Solar Panel Project

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Discipline: Computer Engineering Technology

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Declaration of Joint Authorship

Steven Spiteri, Richard Burak, and Salvatore Angilletta confirm that the following work found in this technical report is a joint effort and is an expression of our own ideas and research. All works cited are property of their respective owners and are properly acknowledged using the APA format. Steven Spiteri has developed the online web interface. Richard Burak has built the MySQL database. Salvatore Angilletta was in charge of managing the Android mobile application. Work on the hardware was distributed amongst the three of us.

Approved Proposal

Proposal for the development of a solar panel project

Prepared by Steven Spiteri, Richard Burak, Salvatore Angilletta

Computer Engineering Technology Students

steve-spiteri.github.io

Executive Summary

As student's in the Computer Engineering Technology program, we will be integrating the knowledge and skills we have learned from our program into this Internet of Things themed capstone project. This proposal requests the approval to build the hardware portion that will connect to a database as well as to a mobile device application. The internet connected hardware will include a custom PCB with various sensors. The database will store historical production and weather data. The mobile device functionality will include the ability to view the system status, DC output power overview, weather factors, past power production data and will be further detailed in the mobile application proposal. This semester I plan to continue working with Richard Burak and Salvatore Angilletta, who also built similar hardware last term and have worked on the mobile application. The hardware has been completed in CENG 317 Hardware Production Techniques independently and the application has been completed in CENG 319 Software Project. These will be integrated together this term in CENG 355 Computer Systems Project as a member of a 3 student group.

Background

The problem solved by project is how to track a solar panel system. With the purposed hardware and companion mobile application it will allow solar panel owner the ability to easily monitor their system status, track their power production, view historical production data, and view weather data from a web interface and simple mobile application.

The hardware, powered by a Broadcom development platform, will operate in series with a solar panel system. Information will be gathered to indicate if all is well with the system and power production overview. Multiple sensors such as temperature, humidity, barometric sensors will be used to gather weather data. Weather data will be available to view at a glance and historically. With this data you understand performance variations day to day.

I have searched for prior art via Humber's IEEE subscription selecting "My Subscribed Content" and have found and read three which provide insight into similar efforts.

The first journal discusses how shade can reduce power generation up to 10-20% annually.(Hanson, Deline, MacAlpine, Stauth, & Sullivan, 2014)

The second journal discusses low cost options for measuring solar panel defects. (Ranhotigamage & Mukhopadhyay, 2011)

The third and final journal we found provides information about how extreme high temperature can affect solar panel degradation. (Kim, Seo, Cho, & Krein, 2016)

In the Computer Engineering Technology program we have learned about the following topics from the respective relevant courses:

- Java Docs from CENG 212 Programming Techniques In Java,
- Construction of circuits from CENG 215 Digital And Interfacing Systems,
- Rapid application development and Gantt charts from CENG 216 Intro to Software Engineering,
- Micro computing from CENG 252 Embedded Systems,
- SQL from CENG 254 Database With Java,
- Web access of databases from CENG 256 Internet Scripting; and,
- Wireless protocols such as 802.11 from TECH152 Telecom Networks.

This knowledge and skill set will enable me to build the subsystems and integrate them together as my capstone project.

Methodology

This proposal is assigned in the first week of class and is due at the beginning of class in the second week of the fall semester. My coursework will focus on the first two of the 3 phases of this project:

Phase 1 Hardware build.

Phase 2 System integration.

Phase 3 Demonstration to future employers.

Phase 1 Hardware build

The hardware build will be completed in the fall term. It will fit within the CENG Project maximum dimensions of 12 13/16" x 6" x 2 7/8" (32.5cm x 15.25cm x 7.25cm) which represents the space below the tray in the parts kit. The highest AC voltage that will be used is 16Vrms from a wall adaptor from which +/- 15V or as high as 45 VDC can be obtained. Maximum power consumption will be 20 Watts.

Phase 2 System integration

The system integration has been completed in the winter term.

Phase 3 Demonstration to future employers

This project will showcase the knowledge and skills that I have learned to potential employers.

The tables below provide rough effort and non-labour estimates respectively for each phase. A Gantt chart will be added by week 3 to provide more project schedule details and a more complete budget will be added by week 4. It is important to start tasks as soon as possible to be able to meet deadlines.

Labour Estimates	**Hrs**	**Notes**
Phase 1		
Writing proposal.	9	Tech identification quiz.
Creating project schedule. Initial project team meeting.	9	Proposal due.
Creating budget. Status Meeting.	9	Project Schedule due.
Acquiring components and writing progress report.	9	Budget due.

