UNIVERSITY of HOUSTON | ENGINEERING

Department of Electrical & Computer Engineering

Annual Capstone Design Conference

April 28, 2017
The Hilton UH Hotel & Conference Center
Houston, Texas

8:30 - 8:55 am	Registration, Waldorf Astoria, Ballroom, Lobby
8:55 - 9:00 am	Opening Remarks by Dr. Steven Pei, Flamingo Room
9:00 - 10:00 am	Technical Program – Oral Session A, Flamingo Room
10:05 -10:30 am	Welcoming Remarks, Plaza Room • Dr. Hanadi Rifai, Associate Dean, College of Engineering • Dr. Badri Roysam, Chairman, Electrical and Computer Engineering
10:30 - 10:45 am	*Coffee Break,* Waldorf Astoria, Ballroom, Lobby
10:45 - 11:45 am	Technical Program – Oral Session B, Flamingo Room
11:50 - 12:45 pm	Lunch, Shamrock, Ballroom
12:30 - 1:15 pm	Keynote Presentation "***"The Global Impact of Electrical & Computer Engineering in Society", Igor Alvarado,*** Business Development Manager for Academic Research, National Instruments Corp. Shamrock, Ballroom.
1:15 - 2:15 pm	Technical Program – Oral Session C, Flamingo Room
2:15 - 2:30 pm	*Coffee Break,* Waldorf Astoria, Ballroom, Lobby
2:30 - 3:30 pm	Technical Program – Oral Session D, Flamingo Room
3:30 - 5:30 pm	Technical Program – Poster Session, Waldorf Astoria, Ballroom
4:55 - 5:30 pm	Break for Team Preparation
5:30 - 6:00 pm	Elevator Talks by CDC students, Shamrock, Ballroom
6:00 - 6:30 pm	Awards Ceremony and Reception, Shamrock, Ballroom

CDC 2017 Technical Program

April 28, 2017

Session A: Oral Presentations

Time: 9:00-10:00 am, Flamingo Room
Faculty Chair: Dr. Steven Pei

Time	Presentation	Page #, Team #
9:00 - 9:15 am	**GROUND SG100 POWER SUPPLY (GSPS)** *Elliot Pucek, Matthew Yepes, Kaisong Fan, and Deedhiti Sharanya*	1, 1
9:15 – 9:30 am	**ARDUINO BASED HOME AUTOMATION** *Osama Eter, Jonathan Soileau, Michael Ngo, and Marvine Adrian Penson*	3, 2
9:30 – 9:45 am	**THE SOLAR OUTLET** *Eliud Serna, Jose Tenorio, Ali Oshkoohi, and Jiwantha Mannapperuma*	5, 5
9:45 – 10:00 am	**AUTOMATED BATCH PRODUCTION AT COVESTRO** *Nathan Prows, Jasmine Hemdani, Keon McEwen, and Ikemefule Onyearugha*	7, 3

10:05 – 10:30 am **Welcoming Remarks and Addresses in Plaza**

- Dr. Hanadi Rifai, Associate Dean, College of Engineering
- Dr. Badri Roysam, Chairman, Electrical and Computer Engineering

10:30 – 10:45 am Coffee Break, Waldorf Astoria, Ballroom, Lobby

Session B: Oral Presentations

Time: 10:45 – 11:45 am, Flamingo Room
Faculty Chair: Dr. Steven Pei

Time	Presentation	Page #, Team #
10:45 – 11:00 am	**DYNABRAILLE: DYNAMIC BRAILLE DISPLAY** *Daniel Lopez, Katherine Perez, Sergio Silva, and David Garcia-Castellano*	9, 4
11:00 – 11:15 am	**CNC LASER ENGRAVER** *Theodore Rodriguez, Logan Golden, Michael Pincus, and Nayam Perez*	11, 6
11:15 – 11:30 am	**FSAE DIAGNOSTIC SYSTEM** *Isaias Amaya, Osvaldo Rodriguez-Martinez, and Otoniel Canuz*	13, 10

11:30 - 11:45 pm	**IEEE ROBOTICS** *Cuong Ha, Kasan Momin, Idam Obiahu, and Tevin Richards*	15, 11
11:50 - 12:45 pm	**Lunch**, Shamrock, Ballroom	
12:30 - 1:15 pm	Keynote Presentation, "**THE GLOBAL IMPACT OF ELECTRICAL & COMPUTER ENGINEERING IN SOCIETY**", *Igor Alvarado*, Business Development Manager for Academic Research National Instruments Corp., Shamrock, Ballroom	

Session C: Oral Presentations

Time: 1:15 – 2:15 pm, Flamingo Room
Faculty Chair: Dr. Len Trombetta

1:15 - 1:30 pm	**SWARM DEMOSNTRATION HARDWARE SYSTEM: APPLIED TO MAINTAINING A WIRELESS SENSOR NETWORK** *Christiana Chamon, Rachel Dunn, Maria Ciara Lalata, and Mable Wan*	17, 9
1:30 – 1:45 pm	**AIR PRESSURE AND TEMPERATURE CONTROLLER** *Mohammad Nazarifar, Abdulrahman Kamal, and Efrain Guajardo*	19, 7
1:45 – 2:00 pm	**EMAG SECURITY SYSTEM** *Justin Crabb, Christopher Gay, Arian Pourmotamed, and King Fung*	21, 8
2:00 – 2:15 pm	**PROJECT: INDEPENDENCE – A PROJECT DEVELOPING AN ELECTRONIC GUIDE CANE** *Moriah Hargrove-Anders, Nancy Ibarra, and Clayton Manchaca*	23, 12
2:15 – 2:30 pm	*Coffee Break*, Waldorf Astoria, Ballroom, Lobby	

Session D: Oral Presentation

Time: 2:30 – 3:00 pm, Flamingo Room
Faculty Chair: Dr. Len Trombetta

2:30 – 2:45 pm	**AUTOMATED SMOKER** *Benito Martinez Jr., Kevin Ngo, and Jonathan DeLeon*	25, 13
2:45 – 3:00 pm	**RESISTOR BOT: A RESISTOR SORTING ROBOTIC ARM** *Michael Brannon, Hazuki Chino, Julio Moreno, and Sarah Thomas*	27, 14

Session E: POSTER PRESENTATIONS

Time: 3:30 – 5:30 pm
Location: Waldorf Astoria, Ballroom

All posters will match talks presented by the undergraduate students in the oral sessions.

Presentations by the following companies are scheduled

KEYSIGHT TECHNOLOGIES CenterPoint Energy Hewlett Packard Enterprise NATIONAL INSTRUMENTS

5:30 – 6:00 pm	**Elevator Talks by CDC Students**, hosted by Dr. Len Trombetta, Shamrock, Ballroom
6:00 – 6:60 pm	**Awards Ceremony and Reception**, Shamrock, Ballroom

GROUND SG100 POWER SUPPLY

Elliot Pucek, Matthew Yepes, Kaisong Fan, Deedhiti Sharanya
Department of Electrical and Computer Engineering
University of Houston
Houston, TX 77204-4005

Abstract

The purpose of the GSPS project is to develop a cost-effective power supply board that can be used for preflight testing of the entire SG100 system. This board will reduce the financial impact and increase the ease of use for ground development environments. During the fall semester, we were able to accomplish most of our goals which included outputting correct voltages for the buck converter and two step down converters under load. The only problem was some transient noise that was introduced into the system by the buck converter and it continued to be a problem throughout the spring semester. During the spring semester, we were able to reduce the transient noise and complete rest of our spring semester goals, which included adapting our circuit to the Arduino to control fan speed, thermal environment and monitor voltage and current.

Introduction

The SG100 Computer is a technology that was originally developed for use on the International Space Station (ISS). It was developed as a high performance and radiation tolerant computer that can handle the higher demands of the more data intensive science and technology systems that are emerging in the aerospace industry. The current design of the SG100 and flight SG100 Power Supply (FSPS) boards are built using high tech space grade components. Such components contribute to a very expensive design and thus make testing very expensive as well. To test the SG100 system before launch a different version of the power supply must be used. This version must be cost effective and use non-space grade parts. This is what is called the “ground” version, or as we call it, the Ground SG100 Power Supply (GSPS). The goal of this project is to create a cost-effective power supply which can utilize standard wall power as an alternative to the Flight SG100 Power Supply (FSPS) for testing purposes.

Methods

By the end of the fall semester, we were able to convert 120 [VAC]/60 [Hz] to 27.2 [VDC] using a full bridge rectifier. From there, the 27.2[VDC] was stepped down to 12[V] utilizing the buck converters. In order to reduce noise from the buck converters reaching the other step down components for the Arduino, we used a recommended filter. The output of the buck converters was filtered using a second order LC circuit which helped reduce the ripple voltage within our tolerances. The ripple voltage was reduced successfully, but there was transient noise that was introduced by the buck converters. This was our biggest issue, because the transient noise could damage sensitive components. We tried various ways to minimize or even eliminate this noise using Zener diodes to cut off large spikes, using pi and low pass filters, as well as using ceramic capacitors close to the converter. Finally, this issue was solved by adding a choke at the output of the buck converters.

During the spring semester, the Arduino was programmed to control fan speed and temperature sensors. The thermal environment control was completed by programming the TC74 thermal sensors to work in unison with the fan system. The fans will start with a 30% duty cycle as a standard and increase in speed as the temperature increases. For redundancy, the Arduino was programmed to monitor voltage and current in order to know which buck converter is currently outputting power.

Results

The transient noise was reduced by using a choke at the output of the buck converters. From the output noise, we determined our cutoff frequency to be around 270-280[kHz], which is close to the switching frequency of the buck converters. This cutoff frequency allows for 3 [dB] attenuation using an inductor with a value of at least 4.0 [µH]. To be sufficient for eliminating the noise completely, we chose a larger inductance value of 90 [µH]. Even though this eliminated the transient noise, the system we breadboarded was picking up RF signals and creating inaccurate readings on the oscilloscope. By using a current probe at the load, we were able to obtain an accurate reading. Figure 1 below shows the two oscilloscope traces for before and after applying filtering to the system and using the current probe.

