Corporate Sponsored Senior Projects Program

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Senior Director of Corporate Development

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BSOE and Silicon Valley Companies

representative research partnerships...
Corporate Sponsors collaborate with faculty to define high-value senior design projects

- Students are engaged in meaningful interdisciplinary team-based learning:
  - Teams of 3-5 students work on the project for two+ quarters (1200 work-hours minimum) to fulfill their graduation requirements
- The corporate sponsor provides a designated liaison as the team’s customer
  - Sponsor helps plan projects to ensure that schedules and milestones are realistic
  - Teams interact with sponsors weekly for project to review project status and progress
- Fall 2014 Program sponsors are signing up now

Corporate Sponsors can receive full intellectual property rights to all results developed by undergraduate students

- A great way to get to know a group of undergraduates who are interested in your company and technology for potential future employment
## Computer Engineering/Electrical Engineering Student Skill Sets

<table>
<thead>
<tr>
<th>Senior Design Area of Focus</th>
<th>Computer Engr. / Electrical Engr. Skillsets</th>
<th>Recent Projects</th>
</tr>
</thead>
</table>
| Systems                     | Location aware systems (from sensors, GPS, or reference marks)  
                                 | Embedded systems  
                                 | Automotive Sensor systems  
                                 | Co-processors and special purpose digital devices  
                                 | Instrumentation platforms  
                                 | Actuators / controllers |
| Signal Processing           | Signal Conditioning  
                                 | Signal / Waveform Recognition  
                                 | Multimedia signal processing (e.g. transcoding)  
                                 | Acoustic effects (e.g. music)  
                                 | Infrared Sensing Technologies - Multitouch Input |
| Robotics                    | Precision Feedback and Robotic control systems |
| Autonomous Systems          |                                            | Residential Electrical Load Monitoring |
| Communications/Networks     | Protocols / Network bridging  
                                 | Specialized low cost / low power RF data links  
                                 | Network traffic monitoring and analysis |
| Remote Sensing/Environment Monitoring | Wireless sensor systems for alternative energy applications |
| Human – Computer Interfaces | New input devices / haptics  
                                 | Gesture recognition  
                                 | Image input  
                                 | Advanced display technologies  
                                 | Human-Computer Interfaces |
| Assistive Devices           |                                            | Bluetooth-enabled crosswalk for the blind  
                                 | Lower limb pneumatic exoskeleton |
| Alternative Energy          |                                            | Regenerative bicycle  
                                 | Ocean Wave Generator  
                                 | Low-cost synchrophasors |
## Computer Science Student Skill Sets

<table>
<thead>
<tr>
<th>Senior Design Area of Focus</th>
<th>Computer Science Skill Sets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer systems</td>
<td>Operating systems, embedded operating systems</td>
</tr>
<tr>
<td>Storage systems</td>
<td>Adaptation of existing file systems, analysis of file system variations, file system utilities</td>
</tr>
<tr>
<td>Software engineering</td>
<td>Agile/Scrum, UML, software forge, software configuration management, general ability to write software in Java, C++, C</td>
</tr>
<tr>
<td>Web engineering</td>
<td>Database-backed web sites, information design, Javascript, HTML/CSS, HTML5, Flash. Cloud computing: interfacing with cloud-based APIs.</td>
</tr>
<tr>
<td>Machine learning/data analytics</td>
<td>Statistical, classification and similarity type analyses on large datasets. Ability to perform visualization of large datasets.</td>
</tr>
<tr>
<td>Mobile applications</td>
<td>Applications for mobile phones and tablets (iPhone/iOS, Android, Windows Phone 7)</td>
</tr>
<tr>
<td>Computer games</td>
<td>Design and implementation of interactive computer games running on a wide range of platforms (mobile platforms, browser-based, Windows)</td>
</tr>
<tr>
<td>Computer graphics</td>
<td>3D computer graphics, procedural generation of scenes, 3D modeling and animation, 3D data visualization</td>
</tr>
<tr>
<td>Proof of concept, emerging standards</td>
<td>Proof of concept implementation of emerging software standards, interface standards, etc.</td>
</tr>
</tbody>
</table>
Corporate Sponsored Senior Projects Program 2013/2014

SPONSORS

SPECIAL THANKS to our sponsors for your generous support of our Corporate Sponsored Senior Projects Program. Your time, experience, and financial support were beneficial to our students and the success of their Senior Design Projects.
What needs to happen to participate in the CSSPP in 2014/2015?

1) Company and the faculty need to come up with a project/projects that are both meaningful to Company and doable by our students in the 20+ weeks associated with the class. We would like to get the potential projects agreed to and defined as soon as possible. Students will decide on projects by Thanksgiving. Company has to come up with a technical contact(s) who will be the "customer" for the student team(s) as they do the work. It involves about an hour a week of engagement with the students, generally via conference call/video conference with intermittent face-to-face visits.

2) Company needs to decide if it wants to own the IP generated by the students during the course of the class. If so, we can send you an agreement we have already gotten UCSC Legal approval on for review by your lawyers.

3) Company needs to commit to give UCSC a gift of $30,000 (Thirty thousand US$) for each project that students sign up to We expect the student decisions to happen in the Fall Quarter and would like the gifts made to UCSC before 12/31/2014, but this could come as late as January 2015.

4) We will offer the opportunity to Company to come to the Baskin School of Engineering to introduce your company and your project(s) to the students. The other companies participating in the program will also be coming to pitch the students on why their company/project is the most interesting to sign up for.

5) We will likely have a Partner’s Recruiting Event at BSOE in February and Partner's Day meeting in late May/early June where our students will show off the results of their work.
INTRODUCTION

We are pleased to provide this booklet highlighting our third year of the Corporate Sponsored Senior Project Program also including this year’s Capstone projects from our non-sponsored student teams in Computer Engineering and Electrical Engineering! Our students have worked very hard during their time at UC Santa Cruz earning their degree and fulfilling this capstone design sequence.

“[If] students are to be prepared to enter new-century engineering, the center of engineering education should be professional practice, integrating technical knowledge and skills of practice” [Sheppard et al., 2009]. Students who have participated in this Corporate Sponsored program have been provided with a unique opportunity to experience working on real-world projects that involve design, budgets, deadlines, teamwork and reviews with their team mentor. They have come away with a sense of professionalism and pride in their work learned challenging skills, experienced entrepreneurship and been introduced to the many implications of intellectual property.