Mechanical assembly and writing progress report. Status Meeting.	9	Progress Report due (components acquired milestone).
PCB fabrication.	9	Progress Report due (Mechanical Assembly milestone).
Interface wiring, Placard design, Status Meeting.	9	PCB Due (power up milestone).
Preparing for demonstration.	9	Placard due.
Writing progress report and demonstrating project.	9	Progress Report due (Demonstrations at Open House Saturday, November 7, 2015 from 10 a.m. - 2 p.m.).
Editing build video.	9	Peer grading of demonstrations due.
Incorporation of feedback from demonstration and writing progress report. Status Meeting.	9	30 second build video due.
Practice presentations	9	Progress Report due.
1st round of Presentations, Collaborators present.	9	Presentation PowerPoint file due.
2nd round of Presentations	9	Build instructions up due.
Project videos, Status Meeting.	9	30 second script due.
Phase 1 Total	**135**	
Phase 2		
Meet with collaborators	9	Status Meeting
Initial integration.	9	Progress Report
Meet with collaborators	9	Status Meeting
Testing.	9	Progress Report
Meet with collaborators	9	Status Meeting
Meet with collaborators	9	Status Meeting
Incorporation of feedback.	9	Progress Report
Meet with collaborators	9	Status Meeting

Testing.	9	Progress Report
Meet with collaborators	9	Status Meeting
Prepare for demonstration.	9	Progress Report
Complete presentation.	9	Demonstration at Open House Saturday, April 9, 2016 10 a.m. to 2 p.m.
Complete final report. 1st round of Presentations.	9	Presentation PowerPoint file due.
Write video script. 2nd round of Presentations, delivery of project.	9	Final written report including final budget and record of expenditures, covering both this semester and the previous semester.
Project videos.	9	Video script due
Phase 2 Total	**135**	
Phase 3		
Interviews	TBD	
Phase 3 Total	**TBD**	
Material Estimates	**Cost**	**Notes**
Phase 1		
Raspberry Pi 3 Kit	$119.99	CanaKit
Barmetric Pressure Sensor	$8.33	RobotShop
DHT-11 Sensor Breakout	$4.04	RobotShop
6V Solar Cell	$5.95	Sayal
Safety Glasses	$5.04	Pyramex
Lead Free Solder (10g)	$4.49	RobotShop
Soldering Iron (25W)	$6.80	RobotShop
Soldering Iron Holder	$4.56	RobotShop
5-pin PCB Header (female)	$0.89	Digi-Key
2x20 GPIO Header	$9.99	Adafruit

Humber PCB Components Kit	˜$40.00	Humber College - Prototype Lab
Custom PCB	**TBD**	Humber College - Prototype Lab
Laser-cut Acrylic Box	˜$30.00	Humber College - Prototype Lab
Digital Multimeter	$14.59	RobotShop
M2.5 Screws/Standoffs	$11.99 (Bulk)	HVAZI
Phase 1 Total	**$267.43**	
Phase 2		
Laser-cut Acrylic Top of Box	**TBD**	Humber College - Prototype Lab
Phase 2 Total	**TBD**	
Phase 3		
Off campus colocation	TBD	
Shipping	TBD	
Tax	TBD	
Duty	TBD	
Phase 3 Total	**TBD**	

Concluding remarks

This proposal presents a plan for providing an IoT solution for the difficulty accessing solar panel data. This is an opportunity to integrate the knowledge and skills developed in our program to create a collaborative IoT capstone project. I request approval of this project.

Abstract

Home owners, who posses solar power generation systems, have difficulty easily accessing power production information and determining the effect of environmental elements. To address this, a product must be created to assist in the monitoring and collection of data to clearly determine power production and its relationship with weather factors. This product monitors solar cell voltage generation, surrounding temperature, light levels, barometric pressure, and humidity. Data retrieved from the sensors is processed on the Broadcom development platform before being sent to a co-located database. Each entry in the database has a date and time associated with it to provide context. The database stores the sensor data and is accessed by both the Android mobile application and the online web interface. The Android mobile application displays the data in an easy-to-read manner for the end user with the option to view it in a graph. The online web interface provides the same functionality with a more interactive approach. This product has the potential to enhance solar panel ownership and research by allowing users to intuitively manage their solar power generation system.

Table of Contents

Illustrations/Diagrams

[1.] Introduction

In the current marketplace home owners, who posses solar power generation systems, have difficulty easily accessing power production information and determining the effect of environmental elements. Home owners have adopted a relatively new technology and should be confident in knowing that information regarding it is always available. Since this product automates the collection and distribution of the data, the responsibility of the home owner is minimized.

With this product it will grant solar panel owners the ability to easily monitor their system status, track their power production, view historical production data, and view weather data from an interactive display and simple mobile application.

The hardware, powered by a Broadcom development platform, will operate in series with a solar panel system. Information will be gathered to indicate if all is well with the system and power production overview. Multiple sensors such as light, temperature, humidity, barometric pressure sensors will be used to gather weather data. Weather data will be available to view at a glance and historically.

This product uses an off-site database which can be accessed through both the online web interface and Android mobile application. This will allow the end user to monitor their solar panel power generation system from a remote location.

A goal when creating this product was to follow a tight budget so the cost of building it has remained relatively low. The price for consumers should remain low and researchers will have a low-cost monitoring solution.

Following AGPLv3, all of our source code will be made available online for public viewing. This is due to the Android application using GraphView and our firmware using Adafruit Python libraries.