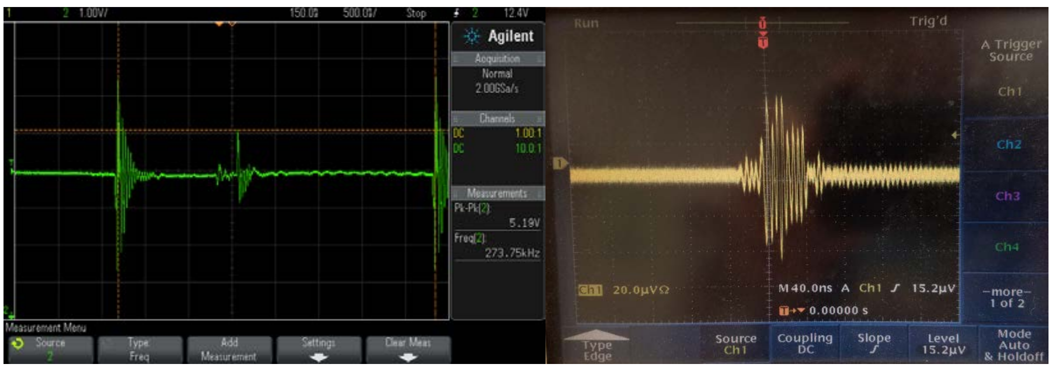

Figure 1: Oscilloscope traces for before (5.19 Vpp) and after (96 µVpp) filtering.

After finishing all the goals for the project, a PCB layout was designed using Diptrace. The 3D model of the project can be seen in Figure 2.

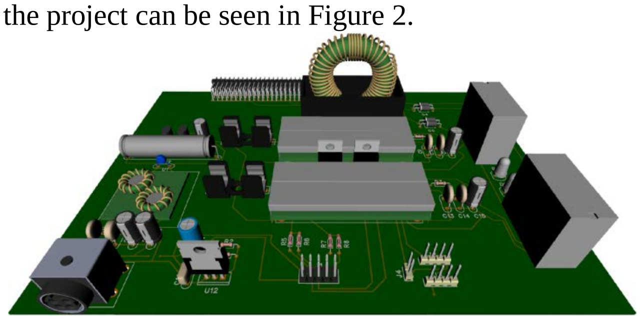

Figure 2: 3D model of Ground SG100 Power Supply

Conclusions

After designing, building, and testing, we have completed all of our goals for the project. The most challenging goal was reducing the unexpected transient noise from the buck converter, but after much trial and error, we were able to reduce the transient noise. We have also successfully tested the outputs under load and all the output voltages were acceptable and matched what we need for powering the Arduino and Cloud Computer. Even though, we had some delays with some of our goals, we were able complete our PCB layout on time.

ARDUINO BASED HOME AUTOMATION SYSTEM

Osama Eter, Jonathan Soileau, Michael Ngo, and Marvine Penson
Electrical and Computer Engineering
University of Houston
Houston, TX 77204-4005

Abstract

This project grants users the convenient ability to monitor and control various electrical devices throughout their home, independent of the user's location. This is done by constructing electrical switches, wall outlets, sensor devices, and a server that can connect to and communicate via the home's local network. By utilizing our designed Android app, users can send requests to see the current state of our electrical devices, to toggle the state, or to set sensor parameters for any electrical switch or wall outlet.

Introduction

The purpose of our project is to help users centralize control of their home through an Android phone application that can be utilized anywhere in the world. This system allows a homeowner to control lights, wall outlets, garage door and receives sensor data like temperature and humidity. Our system differs from those currently found on the market, as there is no monthly fees required to operate the system. All of our deliverables except the phone application are located in the home, including the server that we have created. This eliminates the need to rent a hosted server to control the home automation system.

Methods

For our light-switches and wall outlets, we utilized a small Arduino microcontroller called the ESP 8266-01 due to its small size, 2 available GPIO (general purpose input output) pins, and ability to easily connect to an existing Wi-Fi network. One GPIO pin was used to toggle a mechanical relay that connects/disconnects a 120[Vac] wire. The other GPIO pin was used to provide the user with an external button. Pressing the button would toggle the light/wall switch to the opposite state and contacts the server with the updated status.

For the Sensor-hub and garage door switch, we utilized an Arduino microcontroller called the ESP 8266-12e. The choice of this microcontroller was due to the number of GPIO pins that it provides and its Wi-Fi capability. In order to attain sensor data, sensor modules were connected to the microcontrollers. The Sensor-hub utilizes temperature, humidity, and luminosity sensor modules while the garage door switch only uses a distance sensor module. The Sensor-hub periodically updates sensor values to the Server where the garage door switch updates the server on the state of the garage door if the garage door is opened/closed. In addition, the garage door can be controlled through the app, like the light-switch. Figure 1 is an overview of our system showing how our devices communicate.

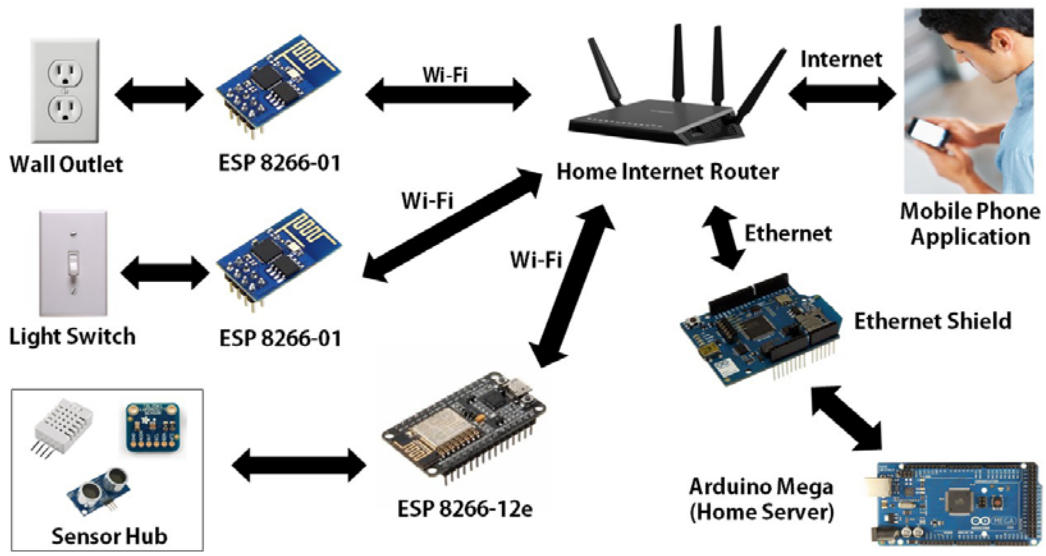

Figure 1: Home Automation Overview

The server of our system consists of an Arduino Mega paired with an Ethernet shield. The shield allows the Mega to connect and communicate with (via Ethernet) a router. After assigning a specific port for our server, we forward that port in the router settings in order to forward the request from the user's phone to the server. The server will then parse the request, process the requested action, and respond to the user accordingly.

The mobile phone application was programmed for Android smartphones using a computer program called Android Studio. The app consists of many images, buttons, and text. The images help to relay to the user of the state of their devices, the buttons allow the user to send a TCP/IP request to the server and the text displays response from the server. The app contains three tabs which include switches, sensors, and parameters. The switch tab allows the user to see and change the state of our devices. The sensors tab allows the user to examine the most updated values from the Sensor-hub. The parameters tab allows the user to set different threshold limits and actions for independent home operation.

Results

We have successfully created and thoroughly tested all of our five electronic devices and mobile phone application. All of our devices are powered using the home's 120 [Vac] and a small 120[Vac]/5[Vdc] rectifier. We created all electrical devices to operate as we explained in our Methods section. In the testing of the system, we utilized an Android smartphone connected to 4G, not the local home network, to control and communicate with our home automation system that was configured in one of the author's homes. After port-forwarding a specific port on the author's personal home router, we were able to communicate with the Android phone application. After connecting all electrical devices to the author's home network, we were able to control, examine, and set sensor parameters for all of our devices.

THE SOLAR OUTLET

Eliud Serna, Jose Tenorio, Ali Oshkoohi, and Jiwantha Mannapperuma
Department of Electrical and Computer Engineering
University of Houston
Houston, TX 77204-4005

Abstract

The Solar Outlet utilizes a 100-watt solar panel to power various electronic devices by utilizing a sealed lead acid battery, which will provide power to the inverter that can be used to power loads. To maximize the amount of power generated, a set of stepper motors, controlled by a microcontroller, are used to give the solar panel the ability to pan and tilt. The microcontroller will be able to do this by utilizing a real-time clock, a magnetometer, and an accelerometer. The constructed wooded frame can hold, pan, and tilt the solar panel.

Introduction

The purpose of this project is to create an efficient solar power supply, which optimizes the position by using a sun-tracking algorithm. With the purpose of powering small to medium sized consumer electronics such as cellphones, laptops, tablets, and portable televisions. Resulting in a product that will fill a niche role between portable battery banks and gasoline generators. Providing an easy to use product that can provide a cost efficient, environmentally friendly, and noise-free source of energy that can provide energy considerably longer than a portable battery bank.

Problem, Need, and Significance

Problem: Portable power supplies such as gasoline generators and battery banks are not renewable and, therefore, they do not last a long time.

Need: A portable device that can track the sun to optimize its output power and operating time.

Significance: The Solar Outlet, a renewable power supply, will be capable of powering multiple loads (for a long period of time) equaling a maximum of 100 watts of output power. The device will be able to last considerably longer than a portable battery bank power source, and when compared to a gasoline generator, the Solar Outlet will be more cost efficient, environmentally friendly, and noise-free. The Solar Outlet has relevance to all individuals looking to power their devices in outdoor environments, particularly those that live in areas with ample sun-light.

Methods

The project is divided into the following modules: solar panel and the mechanical/electrical movement system for controlling the panel position, motor driver circuit, Arduino microcontroller, inertial measurement unit, real time clock module, buck-converter, battery, charge controller, and an inverter. The above modules are depicted below in Figure 1, in a block diagram format.