Throughout this academic year, the students have interacted with their teammates, some have made visits to their corporate sponsor’s worksite and all have solved problems that arose along the way. The students take great pride in their completed projects and all they have accomplished during their time at UC Santa Cruz and the Baskin School of Engineering.

We also take great pride in what the students have accomplished. We are very grateful to our corporate sponsors for their willingness to sponsor this year-long program, mentor our students and provide them with challenging projects to work on.

Arthur P. Ramirez
Dean
Baskin School of Engineering

SPONSORS

SPECIAL THANKS to our sponsors for your generous support of our Corporate Sponsored Senior Projects Program. Your time, experience, and financial support were beneficial to our students and the success of their Senior Design Projects.
Haptics Response Testbed
Stephanie Kwok, James Le, Thomas Moore, Stephanie Weber, Stanley Wu, Nelson Zhou, Elizabeth Zitzer

Abstract
Haptics in the creation of tactile effects in devices using haptic systems. This project focused on the characterization and the simulation of the haptic device's response to various input frequencies. The project was successful in characterizing the haptic device's response and simulating its behavior.

Approach
Research was divided into two sections: hardware and software. The hardware team was responsible for building a testbed that could measure the haptic device's response to different input frequencies. The software team was responsible for developing a simulation model of the haptic device.

Experimentation
The hardware team characterized the haptic device's response to different frequencies by measuring the force generated by the device at various input frequencies. The software team developed a simulation model of the haptic device using a commercially available haptic simulation software.

Analysis
In varying the frequency, the hardware team found that the haptic device's response was consistent with the simulation model. The software team then simulated the device's response to different frequencies and compared it with the experimental data.

Results
The results showed that the simulation model accurately predicted the haptic device's response to different frequencies. The hardware team also conducted a user study to evaluate the user's perception of the haptic feedback.

Conclusion
The project successfully characterized the haptic device's response to different frequencies and simulated its behavior using a simulation model. The results were validated by comparing the simulation model's predictions with the experimental data. The user study also showed that the haptic feedback was perceived as realistic.

Looking Forward
The research team plans to further refine the simulation model and improve the haptic feedback's realism. They also plan to conduct more user studies to evaluate different haptic feedback designs.
Abstract

The aim of this project is to develop a reliable test method in determining the dielectric properties of a material at microwave frequencies. Testing the samples at frequencies of 20-100 GHz will lead to possible applications of the glass at 20-100 GHz. Specifically, we will be testing Eagle XG Glass and a fused silica glass manufactured by our corporate sponsor, Corning Incorporated.

Approach

The Eagle XG Glass has not been tested at microwave frequencies. To work around these unknown variables, we plan to compare two test methods at 3 GHz and 20 GHz.

The transmission line method.

The tapered transmission line method.

Overview

Designed tests to find the dielectric loss tangent of Corning glass samples in the S-band (2.4 GHz) and K-band (18-26.5 GHz) or more specifically microwave frequencies above 20 GHz.

Using the Vector Network Analyzer (VNA) we will be measuring s-parameters to find the complex permittivity [1]. The ratio between the imaginary and real parts of the complex permittivity [2] will yield to loss tangent of the material.

\[ \epsilon'' = \epsilon' - j\epsilon'' \] [1]

\[ \tan(\delta) = \frac{\epsilon''}{\epsilon'} \] [2]

Analysis

The transmission line test was performed by placing a thin sample into a waveguide and finding the difference between it and free space. We noted \( s_1 \) and \( s_2 \), that led us to calculate the loss tangent of the materials.

Large errors in the tapered transmission line test which led us to place emphasis of our project onto the transmission line method.

Results

<table>
<thead>
<tr>
<th>Material</th>
<th>Loss Tangent</th>
<th>Dielectric Constant</th>
<th>Frequency (GHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eagle XG (E)</td>
<td>0.762</td>
<td>3.041</td>
<td>2.4</td>
</tr>
<tr>
<td>Eagle 16 (E)</td>
<td>0.793</td>
<td>3.067</td>
<td>3</td>
</tr>
<tr>
<td>Eagle 1912 (E)</td>
<td>0.832</td>
<td>3.206</td>
<td>3</td>
</tr>
<tr>
<td>Parallel Wave</td>
<td>0.536</td>
<td>1.176</td>
<td>3</td>
</tr>
<tr>
<td>Teflon</td>
<td>0.913</td>
<td>2.45</td>
<td>20</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.865</td>
<td>1.91</td>
<td>20</td>
</tr>
<tr>
<td>Fused Silica</td>
<td>0.854</td>
<td>0.835</td>
<td>20</td>
</tr>
<tr>
<td>Eagle XG</td>
<td>0.804</td>
<td>1.021</td>
<td>20</td>
</tr>
<tr>
<td>UNKNOWN</td>
<td>0.907</td>
<td>1.9054</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 2 – Results from transmission line method.

Potential reasons for error:
- Calibration issues
- Imperfect glass (scratches, cracks, etc.)
- Improper sample dimensions
- Cavity leakage
- Improper handling of samples (finger oils, etc.)
- Placement of samples within waveguide

Conclusion

The transmission line method seemed to work and we believe our other methods would have as well given we had exact samples requested. Unfortunately, this was more difficult than expected due to the precise dimensions we needed.

Acknowledgments

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HP Object Storage Metadata Search
Xiaoyuan Lu, Radhika Mitra, Masahiro Obuchi, Nathaniel Rogers, TJ White

Abstract
Sponsored by HP, this project's goal is to add an Object Storage Metadata Search to OpenStack Swift. The API allows a user to query the metadata of objects, containers, and accounts stored in the Swift system. The output is filtered according to user-specified query statements and attribute lists. The output can also be sorted and be presented in multiple formats in the HTTP body returned. The searchable metadata is stored in a database on a newly created server which is populated by crawlers. These crawlers periodically run on the Account, Container, and Object servers. This RESTful API is implemented in middleware on the proxy server.

Approach
The components of OpenStack Swift that our backend implementation communicates with are:
- **Proxy Servers**: The public face of OpenStack Swift, it handles all incoming API requests. Once a Proxy Server receives a request, it passes the request to the appropriate server.
- **Account and Container Servers**: Each Account and Container is an individual database that is distributed across the cluster. An Account database contains a list of Containers in that Account. A Container database contains a list of Objects in that Container.
- **Object Servers**: Contains the data itself. We add crawlers, or daemon processes, to the Account, Container, and Object servers. These crawlers send the metadata to the Metadata Server which holds all of the requested metadata for all items in the OpenStack Swift cluster. The Metadata Server receives updates as the individual Objects, Containers, and Accounts are updated. The Proxy Server communicates with the Metadata Server over HTTP to fetch information and return the query results.