[2.] Product Description

[2.1] Software Requirements Specifications

[2.1.1] Product Introduction

[2.1.1.1] Purpose

This product is to be used in tandem with a solar power generation system. It is meant to enhance solar panel ownership by providing an intuitive way of gathering and examining data for both home owners and researchers.

[2.1.1.2] Intended Audience

This document is intended for industry professionals and educational institutions for research and evaluation.

[2.1.1.3] Product Scope

The product is built using a Broadcom development platform to interface with a solar cell and a variety of sensors. All of the data is gathered using these on-board sensors, which collect information about the humidity, temperature, barometric pressure, and light level around the hardware. Because the power generation of the solar cell is also tracked, it can be correlated with the weather data and used to further our research into solar energy.

[2.1.2] Overall Description

[2.1.2.1] Product Perspective

This product is aimed to be a new way to gather and display data from any existing solar power generation system.

[2.1.2.2] Product Functions

The various sensors are tasked with gathering the raw data. The DHT-11 is used for humidity, the BMP085 for barometric pressure and temperature, the YL-40 for light-levels, and finally a solar cell may be connected and have its voltage generation measured. The development platform contains software to convert this raw data into readable values. These values are then uploaded to a remote database for future access. This database can be read using either the Android application or the online web interface.

[2.1.2.3] User Classes and Characteristics

The expected user of this product is any homeowner with a private solar power generation system. The software interface is geared towards being simple and accessible for casual smartphone users. A secondary user base can include researchers looking to further work in solar panel technology.

[2.1.2.4] Operating Environment

The mobile application must run on Android API 19 and above, on either a smartphone or tablet device. The software running on the development platform is designed to work with a Linux-based operating system. Finally, the database uses MySQL and is accessed with PHP scripts.

[2.1.2.5] User Documentation

Users will have access to hardware build instructions that provide a step-by-step guide for putting the product together. Instructions for the Linux software configuration are included as part of the build instructions.

[2.1.3] External Interface Requirements

[2.1.3.1] Database

The MySQL database will run on a co-located free-hosting website. The database will use phpMyAdmin to for administrative interaction on the front-end. The information contained includes formatted data downloaded from the development platform. There are two tables, one with a username and password for the Android app users, and on with entries for all the weather data collected (power, temperature, light, barometric pressure, humidity, and time). The database will be populated by data downloaded from the hardware.

(Developed by Richard Burak)

[2.1.3.2] Mobile Application

The mobile application, available on Android platforms, will take the data from the MySQL database and temporarily store it on the target device in memory. It will display the data in an easy-to-read manner for the end user. There is the option to view the data in a graph. The user can customize to see a different range of historical data. The application has a total of three activities: login, main and a settings. The login activity allows the user to log into an account and have access to their data. The main activity has two areas; The main area contains the user's homepage and the other contains the graph. The settings activity allows the user to change the temperature notation from Celsius to Fahrenheit.

(Developed by Salvatore Angilletta)

[2.1.3.3] Online Web Interface

An online web interface will be developed and mirror the functionality of the mobile application. After the user logs in they will have access to their data in an easy-to-read manner. On a single page, the web interface will contain the users most recent data and a table containing historical data. An option will be available for the user to change the temperature notation from Celsius to Fahrenheit.

(Developed by Steven Spiteri)

[2.1.3.4] Additional Hardware

A new top for the product casing will be laser cut to allow mounting of the solar cell and allow routing for the solar cell connection.

(Developed by Steven Spiteri, Richard Burak, and Salvatore Angilletta)

[2.1.4] Other Non-Functional Requirements

[2.1.4.1] Safety Requirements

- This product shall only be connected to an external power supply rated at 5 Volts DC.
- This product is intended to accompany solar power generation systems, therefore requires a trained professional when dealing with high voltage equipment.
- To avoid malfunction or damage do not expose it to water, moisture or place on a conductive surface whilst in operation.
- Do not use this product for anything outside it’s intended purpose.

[2.1.4.2] Security Requirements

- Do not share your identity authentication and password.
- Keep software up-to-date to ensure proper operation.

[3.] Hardware Build Instructions

[3.1] Build Introduction

This section contains all the knowledge necessary in order to reproduce the solar panel project. An individual should be able to recreate this product by following these instructions. Before continuing with this section, be sure to remember all proper safety procedures when interacting with computer hardware and electrical components.

[3.2] Basic System Overview

The system will require the input from the sensors, which will receive their input from the physical environment surrounding them. The data must then be processed and converted to values that are readable and relevant. Once these number values are obtained, they will be displayed on demand, or whenever a user requests it.