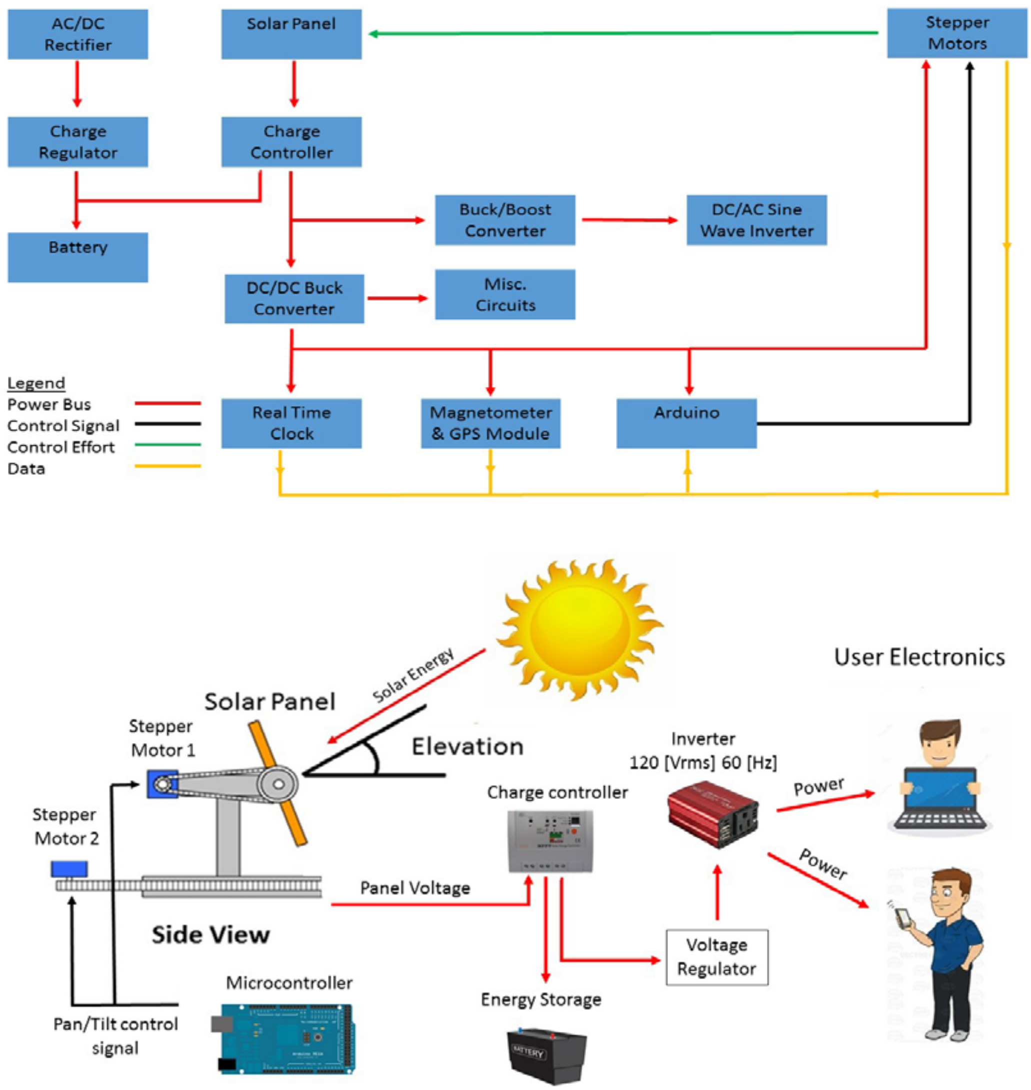

Figure 1. General Block Diagram for the Solar Outlet Device.

Conclusions

The Solar Outlet provides the user with an efficient power source that can last the day. This is achieved using a sun-tracking solar panel and a rechargeable battery. The basic idea is that the battery provides power to the inverter while the solar panel keeps the battery charged during operation. The device is autonomous so that the user is only required to turn on the device by pressing a switch. The Solar Outlet is capable of powering electronics such as cellphones and laptops.

References

[1] NREL's Solar Position Algorithm. [Online].
Available: https://www.nrel.gov/midc/spa/

AUTOMATED BATCH PRODUCTION AT COVESTRO

Nathan Prows, Jasmine Hemdani, Keon McEwen, and Ikemefule Onyearugha
Department of Electrical and Computer Engineering
University of Houston
Houston, TX 77204-4005

Abstract

This project covers the automation of bulk material delivery, recirculation, and packaging portions of the batch production process, at Covestro's Spring TX site to improve its consistency, accuracy, and safety. The site produces a chemical that makes a high-quality polyurethane spray foam used in commercial and residential insulation. The finished good is made by blending chemicals in a vessel while achieving and maintaining several parameters stipulated by a recipe. The entire process was previously done manually by a product technician. Our deliverables include a custom Human Machine Interface (HMI) and its related program to control field devices, a recipe management solution, monitoring of all field devices, a security solution, and training documentation. The overall deliverable is to be able to produce finished goods remotely. We have automated the production process of three blend vessels by using sensors, actuators, variable frequency drives, flow meters, and other field devices. All data from field devices is visually monitored from a centralized control room.

Introduction

Covestro's facility in Spring, TX produces one of the components that is used in a two-part system to make polyurethane spray foam. An A component is mixed with a B component in a 50/50 ratio to make foam. Making the B component is analogous to making no-bake cookies, ingredients are added into a blending vessel, some from large bulk storage tanks, and others from smaller totes and drums. These ingredients are then thoroughly mixed, cooled, and then packaged into 50 gallon drums. The Covestro facility in Spring TX produces the B component in a batch process. The previous process was manually done by product technicians and was prone to human error, which made it potentially unsafe. In the past, errors have led to loss of finished product and raw materials resulting in monetary losses and unsatisfied customers. In addition to being prone to human errors, the previous process did not allow collection of any data. Covestro required an engineering solution to this problem. Our project has automated this process and removed the human error from it. A more consistent product also attracts new clients and has resulted in a happier client base. In order to achieve an automated batch, the current devices had to be updated and controlled from a central location, and software was developed to allow for automatic processing.

Methods

To automate the batch process, our team had to design a solution using existing equipment and only upgrade where necessary. Our team had to purchase and install flow meters, temperature and pressure transmitters, and actuated valves to be able to communicate with a controller. We then had to run wires to each device from the controller using a number of different communication protocols including: PROFIbus, MODBUS/TCP, Ethernet, and AS-I. Once all the hardware was installed and the proper parameters were set to allow for remote communication, our team then had to write all the logic and create custom HMI screens so that a technician could remotely make a batch.

Results

We have automated the bulk raw material delivery, blending and cooling of the three blend vessels and production is now controlled from a central control room. There are 4 HMI screens associated with each tank, a recipe management database and a security implementation that provides a sectional access to product technicians, managers and engineering.
Figure 1 below shows 1 of 3 main blend tank screens that the technicians use to make a batch. The text alongside the process field devices is blurred intentionally to prevent divulging Covestro trade secrets and batch process.
Readers are to note that the screen has real time process monitoring and device control capabilities.

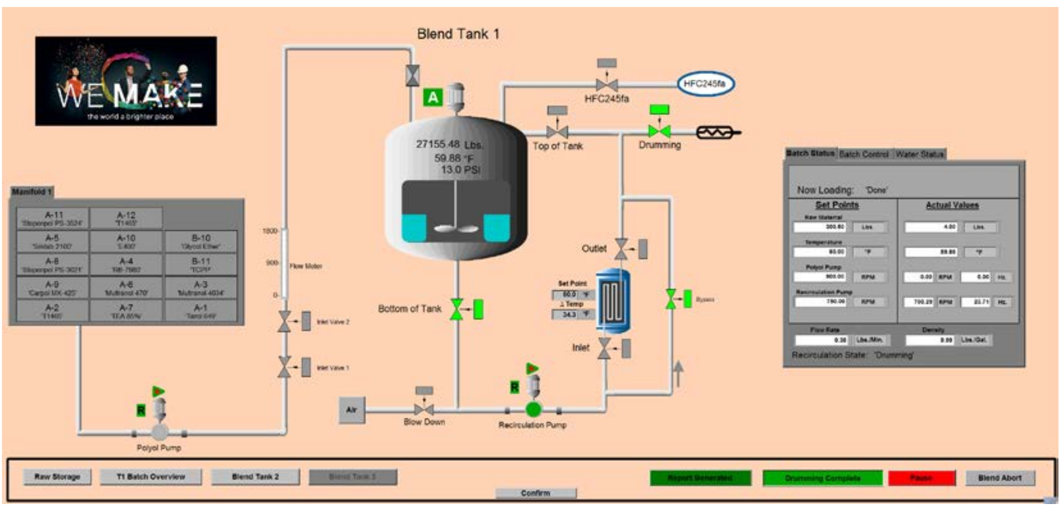

Figure 1: Main batch Screen for blend tank 1

Conclusion

Our team successfully automated the batch process for three blend vessels that allows technicians to remotely make a batch in any of the three tanks. These batches can be made simultaneously or one at time.

DYNABRAILLE: DYNAMIC BRAILLE DISPLAY

Daniel Lopez, Katherine Perez, Sergio Silva, and David Garcia
Department of Electrical and Computer Engineering
University of Houston
Houston, TX 77204-4005

Abstract

Dynabraille, a dynamic braille display, aims to improve the availability and accessibility of information to those who are blind or visually impaired. The display system is comprised of a tactile, refreshable braille display, capable of producing braille characters, driven by custom electromechanical microactuators. Data is translated to braille through a software application and sent wirelessly to the embedded system. This controls the circuit board components and actuates the braille characters. The technology developed for producing braille characters could be scaled to fit alternate applications that would enhance the lives of the blind and visually impaired individuals.

Introduction

Braille literacy in the United States has fallen below ten percent among children and adults who are blind or visually impaired. As reported by the National Federation of the Blind (NFB), this decline is attributed to the lack of a modern implementation of braille. The NFB calls for developers to begin "advancing the use of Braille in current and emerging technologies" [1]. These problems give rise to the need of an emerging accessible and affordable braille display.