Future Work
- Finish implementing whole specification
- Metadata Database (Replication)
- Security - Access control to metadata and Authorized Searchers Feature (from API)
- Improve efficiency of updating metadata
- Middleware capture
- Hook into update daemons
- Choose a more suitable database (SQLite not scalable)
- MySQL? NoSQL? Distributed DB?

Overview

Crawler Structure
One of our design goals is to leave the OpenStack Swift base code the same for easy adding and removal of our crawler code. To accomplish this, we created a different crawler for each of these servers. These crawlers independently retrieve the metadata out of each server’s backend and send it to the Metadata server. The crawlers run at a configurable interval. For Objects, it only sends metadata if a change was detected within the last interval.

Server Structure
The Metadata server was added to the Swift architecture in order to have a database abstraction layer as well as an encapsulated Metadata Search API. The Metadata server has two main source code files:

* **server.py**: is the code that processes the Metadata Search API query. This code parses the query parameters and makes calls to the database abstraction layer to retrieve the requested data. It also receives and processes metadata sent from the crawler and stores by passing to the database abstraction layer.

* **backend.py**: is the code for the database abstraction layer. We used SQLite for our implementation. We have four tables: Object, Container, and Account system metadata tables and a custom metadata table which has URL, key, and value columns.

Conclusion
The Object Storage Metadata Search API gives users greater insight into data stored in their OpenStack Swift Storage systems as well as providing an easy to use, concise, and powerful interface. The ability to query metadata provides a service that did not exist before and gives greater control into how a user sees the data stored in their cluster. The interface has many commands and specifiers that allow quick building of expressive queries.
Capstone Project

Polymer Discovery
Thomas Goddard, Konstantin Litovskiy, Nathan Nichols-Roy, Matthew Reed, Igor Shvartsber, Nicholas Lush, David Zeppa

Abstract

The recognition of polymer images in the literature is a key for automatic understanding of the wealth of polymer data already known. While there exist OSA (Optical Structure Recognition Application) [1] to identify and interpret chemical structures, these tools do not yet work for polymers. Our capstone project extends OSA's capabilities by being able to recognize branches and pendant structures in polymer images. To date, OSA allows the generation of high-level process diagrams of polymer structures, but does not allow for the recognition of pendant structures, such as cross-links or defect structures.

Introduction

Accurate and rapid materials discovery is at the core of innovation, economic opportunities, and global competitiveness. The research community is responsible for bringing new materials to market. In 2011, President Obama launched the U.S. Material Genome Initiative (MGI) and challenged scientists, policymakers, and business leaders to reduce the time and resources needed to bring new materials to market—a process that today can take 10 years or more. There is great potential in leveraging modern data mining, big data analytics, and physical modeling approaches to materials science. OSA, as an important part of materials science, is well placed to play a role in this research. In our work, we have developed a method for the recognition of pendant structures in polymer images, which can be used to identify and provide information about these structures.

Background

Optical Structure Recognition Application (OSRA)

OSRA extends OSA, a tool for creating visual images of chemical structures in documents, to support polymer images that are bracketed and parenthesis and enhance it for non-polymer images. OSRA allows a user to input a polymer image and another image that shows the polymer image. The polymer image is then analyzed to identify potential structures, and the polymer image is used to identify potential structures in the other image.

Results

High Level Process Diagram of P-OSRA

Figure 1 shows a high-level process diagram of the P-OSRA system. The system takes an input image of a polymer structure and outputs a polymer structure diagram. The system uses a combination of machine learning and rules-based methods to identify polymer structures.

Finding and Removing Brackets

At first, we took the approach of using point density data from a vector conversion of a chemical structure to find segments of the diagram that could be brackets. This proved somewhat inaccurate and difficult to implement. Instead, we first develop an algorithm to detect segments in the diagram and then find the boundaries of the segments. We then use a topological approach to find the boundaries of the segments. A segment is defined as a line that is connected to another line at both endpoints. We then use a topological approach to find the boundaries of the segments. A segment is defined as a line that is connected to another line at both endpoints.

Editing the SMILES String

Since we have replaced the brackets by backbone atoms, OSRA then continues to parse the image as a normal chemical structure and red box. Figure 1 shows the new SMILES string (denoted by OpenBabel) that the system is able to produce. OSRA also performs a stress test of the process by replacing a backbone atom with a new atom. The system is able to produce the new SMILES string, which correctly identifies the backbone atom and the atom attached to it.

Acknowledgement

Many thanks and appreciation to IBM Research, Dr. Julia Rieu, Dr. Anand Devanathan, and Dr. Aditya Prakash, for their creating a capstone project in OSA, Dr. Igor Shvartsber, and Professor Linda Woltering, for their support.
Capstone Project

ActiveDirectory Updated
Ian Blake, Matthew Caruano, Ignacio Llamas, Jeffrey Ma, Paul Scherer

Abstract
Imprivata Cortex is a secure mobile messaging platform for healthcare professionals. Our objective is to improve upon the existing platform by designing a system to decrease the size of data updates and make changes available for the users on demand.

This roughly translates to two areas of interest:
- Provide incremental data updates
- Convert from a data-pull model (in which the user gets new data only when it is requested) to a data-push model (where the user gets new data as soon as it is available)

Methodologies
- For the incremental update problem, we create deltas (changes to data), and combine these deltas into a checkpoint system. Only new updates are sent to the clients, as opposed to sending the entire domain directory
  - The checkpoint system monitors and packages deltas accordingly
- To change from a data-pull model to a data-push model, we integrated use of the publish-subscribe ejabberd module.

Publish-Subscribe Implementation
The server compares the timestamp and packages the appropriate delta and/or directory. Subscribed clients will receive the packaged updates as they become available.

Language Interface
The server runs on ejabberd, which is a platform that uses both Erlang and the XMPP protocol. Aside from the server, we use Postgres to help store all the necessary data for the implementation. In addition, there are also Python scripts to help connect the Postgres with the ejabberd server to listen for changes and trigger appropriate actions.

Delta Implementation
The database monitors the clients' updates, inserts, or deletes. There is a server listening for these changes, which packages the updates into deltas or a checkpoint.