[3.3] Budget and Materials

Material Estimates	**Cost**	**Notes**
Raspberry Pi 3 Kit	$119.99	CanaKit
Barmetric Pressure Sensor	$8.33	RobotShop
DHT-11 Sensor Breakout	$4.04	RobotShop
6V Solar Cell	$5.95	Sayal
Safety Glasses	$5.04	Pyramex
Lead Free Solder (10g)	$4.49	RobotShop
Soldering Iron (25W)	$6.80	RobotShop
Soldering Iron Holder	$4.56	RobotShop
5-pin PCB Header (female)	$0.89	Digi-Key
2x20 GPIO Header	$9.99	Adafruit
Humber PCB Components Kit	˜$40.00	Humber College - Prototype Lab

Custom PCB	**TBD**	Humber College - Prototype Lab
Laser-cut Acrylic Box	~$30.00	Humber College - Prototype Lab or Hot Pop Factory
Digital Multimeter	$14.59	RobotShop
M2.5 Screws/Standoffs	$11.99 (Bulk)	HVAZI

[3.4] Time Commitment

Task	**Time Required (Approx.)**
Ordering Parts	1 hour
Parts Delivery	2 weeks
Development Platform Setup	2 hours
Printing PCBs	20 minutes
Soldering PCBs	3 hours
Testing PCBs	30 minutes
Unit Testing Sensors	2 hours
Connecting Circuits	10 minutes
Laser-cutting Box	10 minutes
Box Assembly	1 hour (24 hours to dry)
Mount project in box	5 minutes

[3.5] Development Platform Setup

Once the Broadcom development platform has been acquired, begin by connecting it to a display. Next, connect the keyboard and mouse. You can now plug the development platform into power and begin configuring the operating system. The setup will be explained on screen, and you may begin using the development platform once it has completed. In the top right-hand corner of the screen, select the network you want the development platform to automatically connect to when it boots up (skip this step if the device is using a wired connection). Be sure to make note of the IP address, as it may be required later if remotely connecting to the device. The IP can be found by hovering the mouse over the WiFi symbol on the top-right. Once connected to the internet, open the command line terminal and run the following command:

```
sudo apt-get update
```

This will update the development platform to the most recent version. This is important, as security updates are required to keep the device safe. Next, SSH must be enabled by default, otherwise you will not be able to remotely access the development platform. To ensure SSH starts when the development platform is booted up, run this in the command line:

```
mv /boot/boot_enable_ssh.rc /boot/boot.rc
```

Now that SSH is enabled, VNC must be installed and enabled. VNC allows users to navigate the GUI of the development platform remotely. To install this, run the following commands:

```
sudo install tightvncserver tightvncserver
```

Setup a password for VNC when asked. You will now be able to run VNC server by accessing the development platform through SSH, then interface using any VNC client. To prepare the development platform for use with the sensors, I2C must be enabled. To do this, start by running the following command:

```
sudo raspi-config
```

Use the arrow keys to navigate to advanced options and hit enter. Once there, navigate to I2C and hit enter again. Select "Yes" to have I2C enabled on the development platform. Next, we must prepare the Python program used to interface with the sensors. The program below (solar.py) will show the data gathered by the sensors in the circuit. It will not successfully run until all the sensors have been tested and connected. Simply place the file in any directory on the development platform.

```
#!/usr/bin/python


import Adafruit_BMP.BMP085 as BMP085
```

```
import Adafruit_DHT
import RPi.GPIO as GPIO
import time
import smbus
import sys
import requests

GPIO.VERSION
GPIO.setmode(GPIO.BOARD)
GPIO.setwarnings(False)
GPIO.setup(11, GPIO.OUT)
GPIO.setup(12,GPIO.OUT)

try:
    while True:
        sensor = BMP085.BMP085()
        bus = smbus.SMBus(1)

        humidity, temperature = Adafruit_DHT.read_retry(11, 4)
        # Un-comment the line below to convert the temperature to Fahrenheit.
        # temperature = temperature * 9/5.0 + 32
        temp = sensor.read_temperature()
        pressure = sensor.read_pressure()
        altitude = sensor.read_altitude()
        power = bus.read_byte(0x48)/50
        light = bus.read_byte(0x48)
        time_date = str(time.strftime("%d/%m/%Y %H:%M:%S"))
        print('Temp = {0:0.2f} *C'.format(temp))
        print('Humidity={0:0.1f}%'.format(humidity))
```

```
        print('Pressure = {0:0.2f} Pa'.format(pressure))
        print('Altitude = {0:0.2f} m'.format(altitude))
        print('Sealevel Pressure = {0:0.2f} Pa'.format(sensor.read_sealevel_pressure()))
        bus.write_byte_data(0x48,0x40 | ((0) & 0x03), 0)
        print('Solar Panel (V) = {0:0.2f}'.format(power))
        bus.write_byte_data(0x48,0x40 | ((2) & 0x03), 0)
        print('Light Level = {0:0.2f}'.format(light))
        print('Time = '+ time_date + '\n\n')
        # the next two lines are part of the database uploading, keep them commented out
        # url = 'http://springdb.eu5.org/spring/test_files/insert_test_input.php?id_logi
        # requests.get(url)
        # if the code reaches here, all sensors worked, turn led green
        GPIO.output(11,0)
        GPIO.output(12,1)
        time.sleep(15)

except Exception:
    # if the code reaches here, a sensor failed, led turns red
    GPIO.output(11,1)
    GPIO.output(12,0)
except KeyboardInterrupt:
    GPIO.cleanup()
```

With the development platform now configured, we can move on to the hardware part of this project.