Analysis

Dynabraille's mechanical components and printed circuit board were designed so as to produce tactile braille characters that comply with the standards set forth by the Americans with Disabilities Act. In addition, current braille keyboards utilize expensive piezoelectric material for actuation. Extensive research was performed to identify alternate materials that were cost effective and could produce similar results. Nitinol, a wire whose unique chemical composition allows it to contract when heated, was selected as a possible solution.

Methods

Through various iterations, the braille cell parts were meticulously designed to adhere to standards developed by the Americans with Disabilities Act (ADA), to allow wires to be implemented without shorting adjacent wires, and to enable ease of manual assembly. Each braille cell includes six linear electromechanical actuators, which consist of a strand of Nitinol wire and a miniature compression spring. These components work in unison to produce raised and lowered individual braille dots, which can generate any combination of braille characters. An exploded view of final design is illustrated in Figure 1.

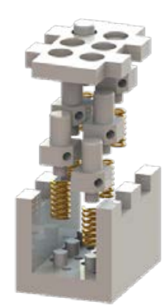

Fig. 1. Exploded view of braille cell.

To control actuation, a custom circuit was developed to enable current to propagate through the individual wires, heating them into their contracted state. Due to strict size constraints, the printed circuit board (PCB), demonstrated in Figure 2, had to be condensed and laid out in an efficient manner. This enabled integration with the mechanical braille cells and could easily be scaled to accommodate a different number of characters. To simplify the assembly process, several surface mount device (SMD) components were preinstalled by the fabrication house which also printed the PCB.

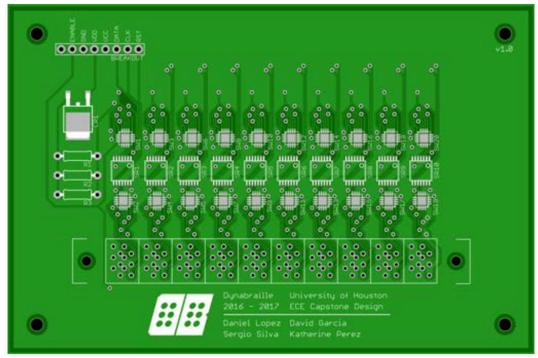

Fig. 2. Printed circuit board which drives current propagation through the system for ten braille characters. Circuit is comprised shift registers, analog switches, and a constant current regulator.

The embedded system controls the digital touchscreen display and receives wireless data from the computer application. Moreover, the software app can translate braille in sixty-six languages, thirteen of which, support grade two braille. Dynabraille is powered via two rechargeable lithium ion batteries which can be internally reconfigured for charging.

Results

The software application can successfully translate braille and wirelessly transmit data to the embedded system. The information is then processed and sent to the circuit, which propagates the signals and current to the appropriate wires. The custom Nitinol-based electromechanical actuators effectively generate individual braille characters as designed. The frequency at which the signals are generated seems to be resulting in current loss. This has been attributed to the physical limitations of the analog switches utilized. Additional testing will be performed to determine an ideal frequency without compromising Dynabraille's ability to produce refreshable braille characters.

Conclusion

Through design challenges and engineering feats, Dynabraille can successfully produce refreshable braille characters. Most notable however, the technology developed can be scaled and applied to different products which may enhance the lives of those who are blind or visually impaired. Further developments would include obtaining feedback from users, so that the product could be tailored to better serve their needs. Dynabraille aids in the modernization of braille and hopes to increase braille literacy worldwide.

References

[1] "The Braille Literacy Crisis in America Facing the Truth, Reversing the Trend, Empowering the Blind." The Braille Literacy Crisis in America. N.p., 26 Mar. 2009. Web. 21 Apr. 2017.

CNC Laser Engraver

Theodore Rodriguez, Logan Golden, Michael Pincus, Nayam Perez
[1] Department of Electrical and Computer Engineering
[2] Department of Mechanical Engineering
University of Houston
Houston, TX 77204-4005

Abstract

The CNC Laser Engraver is a multi-department collaboration between the ECE and the MECE departments at the University of Houston. The purpose of our project is to supply a cost-efficient laser engraver with USB and Wi-Fi compatibility. We want to provide a machine with an output up to 2-watts so that we can bridge the gap between the extremely low and extremely high output lasers currently available on the market today. This is a product that we wanted to make easily operable so anyone from any background will be able to use it with little guidance. Our goals were not only accomplished, but at a cost point that is much lower than engravers with similar build areas and laser power.

Introduction

The project idea erupted from the notion that engravers available today are on two polarizing ends of the spectrum. Engravers are either too small (80 mm x 80 mm engraving area) with a low laser output power (~500 [mW]), or they are too big and dangerous for the everyday use ($C0_2$ laser are very large, costly, and need special safety requirements). With our engraver, we plan to meet in the middle of these polarizing ends. Our engraver has an engraving area of 500 [mm] x 230 [mm] as well as a laser with a maximum output power of 2 [W]. The engraver can be controlled through a user interface we have made via Wi-Fi or USB. The user simply picks their software of choice (We used InkScape) to convert any image into usable G-Code that the machine uses to complete an engraving.

Analysis

We wanted to provide a product that could be used by anyone. The user should be able to know how to use a computer and be able to upload a graphic of their choice so it can be formatted for engraving. This can be achieved by using a third-party software to convert svg files into G-code. We plan to provide a user manual that will assist in the operation of the final product.

Methods

To start our engraver we started with a CAD based software to design the mechanical components of our engraver such as our corner blocks, gantry sides, and carriage box. Using these designs we could 3-D print them at marginal cost. We cataloged the electrical side of our engraver with a program called diptrace. This allowed us to see how all our components were connected allowing a seamless transition from the design to the actual building of the product. Once we had our electrical layout complete as well as properly powered, we were able to start testing our motor controls. Once we were able to control both our X and Y motors we moved on to testing our laser, as well as control through G-Code. G-Code is the language standard for CNC machines that provides an instruction set for the engraving. Once we had controlled motion per G-Code we moved on to fine tuning our software to make sure our engraver was working smoothly.

Results

As seen in figure 1 and 2 below we were able to engrave a company logo into a piece of wood

Figure 1:
Awesome Bites CO into a piece of wood. This particular engraving took a total time of 1 hour and 43 mins at 500mm/min with a 2000 mm/min velocity override. This image had an area of 125x125 mm

Figure 2:
Here in our second image we engraved an image of Dr. Trombetta playing a saxophone. This engraving took a total time of 1 hour and 16 mins at 500mm/min No velocity override 75x75 mm

Conclusion:

We were able to successfully complete the project. Our engraver autonomously engraves into wood and leather based off of the G-Code instruction set provided by the user. We were able to meet our goals of creating a cost-effective product while providing a larger surface area and a stronger laser compared to similar laser engravers on the market.

FSAE DIAGNOSTIC SYSTEM

Isaias Amaya, Osvaldo Rodriguez, and Otoniel Canuz
Department of Electrical and Computer Engineering
University of Houston
Houston, TX 77204-4005

Abstract

In this project we are designing a data logging system for FSAE. FSAE is a yearly student-led racecar competition. We are designing a PCB board that is able to monitor various sensors (Pressure, temperature, RPM) while also storing the data onto an SD card. While also triggering a warning to a mounted LCD screen should a threshold be reached. A circuit is required to prevent the large starting current the radiator fan requires. This is accomplished using Pulse-Width Modulation (PWM) to soft-start the motor. Our custom software will then import the recorded data and display it in a user friendly format.

Introduction

FSAE is a competition where engineering students collaborate and design a racecar. They required a better monitoring system since their current one consists of a single LED that blinks a certain code. Making the user have to search through the manufacturer's datasheet to find the possible reasons for the warning message. We will combat this by designing a data logging system that is able to monitor a given sensor. Amplify its voltage so that a warning is triggered once 3.3V is crossed. Letting the driver known that the engine is overheating, oil pressure is lost, or any other malfunction. For analysis after a practice run the software we designed will take in the recorded data from the SD card and display each logged sensor's value with respect to time. The purpose of this is to find a fault relatively quickly; we will be able to see what sensor stopped working/reading to isolate the problem.

Methods

The initial challenge of monitoring systems is to find a way to record sensor values without altering the readings of the engine's Electronic Control Unit(ECU). For sensors with two terminals, this was done by adding a shunt resistance in series with the sensor. The shunt resistance is negligible compared to the resistance of the sensor, we take multiple measurements at different sensor readings (temperature for engine coolant sensor) to get enough data points to form a graph. We then amplify the voltage across the shunt so 3.3V is reached once our threshold is reached. The following figure shows how our system monitors a sensor.

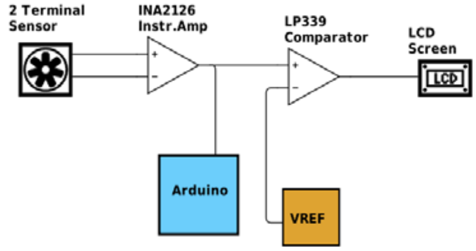

Figure 1 Two wire sensor monitoring circuit

Figure 1 shows how for a two terminal sensor, we amplify the voltage of the shunt resistance. That amplified signal is stored onto an SD card via an Arduino. The amplified signal is compared with a reference voltage. Once the amplified signal crosses the reference voltage a warning is triggered on the LCD screen, powered by a Tiva-C controller.

Results/Analysis

A resulting Printed Circuit Board (PCB) was created to contain all the circuitry needed to monitor 8 sensors. The Arduino was also embedded into the PCB. The following figure demonstrates our project monitoring a sensor.

