot tape measure, stopwatch, "Cantenna" tuned to 915 MHz.

Procedure: Place 915 MHz .5 watt transmitter equipped with the 915 MHz patch antenna 5 feet away from Powercast P2110 Development Kit. Set stop watch for 1 minute. Start the stop watch and record the number of times the built-in LED on the Powercast board blinks within the 1-minute time frame. Record results. Repeat steps1-4 3 more times, but one achiteration, moving the Powercast P2110 Development kit 5 feet further away from the transmitter. Repeat steps 1-5 but with all other antennas.

Results
The directional antenna would take 479 days to charge a Droid 2 battery from 15 feet. The omni-directional antenna would take a number of days so large from 15 feet that it could not be recorded in my experiment. This is because the LED never flashed at 15 feet during testing with this antenna. The directional antenna with the dish would take 80 days to charge a Droid 2 battery at 15 feet. The omni-directional antenna with the dish would take 563 days to charge a Droid 2 battery at 15 feet. With a highly directional antenna, enough power could be captured to power the "Powercast" circuit from 30 feet away.
(I chose to list 15 feet statistics in the results because they are the most practical.)

Conclusions/Discussion
With the Droid 2's battery capacity being 1400 mAH, 80 days would be required for the Droid 2's battery to be charged from 0% to full at an average of 12.5 feet from a .5-watt transmitter with no obstructions. This, however, could only be achieved if the receiver antenna was directional, and had an amplified gain caused by a dish in front of it.

Summary Statement
I tested whether a smartphone battery can be charged by stray radio waves.

Help Received
Father helped building cantenna/test supervising/credit card

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
Olivia E. Wong

Project Number
S0916

Project Title
Harnessing the Green Energy from Oceanic Perpetual Waves

Abstract

Objectives/Goals
The objective of this project is to create an easily manufactured solenoid generator system in order to generate clean-renewable energy with the propagation of ocean waves with the application of Lentz's Law.

Methods/Materials
Magwires were wounded onto a non-conducting plexi tube in three different sections, equally separated by spacers. Two wires were soldered onto each solenoid respectively and brought out to a test point. Place the magnets in a plexi tubes with spacers in the following configurations with opposite polarities: north/south, south/north. Two methods were used to test the efficiency of the solenoid generator: free-fall and using Hooke's spring constant. A buoyancy-regulated platform was created out of PVC and ABS pipes and connectors. An ABS cross fixture contained the solenoid generator. The oscilloscope probes were attached to the test points of the solenoid generator. By dropping the magnetic rod through the center of the solenoid generator, alternating current voltage was observed with the sinusoidal graphs.

Results
The mean power generated by the five magnets is 1.06 Watts in 250 milliseconds. The strength of the magnets was relatively weak and also the gauge of the coils was thin. There are ten peaks, five crests and five troughs. By analyzing each crest and trough, the minimum power measured in Watts in 0.26, the mean is 1.06 Watts, and the maximum is 1.47.

Conclusions/Discussion
The designed system of the tethers, solenoid generators, solar panel impregnated dome, and buoys provide an ecologically beneficial system, which will have minimal to no impact on aquatic life. In order to protect the solenoid generator from being affected by the ocean waves, a dome impregnated with solar panels will dissipate the rouge ocean waves. Moreover, wind turbines may be integrated into the platform instead of the using tethers. The action-reaction principle will be dependent on the platform of the systems. Gear-like systems may be implemented to adjust the height of the system based on the solar interactions to maximize production. Implementing Faraday's Cage among the multiple solenoid generators will prevent electromagnetic interference between the solenoid generators.

Summary Statement
Using Faraday's Law of Electromagnetic Induction and Lenz's Law, the creation of this solenoid generator will convert the unutilized potential green energy of ocean waves to electrical power.

Help Received
My mother helped me with the visual display. My physics teacher, Mr. Lee, provided me with advice, support and taught me the various theories. Lastly, my adviser, James Khoo, helped me construct the solenoid generator and visual displays.

CALIFORNIA STATE SCIENCE FAIR
2011 PROJECT SUMMARY

Name(s)
David A. Zarrin

Project Number
S0917

Project Title
Never Lost Again: Designing a Novel Precision Indoor Navigation System

Abstract

Objectives/Goals
The social impact of precision indoor navigation will be significant in the coming decade. Hospital visitors frequently have difficulty finding one's doctor or locating a patient's room in a large medical facility. Shoppers walk into malls wishing to locate a specific store, a particular aisle in a department store, or even a specific item on a shelf. People spend valuable time looking for a specific conference room, a particular booth in a trade-show, a ride in an amusement park, or a known piece of art in a museum. These are all applications of precision indoor navigation systems. Previous attempts in creating indoor navigation resulted in 10-15 meter accuracy. My hypothesis is that it is possible to build a low-cost, indoor navigation with accuracy of few centimeters.

Methods/Materials
I plan to build several prototypes using radio-sonic, WiFi RSSI, and a novel technique using radio oscillation. I plan to:
1) Build a prototype of an indoor navigation based on ultrasound and radio sensors. The prototype software will use the radio sensors to trigger an ultrasound ping which is received in multiple known locations. The target location will then be calculated based on triangulation and displayed on screen.
2)Use WiFi RSSI technology and develop a mathematical algorithm that can match the RSSI RF signature of a location in a building with a known database of RSSI signatures using a derivative of Maximum Likelihood Probability correlation. I will test the software prototype at Good Samaritan Hospital and an office building with WiFi.
3) Use radio oscillation to calculate the target position. Previous attempts in using radios for sub-meter indoor positioning system have required super-fast electronics and that made the solution not viable for low-cost or indoor commercial use. I plan to build a prototype to prove a new and novel solution.

Results
I built and measured the accuracy of several prototypes. The radio sonic offered an accuracy of down to 2cm, but required multiple sensors. The WiFi RSSI proved to be the most economical with an accuracy of 5 meters. The radio oscillation prototype provided a robust method for building indoor navigation with sub decimeter accuracy.

Conclusions/Discussion
These experiments demonstrated that the radio oscillation provides a robust, low cost, and patentable method for building an indoor navigation system with an impressive accuracy of down to 10 centimeters.

Summary Statement
A Novel Precision Low-cost Indoor Navigation System with Centimeter Accuracy

Help Received
Received research tips from an MIT math professor, my adviser, and C programming assistance from my sibling.