[3.6] PCB Soldering/Testing

The main PCB that holds the I2C circuits, called the Modular Sensor Hat, was provided by Humber College. The board must first be printed, and the components aquired (from the Prototype Lab in J building). Solder the components provided according to the Eagle .brd and .sch files. Be sure to wear safety glasses while soldering, and consider all aspects of your own (and others') safety.

Caution: There is a problem with the Modular Sensor Hat, we have included a quote from our instructor regarding the problem below.

```
"RTC module can charge the CR2032 battery causing damage. To permanently disable the cha
surface mount resistor near the unused I2C header by pushing it off the PCB with a hot s
```

Since this project is not using the RTC, it should not cause a problem, but it is something to keep in mind when building.

Next, the additional Custom PCB must be printed and soldered. The materials required for this step are as follows:

```
10K Resistor (From Pi Starter Kit)
5-pin Header (x2)
2x20 pin GPIO Header
Short pieces (~2cm) of 22 gauge wire (x3)
```

The final step with the boards is to ensure all the connections are working before connecting them. If faulty boards are connected to sensors (or the development platform) they can cause permanent damage to either. Save youself time (and money) by making sure they work before continuing. To do this, power and ground the boards first. Apply 3.3V to pin 1, and ground pin 6. Now we need the digital multimeter. Connect the multimeter to the same ground as the development platform, and use the other connection to probe the different parts of the circuit. Measure both resistance and voltage, to make sure the values are correct. If any problems are detected, resoldering may be required. If the boards pass all the tests, then you are ready to move on.

[3.7] Unit Testing Sensors

To test the sensors, first connect the Modular Sensor Hat to your development platform. Next, connect the barometric pressure sensor to the 4-pin header labelled "DS-RTC", making sure to match the labels on the board and breakout. Next, connect the YL-40 board provided in the Humber components pack to the neighbouring 4-pin header labelled ”PCF - ADC”, also making sure to match the labels. Back on the development platform, run the following command to test the connection to the sensors:

```
i2cdetect -y 1
```

The output should contain 48 and 77. To test the Solar Cell, simply connect it to a multimeter and measure how much voltage is being generated. Try covering it and moving it closer to light to see if the readings varry. Finally, to test the DHT-11, connect it to the Pi's GPIO. Make sure to correctly connect ground and power, as the DHT is fragile. Connect the pin labelled 'S' to pin 7 of the GPIO. In the solar.py file, comment out lines 26-32. This will mean that only the DHT will be read from. Run the program using:

```
python solar.py
```

If the DHT is functioning, then readings will appear on screen, otherwise the program will fail to run. If all of the sensors are functioning, you are ready to connect the circuit.

[3.8] Connecting the Circuit

In this step, the mechanical assembly will be complete. The components required here are:

```
Broadcom development platform
Modular Sensor Hat
Custom PCB
DHT-11 Humidity & Temperature Sensor
BMP180 Barometric Pressure Sensor
YL-40 Breakout Board
6V Solar Cell
Male-to-female Prototyping Wire (From Canakit Starter Kit)
```

To assemble the project, follow these steps:

```
Disconnect the development platform from power
Connect the BMP180 and YL-40 to the Modular Sensor Hat, the same way when you were testi
Install the Modular Sensor Hat on the development platform 3 GPIO header. Connect it so
development platform, and does not extend beyond it
Stack the Custom PCB with the Sensor Hat. This time, make sure the Custom PCB hangs over
does NOT hover over the Sensor Hat
Look at the Custom PCB board file. Connect the DHT-11 to the right-hand 5-pin header. Lo
that the pins go into the correct header input. Make sure it is properly inserted by fol
6, V to pin 1, S to pin 7)
Connect the Solar Cell to the left-hand 5-pin header. The black wire (ground) should plu
connected to GPIO pin 6). The red wire can connect to either header input connected to t
Connect the male end of the prototyping wire to the remaining resistor-connected header
Cell. The female end should connect to AIN2 on the top of the YL-40, which leads to an a
```

Double-check the connections to make sure they are correct. Once you are sure, power up the development platform. Once the development platform has booted up, edit the solar.py file again, removing the comment you made in Step 3. Run the program again, and you should see a flow of readings on the screen. You should see the LED on the Sensor Hat light up green when everything is working fine. If it lights up red, that means a sensor is not connected properly. With a functioning piece of hardware, it is time to make a nice box to put it in.

[3.9] Box Creation and Final Assembly

It is recommended that clear 3mm acrylic is used for the process, but any colour/transparency can be used. To print my box, we used Humber's Prototype Lab, and the helpful staff setup and laser-cut the box for us. It is recommended that you go to them, or find another professional service, to have the box cut.

Once the box has been cut, use acrylic glue to put everything (except the top) together. Be careful when using the glue, as it may contain harmful chemicals. Once everything has dried, you may begin to mount the development platform in the box. The full drying process may take up to 24 hours, but keep an eye on it The picture above has the colour-coded bars to represent the sides that go together. Just follow the lines and make sure the development platform's IO is accessible when in the box.