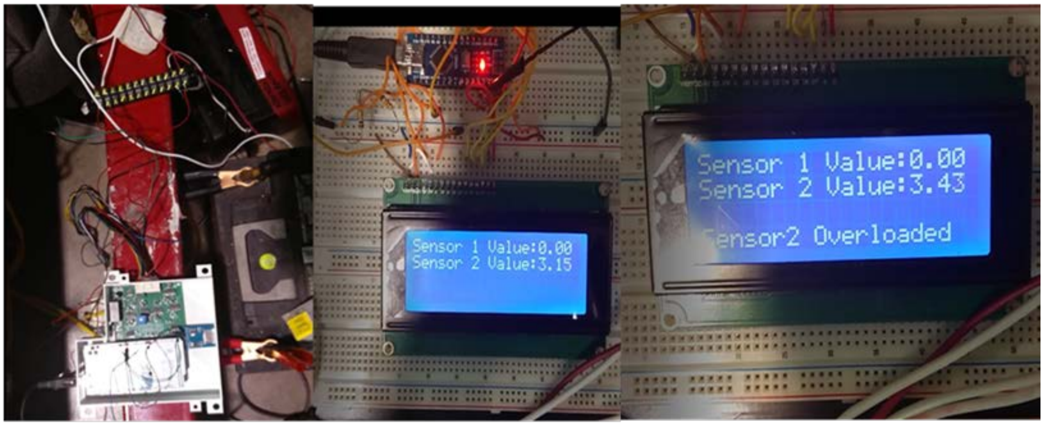

Figure 2 PCB monitoring Engine Coolant Temperature (ECT) sensor

Figure 2 demonstrates the working PCB board. It is connected to the engine's ECT. The engine was left running until the voltage for "Sensor2" reached the 3.3V threshold. Which in turn caused turned the radiator fan on.

The next step is displaying sensor values. Windows Presentation Foundation (WPF) was used for software development. We successfully displayed sensor data over a video recording to mimic what would be happening during a practice run of the vehicle. Google Maps was used in the software to display the coordinates traveled and map out a racetrack.

A circuit was built that successfully starts the radiator fan slowly and allows full control of the speed. This eliminates the strain of suddenly powering on the fan to full speed. Fast starting the motor requires a current nearly twice as much as the full-speed operating current.

Conclusions

We have achieved our goal of building a data logging system for the racecar. Through the form of a designed PCB that embeds an Arduino. A dashboard screen was powered by a Tiva-C controller. Displaying appropriate warnings when certain thresholds are crossed. As well as a functioning circuit that monitors the engine coolant temperature sensor. Turning on the radiator fan when needed. We will now have to integrate it to the racecar and have practice runs to validate our system for that specific racecar. The software is able to take in data and display it to refresh the data every second.

IEEE ROBOTICS

Cuong Ha, Kasan Momin, Idam Obiahu, and Tevin Richards
Department of Electrical and Computer Engineering
University of Houston
Houston, TX 77204-4005

Abstract

This year's IEEE R5 Robotics Competition sought to demonstrate the use of autonomous robots to map tunnels and investigate "buried caches" at tunnel endpoints. Steel wire and electrified cable was used to simulate infrastructure. Surface obstacles and other anomalies were used to represent operational constraints. As such, we designed and built a robot that is capable of autonomously navigating the presented game field to map tunnels, investigate caches, and overcome the presented operational constraints. The competition was held in Denver, Colorado on April 1st, in which 32 teams participated. We placed 12th in the competition, tying with several other teams.

Introduction

The competition consisted of three rounds in which each team need a robot that could autonomously navigate the game field to map tunnels, perform image processing to determine the number of pips face-up on a die, and remove a lid from a container. Each round presented us with a different variation of the field given in Figure 1. For mapping the tunnels, our robot was to differentiate between an objective tunnel and a dead end tunnel. The objective tunnel is the tunnel which contains the steel and electric cables. The dead end tunnels do not contain these cables. In the first round, we were presented with a game field that had a single object tunnel, no dead ends, and no more than two 90-degree turns. For the second round, there was a single objective tunnel, possible dead ends, and no more than three 90-degree turns. The final round field followed the same guidelines as the second, with the addition of one or more surface obstructions.

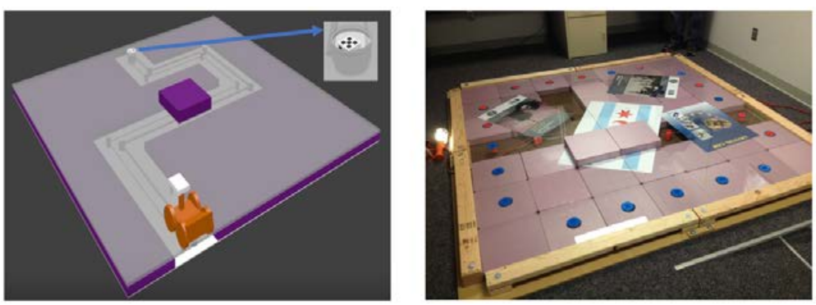

Figure 1: Left) simulated image of the field, Right) actual image of the game field.

Design

For our design, we built a two-wheeled robot. A back, side, and front view of the robot is presented in Figure 2. The robot utilizes a Tiva C Series TM4C123G Launchpad and a Raspberry Pi 3 for processing. The Tiva C controls the main program, performing the autonomous actions. controlling motors, controlling sensors, etc. The Raspberry Pi is used for the image processing functions. The robot utilizes stepper motors in conjunction with Mecanum wheels for motion. For tunnel sensing, the robot utilizes a capacitive sensor and an infrared sensor. The infrared sensor allows us to easily identify a tunnel when there is no paper blocking its view. The capacitive sensor allows us to reliably detect the objective tunnel by finding the cables present within it. The manipulator consists of a claw combined with a linear actuator. The manipulator uses three servos to control downward/upward motion of the linear actuator, rotation of the claw, and opening/closing of the claw. An 8x8 RGB LED display is used to show the tunnel map and a 7-segment display is used to show the number of pips that were found on the die.

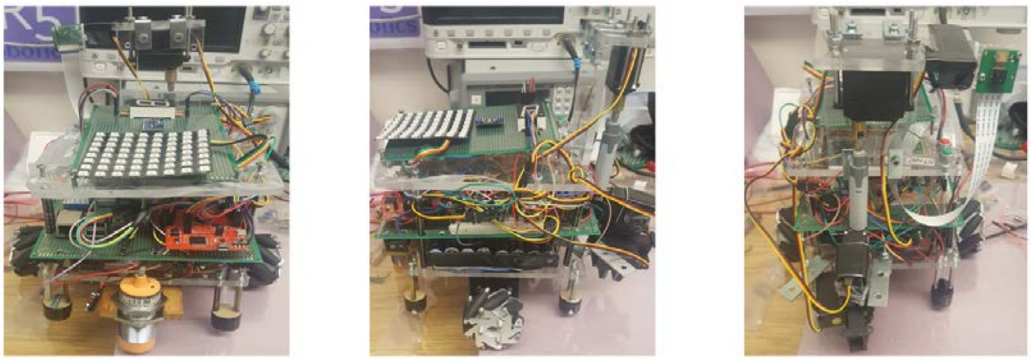

Figure 2: Left) Back view of robot, Middle) Right side view, Right) Front view

Methodology

Starting at its beginning location, the robot first travels around the edge of the field until it locates an endpoint. Once the robot locates an endpoint, it turns and faces the inside of the field, and then continues moving forward. The robot will continue forward until it no longer detects a tunnel or it reaches the next endpoint of the tunnel. If the robot no longer detects a tunnel before it reaches the next endpoint, it will return to the last location a tunnel was detected, and check the grids to the left and right of it. When it locates the tunnel on the left or right of the robot it will continue moving forward using the new path. Once the robot reaches the endpoint, it begins the cache operations. The camera connected to the Raspberry Pi is used to located where the cache is located and at what angle the lid is at. The Raspberry Pi will then send the information to the Tiva C. The Tiva C uses this information to move the robot so that the claw is over the cache and to rotate the arm into the correct position. The claw will be lowered and the lid will be removed. The camera is then used again to determine the number of pips face-up on the die. This number is displayed on the 7-segment display. After this, the robot returns to the starting location by traveling around the edges of the field.

Results

At the time of the competition on April 1st, we had only fully completed the tunnel mapping for the robot. Interestingly, the majority of the other teams also abandoned any attempts to locate and remove the lid from the cache by the time of the competition. In the end, we placed 12th overall, tying with several other teams. During the competition we experienced several reliability issues. We were unable to compete in the first round because a wire on the battery for our LED snapped, and we did not fix it in time for Round 1. In the second round, we experienced issues with one of our motors locking up. For the final round, the mechanism that controls our stop button triggered on its own. After the competition, we continued to work on our robot design. We fixed all the issues that occurred during the competition. We have also been able to successfully implement the cache operations with our object manipulator. Furthermore, we have implemented obstacle avoidance. The robot successfully performs its intended functions of autonomously navigating, tunnel mapping, object manipulation, and obstacle avoidance.

SWARM DEMONSTRATION HARDWARE SYSTEM: APPLIED TO MAINTAINING A WIRELESS SENSOR NETWORK

Christiana Chamon[1], Rachel Dunn[1,2], Maria Ciara Lalata[1], and Mable Wan[1]
[1] Department of Electrical and Computer Engineering
[2] Department of Biomedical Engineering
University of Houston
Houston, TX 77204-4005

Abstract

The purpose of this project is to develop search and control algorithms to enable a swarm of robots to autonomously locate and then wirelessly charge moving sensors. Using a camera and an open-source robot design, we have successfully attained our purpose, proving that engineers can program simple robots to autonomously track moving objects.

Introduction

This project seeks to maintain the batteries of a swarm of sensor nodes using a few charging robots. The applications of this proof of concept are numerous, ranging from charging underwater sensor nodes to charging stations above ground that do not have an easily available outlet. Each of our robots is relatively cheap, small, and easy to use and assemble, making them attractive prospects for outreach and educational purposes.

Analysis

Our swarm is composed of eight sensor nodes and four charging robots. The charging robots are assigned to specific sensor nodes. They must then intercept, align with, and attach to the moving sensor node, before wirelessly charging the sensor node through inductive power transfer. After a set time, the charging robot will target a new sensor node. Fig. 1 shows the functionality of the charging robot.