Technologies/Methodologies Used
- Python (database interface)
- Postgres (database)
- ejabberd (XMPP server platform)
- Written in Erlang
- XMPP (messaging protocol)
- IQ Stanzas (client-server queues)
- Publish-Subscribe Protocol (push-model spec)

Results
- Server determines which client update method is more efficient; to send deltas, a checkpoint, or a combination of both
- Clients no longer need to poll the server for updates
- Connected clients are immediately given updates as they occur
- Maintains backwards compatibility

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CTO, Cortex,  Software Engineer,
Imprivata  Imprivata

Krutarth Shah  Dr. Linda Werner
VP, Engineering  Faculty Advisor
Mobile Products,  Imprivata
Imprivata
Capstone Project

Geo-tagged Sensor Fusion

Bardia Keyoumarsi, Michael Bennett, David Tucker, Vincent Lantaca, Michael Baptist

Abstract

Motivation:
The Lawrence Livermore National Laboratory’s Data Science Initiative was established to advance state-of-the-art technology in the Big Data domain including data collection methodology, storage, visualization, analytics, modeling, simulation, and high performance computing capabilities. To support this initiative, the students and faculty of this School of Engineering (SoE) at University of California, Santa Cruz (UCSC) produced a real-time sensor collection system whose acquired data can be fused with publicly available open data (e.g., social media, climate data, traffic data, etc.).

Objective:
The goal of this project is to produce a web application that will merge gathered data with publicly available information using standard formats and open platforms. Another dedicated application (the iOS) would allow any iPhone to become an information collection source, and relationships among data can be determined using attached metadata. Related data may be visualized using a number of methods including graphing and geographic plotting. Implementation specifics will need to be clearly documented and clearly presented.

In addition to the real-time sensor collection system, the GSF project team has created tools and frameworks for data query, analysis, and visualization of the fused data for utility and ease of adoption to later potential applications.

Approach

The Geo-tagged Sensor Fusion (GSF) project uses a dedicated iOS application that interacts with the iPhone’s onboard sensors to collect various types of data. In addition, a plugable sensor module has been designed to interact with the iPhone’s headphone jack for additional sensory data. The headphone jack is used for power and communication with the plugable sensors. Each sensor is identified by our application when plugged in and transmits data samples to the application.

All the collected data is then sent to a centralized server where it is stored in a NoSQL database. The web application is used to interact with the database to allow users to create their own visualizations. The users have the ability to use the collected data with other publicly available open data to create meaningful visualizations.

Overview

Web Application:
The web application suite runs on the Django platform and uses MongoDB as its NoSQL database. The web app allows users to create visualizations by querying sensory data collected by the iOS app and feeds retrieved from Twitter. The backend of the web app includes a RESTful API that allows the iOS app to upload data and third party applications to access data from our database. All data is stored in a GEOJSON format.

Software Analysis

The web application suite runs on the Django platform and uses MongoDB as its NoSQL database. The web app allows users to create visualizations by querying sensory data collected by the iOS app and feeds retrieved from Twitter. The backend of the web app includes a RESTful API that allows the iOS app to upload data and third party applications to access data from our database. All data is stored in a GEOJSON format.

Hardware Analysis

Plugable Sensor:
The plugable sensor is powered by a three ampere on the left channel of the headphone jack, which is stepped up, rectified, and regulated to around 3V. This is used to power an AT14802A microcontroller which retrieves data from a digital temperature/humidity via I2C.

Signal Processing:
The communication from our microcontroller to the iPhone is through the microphone of the iPhone’s audio jack. We use a contrived AC signal to transfer encoded data over the communication channel. When the signal reaches the iPhone we process the audio samples and decode the bits. The iPhone can request data from the microcontroller by sending a transmission on the right audio subchannel, which is connected to an ADC on the microcontroller.

Results

Over the course of our initial implementation time, under extreme working conditions, we have developed a mobile sensor suite that pushes sensor population, temperature, and humidity data to our web application. In addition to data collected by the iPhone, we have also developed a retriever that requests data from Twitter. The data is stored in our database and is available for viewing via our web app.

Conclusion

The Geo-tagged Sensor Fusion project will allow users to participate in a global survey that will attempt to merge and visualize the massive amounts of unorganized public data available to the population. The use of sensors allows people to add to publicly available data which could be useful for understanding, crime response, and many other applications.

Establishing data relationships provides a better means for producing new research and educating the population as it makes finding relevant information quicker and more convenient.

Acknowledgements

We would like to thank:
- Lawrence Livermore National Laboratory for sponsoring our project and Umitan Goldman for his countless hours of headside and technical support.
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Capstone Project

Wireless Security Device

Jesus De Haro, Ellis Izumoto, Samantha Tak, Dennis Tran

Abstract

Motivation
There are two things that people desire from their passwords and the devices that store them—convenience and security. People have many passwords and user logins that they must remember. It is difficult for a person to come up with different secure passwords for each website and expect to remember them all. Having a device that could identify the user and login to any website he or she desires would add convenience to the user’s life. Furthermore, users do not only want convenience, but they also want security. They want the ease of accessing websites knowing that it is unlikely their passwords or online identities will be stolen.

Objective
The goal of this project is to design and implement a wearable device that will link to other devices through wireless communication and have it securely login to websites of the user’s choice. The wearable must be secured to ensure that the correct person is using the device. This project will play on the principle of convenience, enabling access to passwords over a range of devices based on proximity.

The project assignment is to create a wearable prototype that will authenticate the intended user of the device. The user is then continually maintained to confirm the device stays on the appropriate person. The prototype will sign into websites that would normally require a password input. The device will do this wirelessly and securely, knowing that it is the proper user without having him or her re-authenticate after the device is placed. The wearable will also test for forgotten passwords or forgot that from other users trying to access the wearable device using biometrics.

Approach
Our approach to this project was to first research similar products that were currently in the market. This gave us a glimpse into what components and methods we could use for our design. The next thing we had to do was to research individual components and options and check if they fit into our system requirements. The next step was the prototyping stage where we test modules individually such as the fingerprint scanner, skin contact sensor, and microphone. After testing each component separately, we integrated them into one system. The final stage was the enhancement stage where we start moving our prototype onto a PCB and cleaning up any errors that would inhibit the user experience.

Project Overview

This project’s main goal is to create a prototype of a wearable security device that is able to log into websites that require passwords. The device will authenticate the user with biometrics and will continuously monitor that the device has not lost contact with the user.

Results & Analysis

System Requirements
- Power: limited to a single rechargeable cell
- Temperature: should be less than 100°F
- Size: area limited to 110mm x 110mm x 20mm
- Weight: must weigh less than 8 ounces
- Connectivity: must have two UART interfaces for the fingerprint scanner and wireless communication module

Wearable
The wearable is composed of four main modules: a control unit, a skin contact sensor, a fingerprint scanner, and a wireless communication module. The control unit handles input from the other three components and sends commands to both the wireless communication module and the fingerprint scanner depending on the input it receives from the user on the target device.