The M2.5 kit is required for this step, and you will make sure the development platform is mounted on the standoffs with its IO ports facing the cutouts provided. Before securing the development platform, remove the Modular Sensor Hat from the development platform. Make sure the development platform is securely mounted (but not too tight) before reconnecting the circuit. Briefly disconnect the Solar Cell, and reconnect it by feeding the red and black wire through the holes in the side of the box. The Solar Cell must rest outside of the box to make sure it generates optimal power. Now just put the top on (do not glue) and the build is complete. If the circuit is too tall, you may carefully bend the DHT-11 and AIN2 pin on the YL-40 to accomodate.

[3.10] Build Conclusion

By following this guide, you should be able to reproduce this project with relative ease. While the current construction and parts are great for small scale use and production (student projects, prototyping), but improvements can be made that can make production cheaper and quicker.

The Modular Sensor Hat was provided as a general IO board, containing componenets that can be used for many different sensors and applications. This can be scaled down and combined with the Custom PCB to reduce the amount of wasted PCB material and un-needed components. This will reduce the cost, time to produce, and size of the project. Next, efforts can be made to get the components cheaper and separate. The Canakit Starter Kit is expensive, and not all of the parts are used. Finally, with the smaller scale of the project, the box can be made smaller. Again, smaller means less acrylic is used, and the cost is reduced.

[4.] Software Implementation Instruction

[5.] Mobile Application Design Document

[5.1] Introduction

[5.1.1] Purpose

This document describes the features of the mobile application. The members used the information in this document as an outline for the development of the application.

[5.1.2] Scope

The main goal of this application is to monitor the status of a solar panel by taking information from a database. It will allow the user to view historical data

[5.1.3] Intended Audience

This document is intended to be viewed by the group members, and any Humber College School of Applied Technology and Advanced Learning instructors.

[5.2] Design Overview

[5.2.1] The Problem

Outlined in the project proposal is the problem this application aims to solve. Accessing solar panel data can be difficult. Many homeowners may not be aware of how much power is being generated. Even if they are aware, they may have questions. "Why is it generating so little power?", for example. By allowing weather data to be viewed at the same time, a comparison can be made by the user to see how weather affects power generation.

[5.2.2] Technology Used

The application was developed to run on the Android platform. Android Studio is being used as the development environment, and the application has been tested on smartphones running Android API

23, while emulators have been used to test API versions 19-24. Photoshop and Inkscape were used to generate images used in the application, and Microsoft Project was used to create the project schedule.

Data from the solar panel is stored on a remote server. The application uses a network connection to communicate with the database and display the data.

[5.2.3] Requirements Analysis

As a user, I should be able to login with my credentials and be shown data associated with my solar panel.

As a user, I should be able to view weather data that may be affecting solar panel power output.

As a user, I should be able to view historical data of solar panel power output, humidity, temperature, barometric pressure, and light.

As a user, I should be able to change the application theme from light mode to dark mode.

As a user, I should be able to change the temperature notation from Celsius to Fahrenheit and vice versa.

[5.2.4] User Login

The user must be registered to access the database. When the application launches, a login screen will appear. The user must have a network connection to make the initial connection required to login. Once the login succeeds, the main activity will launch.

[5.2.5] Database Access

With the main activity launched, live data will begin displaying on the initial screen.

[5.2.6] Data Manipulation

The application must allow the user to view the data how they want. For example, they might want to see power generation for a certain range of months or days. These options are provided by using the business logic that the members have created.

[5.4] Work Breakdown

This describes the distribution of work of the mobile application. All work has been completed by members Salvatore Angilletta, Richard Burak, and Steven Spiteri.

Salvatore acted as project manager. His strong organizational skills were well suited for this role. He has developed the project plan with the team and managed the team's performance of tasks. Development of the Gantt Chart was Salvatore's responsibility. He has ensured the Project Team completed the project on time and within scope by leading status meetings.

Richard and Steven have acted as the Project Team. They have been responsible for executing the tasks and producing the deliverables outlined in the project plan. They have ensured effective communication between each other so that development was efficient.

Due to Richard's articulate speech he was responsible for all forward facing content and documentation. He has authored a mock-up, requirement analysis, design document, and architecture diagram.

Steven's skill with software such as Adobe Photoshop CC 2014 and Inkscape 0.91 have allowed him to focus on building the images for an intuitive UI.

Together, Richard and Steven, were also responsible for developing the database schema and establishing initial setup of the database.

Coding has been performed by all team members. All other responsibilities of the project were performed by all team members to allow everyone to gain the experience building an Android application provides.