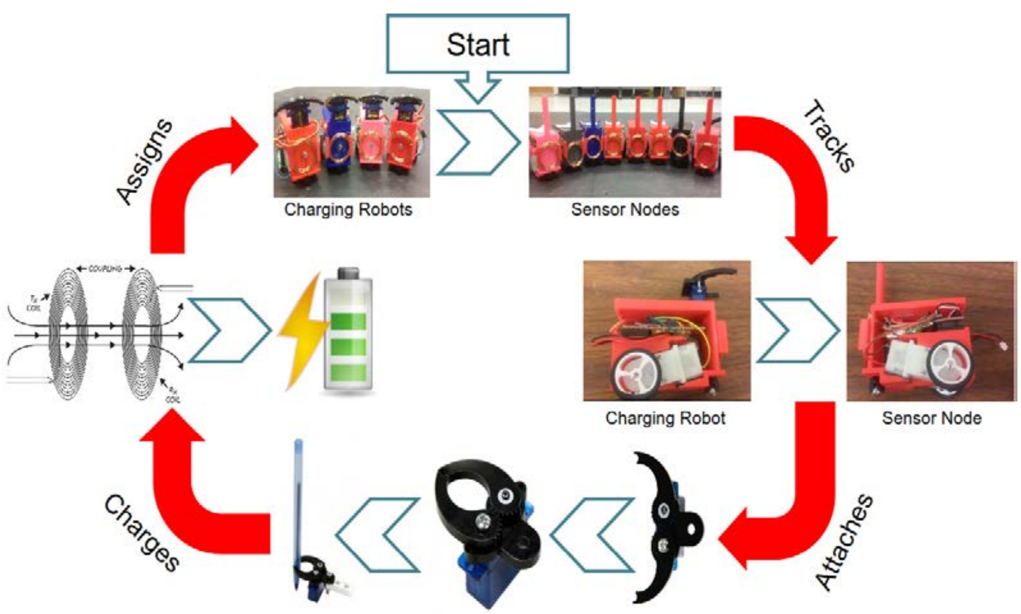

Fig. 1. Functionality overview diagram.

Methods

Fig. 2 depicts our project's overall system, consisting of an arena with an overhead camera that identifies each robot and tracks the location and orientation of each vehicle through a chevron-shaped tag. The charging robots and sensor nodes are controlled by separate central computers through coordinator XBee modules. The base design of our robots is an open-source design[1] illustrated in Fig. 2. Final designs for the sensor nodes include a 3D-printed rod for attachment, a supercapacitor in parallel with a resistor to simulate battery life, an inductive coil to receive power, and an LED system to indicate charge status of the capacitor. Final designs for the charging robots include a latching mechanism composed of a gripper, and an inductive coil to transmit power.

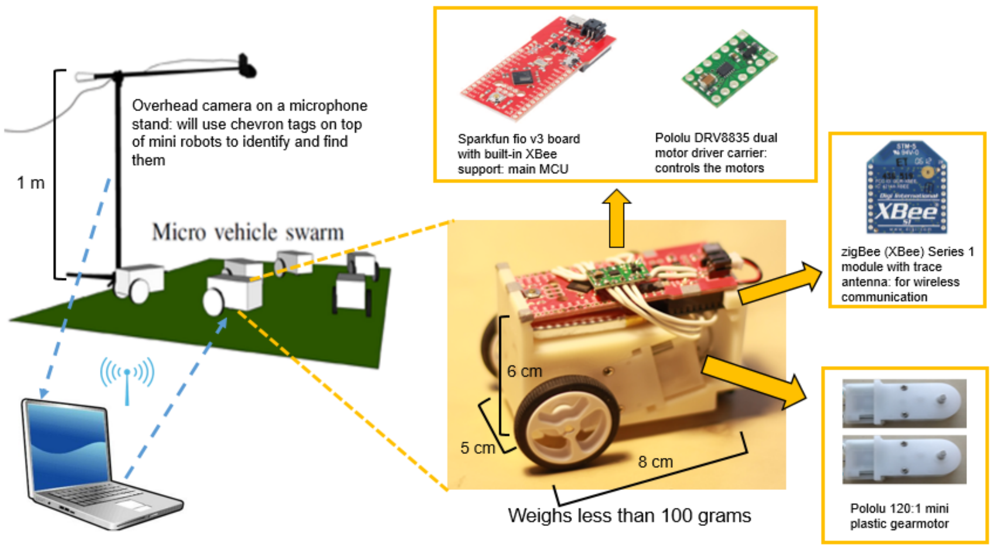

Fig. 2.System overview diagram.

Results

The sensor nodes are controlled with a Matlab random walk with drift simulation with collision avoidance. Munkres' assignment algorithm assigns charging robots to sensor nodes based on lowest voltage and shortest distance. The charging robots are controlled by a distance-based curvature algorithm. Based on information from the overhead camera, the charging robot can calculate its left and right wheel velocities to follow the algorithm's trajectory. An alignment algorithm controls the orientation of the charging robot to properly align with the sensor node.

Conclusions

We have constructed a system of robots that can maintain the battery life of moving sensors. We hope that our project will be used to inspire future engineering students.

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[1] J. Yu, S. Han, and D. Rus. "microMVP: A Portable, 3D-Printing Enabled Multi-Vehicle Platform for Robotics Research and Education." Internet: arc.cs.rutgers.edu/mvp, Sept. 15, 2016 [Sept. 23, 2016].

AIR PRESSURE AND TEMPERATURE CONTROLLER

Mohammad Nazarifar, Abdulrahman Kamal, Efrain Guajardo
Department of Electrical and Computer Engineering
University of Houston
Houston, TX 77204-4005

Abstract

During LASIK vision correction procedures, the cornea may experience overhydration and result in inaccurate correction. The Air Pressure and Temperature (APAT) Controller ensures that the level of corneal hydration is not excessive by applying controlled air. The controlled air is maintained at a manually adjustable pressure and temperature as it is expelled from the device using a pressure valve and a heat producing coil. The measured air properties are adjustable in real time and are shown on a display screen for user feedback and input.

Introduction

LASIK and other laser eye surgeries are popular procedures for correcting common vision problems such as nearsightedness, farsightedness, and astigmatism. These procedures use a laser to cause corneal ablation which is the process of removing tissue within the corneal. The removal of the tissue reshapes the eyeball to form a more spherical shape which allows for enhanced vision. However, during the surgery some patients may experience excessive corneal hydration which could lead to slight laser refraction that causes inaccurate vision correction results. To tackle this problem, the team set out to create a device that can regulate the overhydration of the cornea by applying controlled air.

Analysis

The APAT Controller's purpose is to minimize the effect of overhydration within the cornea during a surgery. The method of dehydrating the eye was chosen to be a source of air that is directed towards the eye as it would not interfere with the surgery. To do this the device will have two main systems, one for temperature control and one for pressure control. The device will be capable of detecting and adjusting the air characteristics and a single power supply is created to power all the different components in the device.

Methods

The two-major systems function independently and are controlled by an Arduino microcontroller. An LCD screen is used to provide feedback to the user as well as user input to adjust the air properties. The overall design is shown in Figure 1 below which describes how all the systems behave.

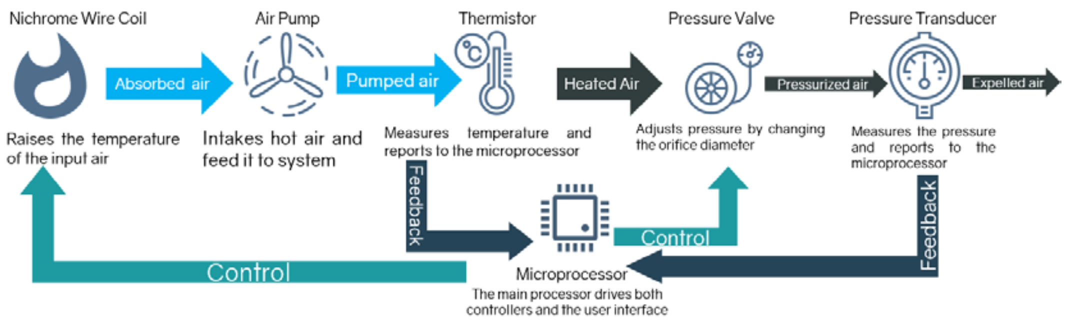


Fig. 1. The overall design of the project with the basic functionality

The pressure control system is a closed loop feedback system where a pressure transducer functions as a sensor that measures the relative pressure of the air as it flows through it. The pressure is translated into a voltage which is sent to the Arduino. The pressure is controlled by using a pressure valve that can adjust the orifice of the air flow resulting in varying pressure in the system. The feedback from the Arduino is translated to current for finer control of the pressure through a current driver circuit.

As for the temperature control system, a thermistor was chosen to measure the temperature of the air as it escapes the device. Similar to how the transducer measures the air pressure, the thermistor will translate a temperature measurement into a voltage which is also read by the Arduino for feedback. The heat is produced using a nichrome alloy wire which is chosen due to its high reliability in terms of rapid heating and cooling as well as its stability at high temperatures.

Results

The APAT controller is capable of reliably adjusting the air properties. The pressure system can output a maximum pressure of 4 [psi] and the temperature system can output a maximum temperature of 30° C. These measured values are within the limits given to us by our sponsor AJ Medical for an effective operation of the device. For the pressure system to work properly, the construction of a current driver gave us the required 300 [mA] needed to operate the pressure valves. As for the temperature system, the design of an acrylic heating chamber gave us the isolated heat control needed to protect our electronic components from high temperature exposure.

Conclusion

Lasers are an important tool in vision correction surgeries so it is imperative that all variables that affect the laser's performance are controlled. Overhydration of the cornea is an issue that needs attention to reduce the problem of inaccurate procedures. The design of the APAT controller can manually adjust the temperature and pressure of the outputted air going to the cornea and fix the issue of overhydration in the eye. The main user, ophthalmologists, will operate the device and determine the pressure and temperature values for the air. This device will improve the results of eye surgeries everywhere and give patients reassurance of a successful procedure.