Target Device
The target device is any device that supports a Google Chrome browser such as a mobile phone or computer. For the design to work properly the user must install a Chrome App and connect a USB wireless communication module.

Security Flow Diagrams

Acknowledgments
Our team would like to first thank the Baskin School of Engineering at University of California, Santa Cruz for giving us the opportunity to participate in the Senior Design course. Also, we thank SEC for providing us with components through the design process. We would like to thank McAfee, Intel Security, especially Christian Rohrer, Cal Woodward, and Peter Wyler. We also want to thank our instructor David Munday and TA Ethan Papp for the guidance they provided.
Abstract

In main distributed systems, many important data processing algorithms are used. They can be processed in a faster manner and can be compressed to reduce the amount of data bandwidth available to applications. This is achieved through efficient design of hardware compression. The proposed system is designed to compress the data sent over the network, which reduces the amount of data that needs to be transmitted. This is achieved by using a hardware compression technique called compression-based on a parallel approach. The compression engine is designed to be scalable and can be integrated with existing systems.

Overview

The proposed compression system is designed to be scalable and can be integrated with existing systems. The system is designed to compress the data sent over the network, which reduces the amount of data that needs to be transmitted. This is achieved by using a hardware compression technique called compression-based on a parallel approach. The compression engine is designed to be scalable and can be integrated with existing systems.

Decompression

The decompression system is designed to be scalable and can be integrated with existing systems. The system is designed to decompress the data sent over the network, which reduces the amount of data that needs to be transmitted. This is achieved by using a hardware compression technique called compression-based on a parallel approach. The compression engine is designed to be scalable and can be integrated with existing systems.

Compression

Compression is achieved by reducing the amount of data that needs to be transmitted. The system is designed to compress the data sent over the network, which reduces the amount of data that needs to be transmitted. This is achieved by using a hardware compression technique called compression-based on a parallel approach. The compression engine is designed to be scalable and can be integrated with existing systems.

Decompression

Decompression is achieved by reducing the amount of data that needs to be transmitted. The system is designed to decompress the data sent over the network, which reduces the amount of data that needs to be transmitted. This is achieved by using a hardware compression technique called compression-based on a parallel approach. The compression engine is designed to be scalable and can be integrated with existing systems.

Results

From Figure 1, the compression ratio of 5:12 was achieved, which is significantly higher than the compression ratio of 1:4 achieved by the parallel approach. The system was able to achieve the compression ratio of 5:12 by using a hardware compression technique called compression-based on a parallel approach. The compression engine is designed to be scalable and can be integrated with existing systems.

References

Capstone Project

Variable Signal Delay

John Gustafson and Kelly McNutt

Abstract

Applied Signal Technology has funded this senior design project to create a variable signal delay. A signal delay is something that can increase the phase of a wave without distorting the signal. The goal is to create a system that takes an analog signal and output the signal with a delay. The delay can be as small as 50 picoseconds and as much as 40 microseconds. To implement this delay we will be using a convolution on the input wave with a shifting set of coefficients.

Approach

- **Main Components**
  - The system is made up of a few parts: The delay controller, the fine delay, the course delay, the DAC, and the ADC
  - A user interface is needed to specify the time delay
  - The prototype is made on the PSoC5 Cypress Controller
  - The final design is made on the Xilinx Kintex 7 FPGA
  - The DAC and ADC are implemented on the FPGA

- **Fine Delay**
  - Takes in data from the ADC to a 16 by 12 bit buffer
  - Uses the buffer to do a 16 tap convolution with sinc function coefficients
  - To create a delay, a different set of 16 equally spaced taps are chosen from the sinc function
  - The set of coefficients used are determined by the delay controller
  - The output is sent to the course delay

- **Course Delay**
  - Takes in data from the fine delay
  - Uses a circular buffer of length 1048676 by 12 bits to store the wave
  - The delay controller tells the course delay what address to output to DAC

- **Delay Controller**
  - The human interface with the fine and course delay
  - The delay controller evenly changes the fine delay

Overview

- The delay controller acts as the brain of the microcontroller. It controls the delay values that alter how much of the rest of the design delays the output
- User input drives the delay controller, which then drives the circular buffer and the coefficient RAM. The fine delay convolution grabs data from the coefficient RAM. The rest of the process runs ADC to DAC.

Analysis

- There are two main obstacles to overcome when designing a digital filter:
  - The math behind the fine delay
  - Parallel programming in VHDL
- The fine delay works by having 1024 coefficients hardcoded into memory. The filter grabs 16 equally spaced taps and pipeline multiple these taps with the ADC 16 by 12 bit buffer. The 16 numbers are then cascade added and output to the circular buffer
  - Shifting the coefficients causes a delay by centering the 16 incoming wave data points around the center of the set of 16 coefficient taps chosen.
  - Each operation had to be done in sets of one clock cycle to keep the speed around 200 MHz. Each function had to be pipelined and done in increments.
- The course delay is a circular buffer in VHDL which utilizes its own programed RAM

Results

The PSoC prototype has a working fine delay and course delay but the code runs slowly. The fine delay on the PSoC has an amplitude distortion when the delay is shifted, but does increase the delay precision up to 8x. The KC705 final design runs a 245.76 MHz sampling rate and gives us 2.85Gb/s of data to process.

Conclusion

The coefficient shifts are able to increase the resolution of a phase delay as long as the code is properly implemented in parallel. Otherwise the added code slows down the throughput to a point where implementing a pure course delay would have more precision. At our optimum we can increase the resolution of our sampling frequency by 8x.
Capstone Project

Serene Source
Gahl Levy, Michael Parker, Daniel Shubin, James Thomas, Aastha Verma, Sable Yemane

Chef Plugin
Abstract
The Chef Plugin allows users of Serena Release Automation to interface with Chef, an application management tool. Chef describes infrastructure as a series of resources that should be in a particular state, packages that should be installed, services that should be running, and files that should be created. This plugin allows users to easily create and automate Chef tasks which manage Chef resources and provision and configure machines.

Technologies Used
- **Serena Release Automation** - A platform to automate the deployment of new software and updates to machines both locally and in remote locations.
- **Chef** - A tool for configuring and maintaining servers as well as provisioning and configuring new machines.
- **Groovy** - Cross Platform Scripting language used to execute the processes in the plug-in Serena Release Automation.
- **XML** - A language used for User Interface definitions of plugins for Serena Release Automation.
- **Maven** - Build automation tool that describes how software is built and its dependencies. Used to build the plugin for the Serena Release Automation Software.