[6.] Schedule/Progress Reports

[6.1] Schedule

Phase 1

- Week 1 - Project Selection

  Tue. 9/6/16 - Mon. 9/12/16

- Week 2 - Project Proposal

  Tue. 9/13/16 - Mon. 9/19/16

- Week 3 - Project Schedule, Initial Meeting

  Tue. 9/20/16 - Mon. 9/26/16

- Week 4 - Budget, Status Meetings

  Tue. 9/27/16 - Mon. 10/3/16

- Week 5 - Acquire Parts, Parts Acquired Milestone, Progress Report

  Tue. 10/4/16 - Mon. 10/10/16

- Week 6 - Mechanically Assemble, Mechanically Assemble Milestone, Status Meeting, Progress Report

  Tue. 10/11/16 - Mon. 10/17/26

- Week 7 - PCB Fabrications, Interface Wiring, Status Meeting, Power Up Milestone

  Tue. 10/18/16 - Mon. 10/24/16

- Week 8 - Placard Design

  Tue. 10/25/16 - Mon. 10/31/16

- Week 9 - Project Demonstration, Progress Report

  Tue. 11/1/16 - Mon. 11/7/16

- Week 10 - Peer Grading Demonstration

  Tue. 11/8/16 - Mon. 11/14/16

- Week 11 - Individual Build Video, Status Meeting

  Tue. 11/15/16 - Mon. 11/21/16

- Week 12 - Progress Report

  Tue. 11/22/16 - Mon. 11/28/16

- Week 13 - Presentation Powererpoint

  Tue. 11/29/16 - Mon. 12/5/16

- Week 14 - Build Instructions

  Tue. 12/6/16 - Mon. 12/12/16

- Week 15 - Final Script, Final Film, Phase 1 Milestone

  Tue. 12/13/16 - Mon. 12/19/16

Phase 2

- Week 1 - Scheduling and Group Meetings

  Mon. 1/9/17 - Fri. 1/13/17

- Week 2 - Group Project Status Update

  Mon. 1/16/17 - Fri. 1/20/17

- Week 3 - App, Web, and Database Software Requirement

  Mon. 1/23/17 - Fri. 1/27/17

- Week 4 - Group Project Status Update

  Mon. 1/30/17 - Fri. 2/3/17

- Week 5 - Group Project Status Update

  Mon. 2/6/17 - Fri. 2/10/17

- Week 6 - App, Web, and Database Independent

  Mon. 2/13/17 - Fri. 2/24/17

- Week 7 - Group Project Status Update

  Mon. 2/27/17 - Fri. 3/3/17

- Week 8 - Group Integration

  Mon. 3/6/17 - Fri. 3/10/17

- Week 9 - Group Project Status Update

  Mon. 3/13/17 - Fri. 3/17/17

- Week 10 - Group Troubleshooting

  Mon. 3/20/17 - Fri. 3/24/17

- Week 11 - Group Project Status Update

  Mon. 3/27/17 - Fri. 3/31/17

- Week 12 - Project Demonstration at Open House

  Mon. 4/3/17 - Fri. 4/7/17

- Week 13 - Group Presentations

  Mon. 4/10/17 - Fri. 4/14/17

- Week 14 - Group Final Report

  Mon. 4/17/17 - Fri. 4/21/17

- Week 15 - Group Video Script

  Mon. 4/24/17 - Fri. 4/28/17

[6.2] Progress Reports

[6.2.1] Progress Report 3/02/2017

To: Kristian Medri

From: Richard Burak

This status report will give you an idea of what our group has done for our project so far, what we plan to do in the near future, and any problems we have encountered. This week, Salvatore, Steven, and I have created the skeleton for our technical report in markdown using Texts. A Requirements Specification is written within this skeleton, and includes a description of the project and a breakdown of the work we assigned ourselves to. A template from a book was used (Wiegers, K. E. (1999). Software requirements. Redmond, WA: Microsoft Press).

We have roughly planned out the web interface, and Steven had begun work on a basic and functional version. It will be hosted on the same co-located server as the database.

Meanwhile, I have worked on a way to integrate the hardware with the database. Because many of the PHP scripts were written in the Software Project course, it was just be a matter of adding code to our Python program. Next, I hope to explore more ways on managing the data to improve efficiency and add redundancy.

Finally, Salvatore has been working on improving the Android application. The application is working well, but it could use some polish to be more presentable, better performing, and more efficient.

Getting used to the markdown language is a challenge, but it is a welcome skill to our portfolios. The problems encountered were with learning markdown formatting. The solution was to find online resources to help us learn the language, as well as ask you for some assistance during class periods.

Financially, no significant changes have been made to the budget. We hope to improve our hardware by 3D printing a new case component to hold the solar cell in place on top of the box. This will be free for us at Humber, but we must make an effort to estimate the cost of this and add it to the budget. All other parts were purchased last semester, and we have no plans of adding more components to the hardware.

Regarding progress made in the previous semester, the database and Android application are mostly complete, and fully integrated with each other. This means there is less work needed here, and our time can be allocated to other parts of the project. All of our hardware from last semester is in working order, but we have decided to use mine as our primary development platform for this class.

I believe we have solid plan in place for our project, and we hope to remain on schedule throughout the semester. We do not expect to encounter many problems during our development, so I am confident we can continue to meet your expectations with our project.