EMAG SECURITY SYSTEM

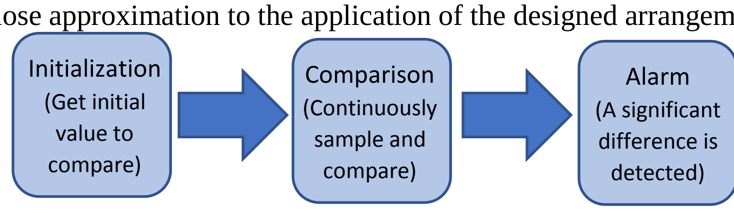
Justin A. Crabb, Christopher Gay, Arian Pourmotamed and King Fung
Department of Electrical and Computer Engineering
University of Houston
Houston, TX 77204-4005

Abstract

A security system is discussed that uses an Arduino to cancel the signal seen by an antenna, and then alerts users when a signal between loop antennas changes significantly. A receiving antenna was placed between two initially identically fed transmitting antennas and sampled by the Arduino. It controls the feed to one transmitter (the canceller) until the receiver receives the smallest signal possible. That signal value is then sampled to set an initial value for future comparison. When a significant difference between the received signal and the initial value is seen, indicating that the secured environment has been interfered with, an LCD screen alerts the user by showing messages and flashing the screen.

Introduction

Our team conducted research on efficient use of antennas with the help of control systems. The design setup consists of a microprocessor that controls the signal between three medium band loop antennas to detect any interference in the network. A security system is a close approximation to the application of the designed arrangement.



Analysis

Our project is a prototype for applications such as motion detectors and environmental security systems. The composition includes three inductive medium band loop antennas, a microprocessor, and a controller unit. The electromagnetic inductance based wireless security system operates with a low power supply and does not require line of sight as low frequency signals penetrate most materials very well, which makes it superior to wired sensors and surveillance systems [1].

The antennas used in our prototype had a resonant frequency of 528 [kHz] which is not the ideal frequency band for a detection system. Higher frequencies (i.e. VHF and UHF bands) are more susceptible to environmental changes and can travel further distances, while lower frequencies are semi oblivious to environmental changes and attenuate faster. However, our choice of antennas was limited to lower frequencies. In the available frequency band, we were limited to loop antennas. Considering the relation between frequency and size of antennas, AM loop antennas were the most logical choice.

Methods

A 100 [kΩ] digital potentiometer for the magnitude controller is controlled by an Arduino Mega 2560. The Arduino program has two phases: arming and set. When arming, the program looks to alter the signal from the canceller until the receiver sees as little signal as possible. It does this by changing the potentiometer value, starting with maximum resistance and reducing it from there until a minimum is found. It then sets the potentiometer to this minimum value and records the magnitude of the signal that the receiver sees. After that, in the "set" phase, the Arduino continually checks the received magnitude. When that value crosses a programmed threshold, the Arduino sets off the alarm. A threshold of 0.3 [V] was seen to be enough range for normal variances in signal to be ignored, but for major interference with the secured area to trip the alarm.

Results

Throughout the project development we have needed to calculate and test several sets of data to achieve optimization, such as the amount of turns for the loop antennas that would result in the best impedance matching. We found 45 turns to be the optimal number for this. This impedance is also related to the operating frequency. We chose to test the antennas empirically, adding a few turns at a time until they worked well enough for us.

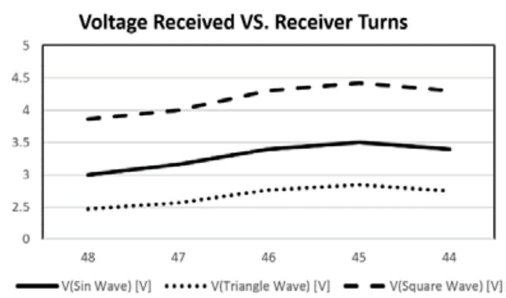


Fig. 1. A plot showing the voltage received vs the turns on the sensor.

This relationship between distance and power was tested and recorded for both the fixed transmitting antenna and the modified transmitting antenna. The plot of voltage received vs distance is shown in *Figure 2*.

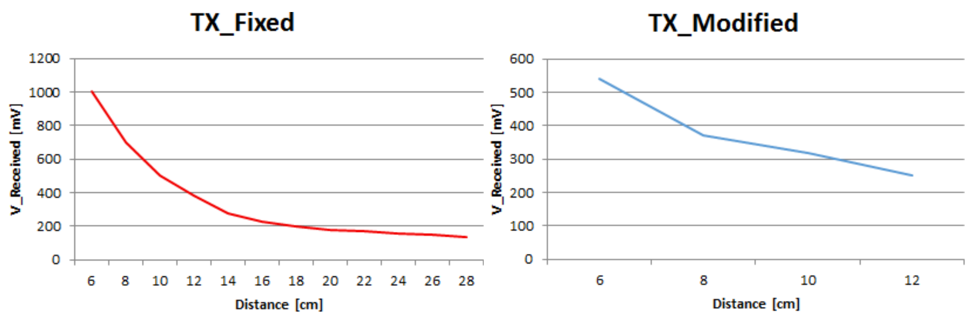


Fig. 2. A plot showing the voltage received from the sensor vs the distance between the sensor and the transmitter for the fixed transmitted signal (left, red) and the modified signal (right, blue).

Our system could only effectively interact within a few centimeters. This could be addressed in further work with bigger loops or more power. We were successfully able to create a system that would use a second transmitter to reduce the signal seen by a receiver, and then detect major changes in a small environment.

References

[1] "The Advantages of a Wireless Security System." *The Advantages of a Wireless Security System*. Alarm.com, 13 Apr. 2015. Web. 22 Apr. 2017.

PROJECT: INDEPENDENCE – A PROJECT ON DEVELOPING AN ELECTROINC GUIDE CANE

Moriah S. Hargrove Anders[1], Nancy Z. Ibarra[1], and Clayton Z. Manchaca[1]
[1] Department of Electrical and Computer Engineering
University of Houston
Houston, TX 77204-4005

Abstract

The purpose of *Project: Independence* is to develop a prototype electronic guidance device for use by visually impaired (VI) users. The product developed by the team is called the *IndieCane* and features crosswalk detection, redesigned GPS navigation assistance, and ultrasonic obstacle detection. Design goals for the device were met, and the user, with the assistance of the *IndieCane,* is able to detect obstacles up to 3[m] away as well as get the cardinal direction and distance reading to points of interest up to 2.5[km] away.

Introduction and User Analysis

VI individuals are currently limited to imperfect guidance such as service dogs and their own memory, both of which require significant route training. Thus, there is a need for a comprehensive device to help VI users navigate independently without reliance on a sighted person.

As part of the design phase, the team met with a partner from the University of Houston Center for Students with disAbilities. This visually impaired participant provided insight to challenges in her daily life. The participant brought up issues with guide animal reliability in crowds and at night and about the significant amount of time and outside help required to learn a route to a new location both for herself and her animal. She also brought up how safely traversing crosswalks can be confusing, how difficult it is to use traditional turn-by-turn navigation, and how the guide cane has limited reach with obstacles [1].

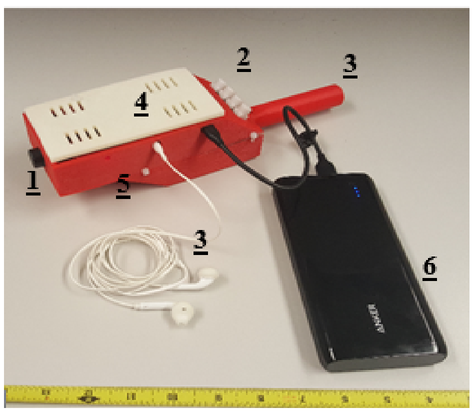
The team took these challenges and designed the *IndieCane* to address them.

Methods

Issues with turn-by-turn navigation are addressed by redesigning the GPS available to the user. The *IndieCane's* navigation assistance uses GPS and compass modules cooperatively. The GPS module uses user coordinates to calculate headings and distances to saved locations relative to user's position. This information is then outputted to the user via audio output. The compass module reports the user's current heading to the user via audio output. The user can then use the GPS module to report destination information and orient themselves towards nearby locations. Together these two modules can be used cooperatively for the user to orient themselves towards desired location without having a reliance on the visual cues associated with traditional turn-by-turn navigation.

Issues with safe navigation through crosswalks are addressed in the crosswalk detection feature which is designed to alert the user when the device positively identifies a white crosswalk stripe. This crosswalk detection was originally planned to be supported through a neural network to help account for deteriorating appearances and different designs of crosswalks. Due to time constraints, the crosswalk detection was implemented through HSV thresholding. Thresholds were determined experimentally and represent values for hue, saturation, and value of the color of each pixel in an image. Thresholding with HSV values allows categorization of pixels independent of color or shade of each pixel. The camera used to take the images for analysis is installed underneath the device on the plane that is diagonal to ground. This is so that the camera is primarily pointed at the ground during image taking. When an appropriate range for white is found within the camera's 20 by 20 pixel viewing window, the device will indicate through an audio output that a white crosswalk stripe is detected with a "beep" sound. This function relies heavily on the user's ability to interpret their surrounding environment as it will not distinguish between the white in a crosswalk and the white of another object.

Finally, the guide cane's limited range is addressed through extended obstacle detection, implemented using an MB1010 ultrasonic sensor. The sensor sends a distance reading to our microprocessor. The program interprets the distance and splits the reading into range thresholds that send output pulse of variable frequency to a vibration motor in the device's handle as haptic feedback indicating distance. Range thresholds are set for every 0.5 meters of distance read and cover a range of 0 to 3 meters.



1. Ultrasonic sensor for obstacle detection
2. Power saving on/off buttons for function
3. Audio & Haptic feedback
4. Internal: compass & GPS modules for navigation assistance
5. Hidden: camera for crosswalk detection
6. Battery pack for 48 hour use

Fig. 1. Final *IndieCane* device. Buttons are used to lessen power usage, audio output is given to user via audio jack, haptic feedback is given to user through device’s handle, and vents are used to help cool device.

Conclusions:

The team was able to accomplish functionalities of device established in the initial design phase. The *IndieCane* passed satisfactory reliability testing at the prototype level and would need to go under a more rigorous design and testing phase if it were to be produced for market. The *IndieCane* successfully combined navigation assistance, obstacle detection, and crosswalk recognition - a combination untested by previous projects.