Approach
- Install, configure, and learn how to use Chef.
- Determine necessary functionality for Chef Plugin.
- Write Groovy scripts to execute plugin tasks.
- Define plugin user interface with XML.
- Build Groovy scripts and XML into a plugin for Serena Release Automation with Maven.

Results
- The plugin allows for the automation of Chef processes through Serena Release Automation.
- Automated deployment of chef recipes.
- Automated management of assets on chef server.

Conclusion
By creating a plugin and a mobile application for Serena Release Automation, this project helps to expand the scope of Release Automation by allowing users to automate Chef processes and have faster and simpler access to Serena Release Automation. The Chef plugin allows DevOps engineers to maintain their existing Chef infrastructure while gaining access to more powerful features provided by Serena Release Automation. The mobile application for Serena Release Automation gives DevOps engineers the flexibility to interact with Serena Release Automation from anywhere.

Motivation
DevOps bridges the gap between software development, IT, and QA to make software release and management faster, easier, and more consistent. This is accomplished partly through release automation: the automated deployment of software, updates, and machine configuration. Continuing in this theme, the goal of this project is to abstract away details of release automation to make it a simpler process for DevOps engineers. This was done by creating new functionality for Serena Release Automation: a Chef plugin and a Mobile application.

Serena Mobile
Abstract
Serena Mobile gives DevOps engineers the ability to manage Serena Release Automation from anywhere. The mobile application allows for the approval of process requests, the requesting of new processes, and viewing the status of processes that are currently running or scheduled for the future. These features allow for the deployment of software, updates, and machine configuration without extra navigation that is needed when using a web browser.

Technologies Used
- **Serena Release Automation** - A platform to automate the deployment of new software and updates to machines both locally and in remote locations.
- **FluidUI** - QT tool to create mockups for mobile user interfaces.

Approach
- Determine which core features of Serena Release Automation that would give the most utility to a mobile application.
- Create a mockup user interface to test the flow and the layout of the mobile application.

Results
- Developed a functioning mobile application.
- Mobile features included.
- Approval of Process allows users to approve or deny processes.
- View Process allows users to view running or scheduled processes while also being able to pause or cancel a process.
- Request Process allows users to schedule new processes.

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Interactive Visualization of the Next Generation Science Standards

Austin Coleman, Stephen Domenici, Jonathan Eboh, Mesuilame Mataitoga, Henry Ta

Abstract

Sponsored by Tangle, Inc., our application is an Interactive Visualization of the Next Generation Science Standards (NGSS). "The Next Generation Science Standards establish the learning goals in science that will give all K-12 students the skills and knowledge they need to be informed citizens, college ready, and prepared for careers." Our application allows the display and manipulation of a 3-dimensional representation of the NGSS. This gives teachers and curriculum designers an improved experience when viewing the NGSS on zSpace2, iPad, Android, and web platforms. zSpace is an immersive, interactive 3D display. The zSpace version of the application allows users a level of interaction that is not present in existing textual representations.

Our internal 3D representation of the NGSS will allow teachers and administrators to use the 3D capabilities of the zSpace computer to visualize this graph. Users can manipulate the graph along three axes. The iPad allows users to manipulate a 3D representation of the NGSS.

Usability

Our visualization of the NGSS is optimized for human intuition via the use of cognitive lenses. It is targeted toward teachers and curriculum designers that are exploring or have adopted the NGSS. We’ve designed the tool to cut through the complexity of the NGSS. The Visualizer of the NGSS focuses on visualizing and connecting the different performance expectations of the NGSS that would otherwise be difficult to see in a strictly text-based document format.

Our visualization offers two methods of interaction. The first method is accessible through the zSpace hardware, which uses a combination of trackable eyewear and a trackable stylus to produce an image that has depth relative to the user's surrounding. The second method is offered through the iPad hardware which displays an image that has depth relative to the screen display on the iPad. This display on the iPad uses the touch interface to interact with the graph.

Technologies Used

Back-end

- JSON for parsing the data
- Unity 3D to build an internal representation of the NGSS data

Front-end

- NGUI for user interface
- zSpace virtual holographic display, stylus, gestures
- iPad Finger Gestures for generating meaningful interaction

Figure 1: 3D Display

Figure 2: User Interface

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Overview

The NGSS is described by their website as a set of national education standards that are rich in content and practice, arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked science education. "Visualization of the NGSS separates the standards into nodes. Each node corresponds to a performance expectation for a student at some grade level or grouping of grade levels. The performance expectations are comprised of three dimensions: Science and Engineering Practices (SEP), Disciplinary Core Ideas (DCI), and Crosscutting Concepts (CC). The SEPs describe behaviors that scientists engage in as they investigate and build models and theories about the natural world and the key set of engineering practices that engineers use as they design and build models and systems. The DCIs focus on the K-12 science curriculum instruction and assessments on the most important aspects of science. The DCIs are divided into four domains: the physical sciences, the life sciences, the earth and space sciences, and engineering, technology, and the applications of science. The CCs tie together the broad diversity of science and engineering core ideas. They provide students with connections and tools related to different disciplinary content.

For example, Fig. 2 displays different pieces of the performance expectation named "K-ESS3-2" which refers to a performance expectation in the DCI of Earth and Space Science that deals specifically with Earth and human activity. Fig. 2 shows how students can demonstrate understanding of the Earth and Space Science DCI: "Defining and Delimiting an Engineering Problem". One of the CCs includes "Cause and Effect", where "Events and causes that generate observable patterns". The third section of Fig. 2 is comprised of the three types of connections in graph connections, which are connections to performance expectations within the same grade, Across-grade connections, and CC connections which are connections to performance expectations within the same grade, Across-grade connections, which are connections to performance expectations within other grades, and Common Core State Standard (CCSS) connections, which are connected to information presented in the CCSS. There are over 1,000 connections between the performance expectations. Our 3D representation of the connections gives a better understanding of the connections than a text-based representation of the connections. Fig. 1 shows A 3D visualization of the connections where the different node shapes and colors correspond to different DCIs associated with the corresponding performance expectations.
We are very pleased to include posters for the Senior Design Projects that were done without industry sponsors. Some of these projects were instigated and/or sponsored by research at the Baskin School (e.g. CITRIS, CenSEPS), while others were created by students with the assistance of faculty mentors and TAs.