References

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AUTOMATED SMOKER

Benito Martinez, Kevin Ngo, and Jonathan DeLeon
Department of Electrical and Computer Engineering
University of Houston
Houston, TX 77204-4005

Abstract

The Automated Smoker team is working on a charcoal and wood fired smoker that self-regulates its internal temperature and monitors food temperature, removing the need for an experienced BBQ cook. Using a custom temperature control system, the smoker is able to regulate temperature by automatically adjusting various components to regulate the flow of air while the smoker is in use. The smoker is designed to be user friendly by incorporating a graphical touch screen interface that allows the user to specify their desired cook and adjust components manually if desired, enhancing the BBQ smoking experience for users.

Introduction

Slow smoking meats using charcoal and wood fired smokers require a large amount of time, up to 12 hours at times. Additionally, control of temperature and air flow and the inconvenience of having to monitor the process throughout poses a problem to those who are novices to BBQ smoking. Our solution to this problem comes in the form of an automated smoker based on the notion of a "set it and forget it" nature of conventional ovens. We achieved this solution by designing a smoker that uses a microcontroller to regulate temperature using a custom control algorithm with feedback coming from an ambient smoker temperature reading. The microcontroller, using periodical temperature readings, adjusts a smoke damper, electronic ball valve, and PWM PC fan to regulate the internal temperature and simplify the smoking process for the user. The user interacts with the system using a touch screen user interface. Users are able to simply set the desired meat to be smoked, follow simple starting instructions, and "forget it", eliminating the need for constant monitoring throughout a cook.

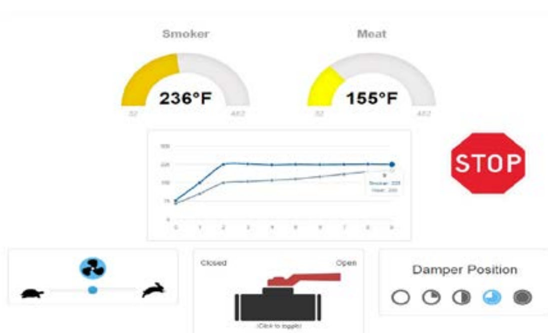

Fig 1. Manual Mode for User Interface

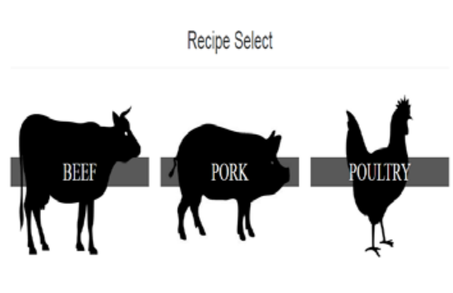

Fig. 2 Automatic Menu Select

Methodology

Our design consists of an Ugly Drum Smoker (UDS) with a touch screen user interface that allows for easy use, experienced or not. When in use, the goal is to have the internal temperature within a ±5% error of the target temperature. The temperature control system design is shown in Figure 1 below. The system feedback is temperature readings taken at a sample rate of 5 seconds. PID control is used to adjust the fan speed using a PWM signal, proportional to the distance away from the target. The system uses on/off control to adjust the ball valve when overshooting the target by more than 5°F. The system uses a step function to adjust the servo-controlled exhaust damper for aggressive temperature reduction.

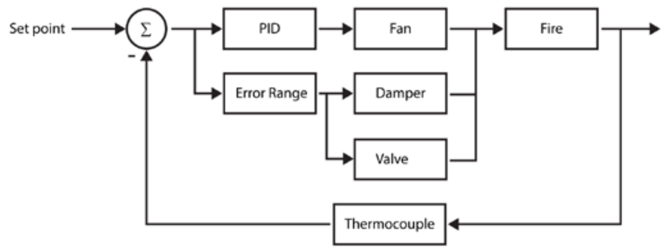

Fig. 3. Temperature Control Flow Chart

The system was tuned/adjusted using a trial and error approach. What we're looking for with the data is how long it takes the smoker to reach set temperature, when does the slope of the temperature increase begin to drop significantly, does it reach set point, etc. We compare these changes to the current position of the servo and fan speed to determine what needs to be changed to get a better result.

Results

Figure 4 shows the temperature regulation at 225 F°. From the data we accomplished regulating the internal temperature within a ±5% error of 225 F°. Although temperature was oscillating, average temperature was 224F°.

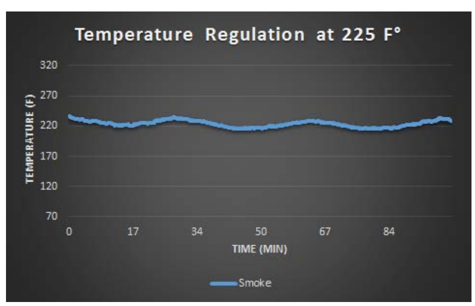

Fig. 4. Temperature Regulation at 225F°

Conclusion

Our tests presented the difficulties in recovering from overshoot in temperature. We realized that it was easier to bring our temperature up compared to the time it took to bring it down. From Figures 3, it shows that temperature regulation was possible, but could have been done more efficiently and effectively. What could have made it more efficient was a better intake system that consists of a ball valve that can partially close and a fan(blower) that could be fully turned off. From our test results, we conclude that the Ugly Drum Smoker(UDS) design provides professionally smoked BBQ.

Resistor Bot: A Resistor Sorting Robotic Arm

Michael Brannon[1], Hazuki Chino[2*], Julio Moreno[2], and Sara Thomas[2]
[1]Department of Electrical and Computer Engineering
[2] Department of Mechanical Engineering
University of Houston
Houston, TX 77204-4005

Abstract

The Resistor Bot project is to create a robotic arm that automates the task of sorting resistors with the aim of inspiring interest and enthusiasm in future engineering students. The Resistor Bot is a standard configuration robot arm with shoulder, elbow and wrist joints and 300˚ of rotation at the base. It operates by picking up a resistor from a tray, carrying the resistor to a camera for identification, and placing the resistor in the correct bin. The project design, programming, and construction goals have all been met within 15% of target. However, the poor reliability of hobby grade servo motors has hampered completion.

Introduction

Sorting resistors is a time consuming and tedious task due to the fact that resistance value is codified in colored bands. The University of Houston Electrical and Computer Engineering Department (ECE) regularly produces piles of unsorted resistors in its laboratory classes and has additionally just installed a display window in one of its labs. Therefore, the Resistor Bot project is to design, program, and manufacture a robotic arm that automates the simple task of sorting resistors with the aim of inspiring interest and enthusiasm in future engineering students. The Resistor Bot has additionally been designed with the upmost adaptability so that it may be repurposed for future, as of yet undetermined, projects. Key adaptability design changes include an expanded range of motion and a lift capacity of 400 grams. Initial usage is as a showpiece for the ECE department to promote the department to prospective students and other visitors. The project advisor is Dr. Leonard Trombetta, and the project sponsor is the University of Houston ECE department.

Specifications & Operation

The Resistor Bot is a standard configuration desktop arm, with shoulder, elbow and wrist joints, mounted on a 38x38x5" wood platform. The armature is polylactic acid plastic (PLA), enabling a 1.5' reach available through 300˚ of rotation at the base. It is additionally equipped with an electromagnet, instead of a traditional gripper, and a camera at the end of its 'hand.' The system includes a second camera attached to a 1' high tower bolted to the platform. All components are controlled by a Raspberry Pi 3, which utilizes Python and OpenCV3 for image processing and motion control.

The Resistor Bot is activated with the touch of a button. Upon activation, it functions by scanning resistors spread out in a tray with its 'hand' camera, which is tasked with identifying a resistor with enough separation from its neighbors that it may be picked up individually by the electromagnet. Once a candidate resistor is identified, the arm moves into position and activates the electromagnet to pick up the resistor. The resistor is then carried to the 'tower' camera, which identifies the resistor value. The Resistor Bot then places the resistor into the correct bin or a bin for unidentified resistors.

Servo Motors

The Resistor Bot project utilizes servo motors at the shoulder, elbow, and wrist, rated at 20-50 kg·cm torque with a 20% margin of safety. Hobby grade servo motors were used for the project due to budget constraints. However, hobby grade motors are not generally tested before shipping, and the project received 2 servo motors that did not function at all. Additionally, servo motors were received that did not fulfill the manufacturer's rotation specifications, rotating 80˚ versus the specified 90˚ for example. Finally, a grounding issue caused a current spike which destroyed 2 sets of servo motors. All of these issues, in addition to shipping issues, contributed to substantially delay the project.

Results

Target Objective	Test Results
Access 80% of 3'x3'x3' volume	82%
Identify pick-up-able resistor 90% correct	80%
Identify reistor value 95% correct	80%

Preliminary results are listed in the table above as trouble obtaining operational servo motors for shoulder, elbow, and wrist actuation has delayed the project. Accessible volume was determined by tracing accessibility on a paper model and then calculating the area accessed. Final result will differ as rotation is limited by the introduction of set switches to calibrate arm rotation at the base. However, the sponsor has approved the reduction in accessibility as it will not reduce Resistor Bot functionality. Preliminary tests for identifying a pick-up-able resistor and the resistor value target objectives were carried out in abbreviated trials of 20 and 10 independent tests respectively. Final trials are to include 50 independent tests.

Conclusion

The Resistor Bot project is considered a success as all of the individual parts of the project are functioning. However, issues with the servo motors and the control circuit have added substantial delays, which eliminated the time scheduled for troubleshooting the integrated system. Given the unreliability of servo motors, a larger margin of safety and careful scheduling is recommended for all future projects involving hobby grade servo motors. Nonetheless, it should also be noted that several issues were also encountered programming the image processing required to identify a pick-up-able resistor and to identify resistor value. Multiple methods were tested for each of these tasks before arriving at project specific programs capable of being fine-tuned to meet the target objectives. Additionally, the team produced 3 armature iterations, including wood and ABS plastic versions, before arriving at the final PLA version. Finally, the entire team followed standard engineering processes, including the creation of spreadsheets to calculate required motor torques and assure sufficient armature strength, and the team stands behind the Resistor Bot as a well-engineered project.

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