We have selected three of these projects for presentation in the program, and all were invited to display their posters that summarize their projects.
Capstone Project

Motorized EMG-Controlled Hand
Taylor Furtado, Kyle Lawrence, Alexander Lynchosky, Ivan Romero, Michael Sit

Motivation
This project was proposed by Taylor Furtado, a congenital amputee with over a decade of experience using traditional prosthetics.

Although the costs of traditional hook and pulley prosthetics are simple to learn, these prosthetics can cause significant discomfort after prolonged use, and lack dexterity. The total cost of maintenance and production of such prosthetics can reach upwards of $50,000. Alternatively, modern myoelectric prosthetics provide higher functionality, however all is may cost the user over $10,000.

We sought to develop an inexpensive prosthetic that would be capable of grasping and rotating a variety of objects. This prosthetic gives the user a higher degree of dexterity, while providing feedback in its operating environment. The components we chose for our design have led to a functioning prosthetic that costs less than $1,000.

Approach

A key concept of our design was product accessibility. We actively sought to purchase materials that were both inexpensive and easy to use for the experienced hobbyist. To reduce the cost of production, we used a 3D printer to create the mechanical structure of the prosthetic.

We also wanted our prosthetic to have a higher degree of functionality than traditional prosthetics, to do so we developed a means to articulate fingers individually and integrate a rotating wrist.

Most importantly, we wanted the prosthetic to be comfortable. Rather than activating the prosthetic via a user actuation, we used sensors that detected surface muscle activity in the shoulder to drive the hand. We added features that enable the user to calibrate the feedback responses of the prosthetic, so that they can take the device to their needs.

Overview

The hand component performs all of the actuation as indicated by the user and collects environmental data to be sent to the commander.

The prosthetic is capable of opening and closing three individually actuated fingers. To increase dexterity, a mechanism was devised to allow the fingers to curl around objects. An arm was designed that could rotate grasped objects 180°.

User commands are monitored by ElectroMyoGraphic sensors (EMGs). The EMGs can measure the surface activity of one group of muscles to open or close the fingers accordingly. The second set can monitor for wrist commands. A single flex can indicate left spin, and two sequential flexes will cause the hand to spin right.

The command module receives sensor data from the hand in order to monitor for potentially dangerous environments. This information provides the user with tactile and visual feedback, alerting the user of potential risks.

The design of our hand enables it to be mounted onto most standard prosthetic boxes. The fingers are constructed to be easily replaced or altered, giving the user the opportunity to make their own modifications.

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Analysis

Our developments have led to the creation of a prosthetic that can be successfully controlled by user commands. The hand is capable of grasping and lifting around objects, and in addition, the rotating wrist provides a higher degree of freedom unseen in many traditional prosthetics.

We were successful in creating this device, while maintaining a budget of $1,000. By providing a GUI, we also allowed the user a means of adjusting the prosthetic to their needs.

Results

The following image is a completed model of our prosthetic. Included in the image are the EMG sensors used to read user controls, the command module and OLED display, as well as the prosthetic hand.

Conclusion

Upon integration our model was capable of grasping and lifting objects weighing up to five pounds. Through extensive searches, we found inexpensive components, the final cost of our model was $855, including a standard tax and shipping. The successful prototype is indicative of future models that have the potential of offering a higher degree of control at a lower expense. Overall, we were successful in achieving the desired functionality for the prosthetic, and were able to expand upon our model to increase it's overall usability.
Capstone Project

Motorcycle Safety System

Olivia Krzeminski, Zach Nissen, Yu Chung, Matthew Stormo, Andrew Bao

Raspberry Pi

We use a Raspberry Pi small form factor PC to process video through a 5 MP camera module. OpenCV and UNO are used for the remainder of our algorithm. Raspberry Pi sends an alert to one of the UNOs. Each component is explained more below:

- Camera Module
  - 5 megapixel camera
  - 1.2GHz CPU
- Raspberry Pi
  - Runs OpenCV and feedback software
- Communication over SPI and UART with the UNOs
- OpenCV
  - Computer Vision library to process video data
  - Edges detected that serves each frame
- Local Binary Pattern Cascade
  - Before the detection phase, this unit is generated with 16,000+ images on a server to speed up detection
  - Edges ordered to OpenCV and a decision tree like

![Local Binary Pattern Cascade Diagram](image1)

Figure 2: Local Binary Cascade Diagram

**Approach**

The system structure of our design can be seen below Figure 2. The key component of our system other than UNO microcontrollers, are the cameras used to see the road. We then use Raspberry Pi to process the video, which includes real-time edge detection and classification. Raspberry Pi sends an alert to one of the UNOs. The UNO microcontrollers communicate via SPI where the Raspberry Pi serves as the Master and the UNO the Slave.

![System Block Diagram](image2)

Figure 3: System Block Diagram

Overview

![Sensors Locations](image3)

Figure 3: Sensor Locations

**Sensors**

![Microwave Sensor with Antenna](image4)

Figure 4: Microwave Sensor with Antenna

- **HB100 Microwave Sensor**
  - Use to detect danger in front and behind the motorcycle, maintaining both speed and distance of approaching objects.
  - Capable of detecting vehicles up to 19 meters away.
  - Our system uses these sensors to train the model on data under 10 meters that the camera module is incapable of seeing.
  - Mobility used for low-speed detection, up to 15 mph.
  - Antenna used between the motorcycle and the object of interest.
  - Incorporated a 1/8th dielectric horn antenna that reduces the detection angle to 20 degrees. This reduces radiation outside of this range of the road.

![Raspberry Pi Camera Module](image5)

Figure 5: Raspberry Pi Camera Module

- **Raspberry Pi Camera Module**
  - 5 megapixel camera
  - Delivers 1920x1080 video to the Raspberry Pi at approximately 30fps.

![Ultrasound Sensor](image6)

Figure 6: HC-SR04 Ultrasonic Sensor

- **HC-SR04 Ultrasonic Sensor**
  - Can accurately measure distances up to 4 meters away.
  - Primarily used to detect incoming danger to the side of the motorcycle, where a vehicle is entering into a motorcycle's lane.

![Ultrasonic Sensor](image7)

Figure 7: Ultrasonic Sensor

ChipKit Uno

The chipkit UNO32 microcontroller used in the projectMain functions: One UNO communicates the feedback system to the user through wireless communication. Second, two UNOs control all sensor inputs and data handling including the camera modules and also sends alerts to the user. Each of the UNO features is highlighted below:

- SPI
  - Communication between UNOs
  - Communication between an UNO and Raspberry Pi
  - Reading the velocity of the bike
- UART
  - RS-485 communication to either UNO
  - Communication to computer for logging
- Change Notice Intervals
  - Sending distance to twin sensor system
  - Detecting relative speeds for vehicles behind and in front of motorcycle
- ADC
  - Reads analog from microcontroller to detect relative distance

**Haptic Feedback**

As vehicles are detected by the sensors in our system, we process a certain detection to be dangerous to the rider, we will send a vibration through the handlebars. We experimented with a variety of forms of vibration motors that were mounted at different locations on a motorcycle. The four locations of the vest are chosen such a way that it will tell the user specifically where there is a dangerous vehicle detected. The motor location are on the left and right back shoulder blinks, and front left and right brisk area; Each location will be triggered when a danger is detected at that respective direction on the road.

![Analysis](image8)

Figure 8: Analysis

**Analysis**

One of the goals of our project is to detect danger more than 60 mph. We can calculate the braking distance relative to the speed of the motorcycle from the equation:

\[ \text{D} = \frac{v^2}{2a} \]

Where \( v \) is the speed of the motorcycle, \( a \) is the deceleration, and \( t \) is the braking time.

The brake distance will be less than 60 m. Since the motorcycle is being driven at 60 mph, it is relatively difficult to stop a motorcycle. However, if a pedestrian is in front of the motorcycle, they are stopped for the safety of the rider. If a pedestrian is not in the line of sight, the motorcycle will continue driving.

**Conclusion**

For every braking case, we assume the worst case scenario when determining the time to stop. For example, when calculating the speed, we use the assumption that the speed is 60 mph. We have a system to handle a variety of situations that may occur:

- **System Design**
  - Takes a distance of 57.7 meters to stop completely when traveling at 60 mph. To slow the rider has reached the 67.4 meters to safely stop the motorcycle. This is done by taking the right wheels first. From this simulation, we found that our system needs to be able to detect vehicles up to 70 meters away with a look ahead response time to still be able to steer the rider safely while the minimum stopping distance.
Capstone Project

Portable Supercapacitor Charger

Becker Sharif, Mimi Petersen, Adam Holman

Abstract

Supercapacitors are an energy storage device with an extremely high power density, which gives them an advantage over conventional batteries in their ability to charge and discharge very quickly. To utilize the function of this emerging technology we created a device with the capability to charge in minutes enough energy to charge an iPhone 6S, something that would take a conventional battery hours. Once quickly charged, this portable device can be unplugged and charged by an electronics device that has a USB connection.

The final design consisted of a modular system which contains two devices: a 350W switch-mode power supply which outputs 24V at up to 15A and the supercapacitor bank with the circuitry which controls the charging of the supercapacitors and the discharging of the supercapacitors to the USB port.

Approach

The approach of our design was split into three subsystems: the charging circuitry, the supercapacitor bank, and the discharging circuitry. We focused initially on how supercapacitors worked and how to efficiently and quickly charge them. We compared the charging times of constant current vs constant voltage.

After determining that the 350F supercapacitor provided for the highest energy density at the lowest price point, we connected the supercapacitor bank and tuned the circuits.

We chose a charge controller IC which provided constant current of 20 Amps to minimize charge time to a quick 30 seconds. To provide enough power to transfer such energy in such a short time, we built a 350W power supply, modified after the Mean Well power supply.

The discharging circuit was built around a buck/boost converter which could utilize 90% of the available energy in the supercapacitors to charge a mobile device.

After integrating the three subsystems into a final prototype we designed and built PCBs for the circuits and built a final enclosure for the device.

Overview

AC-DC Power Supply:
- Input from a traditional 120 VAC wall outlet.
- Switch-mode half-bridge topology provides up to 94% efficiency.
- Capable of providing 350 W of power.
- Minimal output voltage ripple provides a stable power input to the charging circuit.

Charging Circuit:
- Provides constant current of 20 Amps for increased charging time.
- Buck/boost converter provides for efficiency up to 94%.
- Control loop regulates output current to an accuracy of 6%.

Supercapacitor Bank:
- Twelve 350F Supercapacitors provide 4.2 Watt Hours of energy.
- Connected in a parallel-series configuration to provide maximum voltage of 16.2 V.
- Stores enough energy to charge an iPhone battery up to 65%.

Discharging Circuit:
- Buck/boost converter maximizes efficiency, up to 90%, to use as much energy from supercapacitor bank.
- Converter regulates output voltage to 5 V as the supercapacitor bank drops in voltage down to 2.7 V.
- Provides 5 V DC @ 700 mA to USB output compatible with all mobile devices.

Analysis

Our two quantitative goals were to charge the supercapacitor bank in under 3 minutes and deliver at minimum 90% charge to the phone. In order to achieve these two goals we chose the best configuration of supercapacitors to store energy without reducing the charge time and maximize the efficiency of the discharging system.

Efficiency

The discharging circuit utilized the LT3115 IC to perform the buck/boost power converter operation, with the following efficiency:
- Efficiency from 16.2 V to 7 V: 92%
- Efficiency in supercapacitor bank from 16.2 V to 7 V: 92%
- Efficiency from 7 V to 5 V (minimum input for boost): 84%
- Efficiency in supercapacitor bank from 7 V to 5 V: 80%

Total Energy Stored in the Supercapacitor: 12414 J
Total Energy Delivered to the Super Capacitor: 12414 J
Total Efficiency of Shunting Circuits: 0.919

Results

We created a portable charger prototype that utilizes supercapacitors as the main energy storage device. We charged the supercapacitor bank at 20 Amps in about 30 seconds, using a 350W AC/DC power supply. The supercapacitor bank and discharging circuit provide enough energy to charge an iPhone 5S to 60%.

As supercapacitor technology is improving, we constructed a scalable prototype which can be tailored to meet the energy requirements of different devices in both home and industrial applications. Instead of being used to charge a phone, the energy storage capacity on this prototype is sufficient to power a small lamp or power a remote.

Conclusion

Supercapacitor technology is continuing to grow and new materials are being used to increase energy density. Materials such as graphene are also being explored in conjunction with supercapacitor technology to possibly create energy storage devices that are even smaller and lighter than traditional lithium ion batteries with increased storage. Once supercapacitor technology has advanced, our circuitry and design can be easily modified to charge the newer, smaller supercapacitor bank.

We believe that supercapacitors have not yet found their place in the market. This project is just the beginning; however, once they do they will replace batteries as the superior energy storage alternative.

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