[6.2.2] Progress Report 16/02/2017

To: Kristian Medri

From: Salvatore Angilletta

Over the past two weeks, Richard, Steven and I went to the new prototype lab in J233 to cut and glue an acrylic holder for our solar cell. We modified the existing Coral Draw file and laser cut the necessary pieces. We then decided to glue the pieces together with acrylic cement, and we got to experience the new venting chamber in the prototype lab.

Development has begun on the online web interface. A working login function has been created and initial tests for data manipulation have been completed. Our research into data presentation for HTML5 has lead us to use Chart.js. This is an open source HTML5 Javascript library that allows us to make our data presentable in interactive graph form very easily.

Lastly, we have started integration of our hardware with the database. Last Friday we pushed real data to our database for the first time. A new test user was created to use this real data across the mobile application and web interface. Besides little formatting issues, everything pushes fine. More pushes to the database will occur.

Our report is on track to comply with OACETT standards for technical reports. Since the last status update we have added and you have looked over our Introduction, Abstract and Declaration of Authorship sections.

Financially, as stated in the last status report we needed to get an estimate on how much our solar cell holder would cost. We emailed HotPopFactory.com to get an estimate for how much the entire case would be as a whole on the recommendation that you gave us. The estimated price of the entire case with the new top was about $31.60. This will be reflected in the budget.

In terms of bugs, we have encountered one in the mobile application. The library resource we used to display graphs has a known problem for not displaying anything if you let it dynamically adjust the x or y axis. When we pushed the real data to the database, there were some issues with displaying the power of the solar cell. This problem was solved by letting the y axis be a set minimum of zero.

[6.2.3] Progress Report 10/03/2017

To: Kristian Medri

From: Richard Burak

Since the last status update, we made sure to continue working on the project at a steady pace. Mid-term exams during this time required all three of us to focus our attention elsewhere, but relevant progress was still made. Most of the work was done for the web interface, but some slight database changes were made along with a filming session.

One of the PHP scripts used to receive data from the development platform was changed to process the barometric value (dividing it by one thousand for kPa instead of Pa). This was done on the basis of having the web-hosting service process the data, while preventing the user's device and the hardware from doing extra work.

I also made a change to the way webpages communicate with each other in the web interface. Previously, we were using GET to transfer data, but this was unsecure as the user's ID was displayed in the URL. Since redirection cannot be used with POST, I changed the pages to use PHP SESSION variables to keep the information more secure, while using less bandwidth when accessing new pages.

Since the hardware is fully developed, and the database and application are stable, the three of us are focusing our efforts on the online web interface. The goal is to have an aesthetically pleasing interface, while ensuring it is efficient and intuitive. Graphs from the previously stated JavaScript library will be displayed in one of four quadrants on screen, and they will randomly cycle between data at different intervals. This will provide an interesting way to show data on a large display. We decided to use HTML frames to evenly split the screen and have individual timers and pieces of code running.

On Sunday March 5th, we met with media instructor George Paravantes and one of his students to film the video for our project. The student came early and was prepared with all of the required recording equipment. The three of us were interviewed about our project, and our experience at Humber College, before filming some footage of our hardware and mobile application. Allowing someone who specializes in media studies, and who has professional equipment, film us will ensure a high quality video that should positively frame the Solar Project and Humber College.

No changes have been made regarding the budget, as most of the work recently has been software engineering and development. Since most aspects of the project are in a functional state, all three of us are working on the online web interface while updating our technical report weekly. No problems were encountered, and I hope we can continue at a steady pace for the remainder of the semester.

[6.2.4] Progress Report 24/03/2017

To: Kristian Medri

From: Salvatore Angilletta

Over the past two weeks we have been integrating the database with the mobile application further by pushing and testing enough data to populate the graphs for one week and one month worth of data. In doing so we have encountered a problem with the temperature graph and light level graph. They weren't displaying the data properly or at all. With our troubleshooting, we were able to pinpoint the problems and smoothly iron out the bugs.

Further development in the web interface has proven to be productive. We are in the process of finalizing our methods and should be on track to be integrated with our project soon. We can grab data from our database and insert it into a graph that is displayed to the user. The only thing left is to display multiple of these graphs with different data sets and make it look nicer for the end user.

Lastly, we further tested our hardware. We made sure that the hardware was able to run for extended periods of time under the supervision of Richard. He took the project home over a night and we changed the hardware to push to the database every 15 seconds. This is not reflective of how the project is suppose to work in the real world but is sufficient enough for testing and populating the database. We simulated day and night cycles to the best that we could. Richard was sure to keep an eye on the project and take safety measures.

Financially there has been no adjustments to the budget. This is because all of our progress has been primarily made through software and no additional hardware has been added. Also, we have tried contacting George again with asking for the student's email address as recommended.

We feel like we are on track and in the near future there will be more integration between hardware and software. More testing of hardware and more development into the software portion will occur, more specifically the web interface.

[7.] Conclusion

With this product, home owners should have an easy time accessing the power production information of their solar power generation system. This product monitors solar cell voltage generation, surrounding temperature, light levels, barometric pressure, and humidity. The database stores the sensor data and is accessed by both the Android mobile application and the online web interface. The Android mobile application displays the data in an easy-to-read manner for the end user. The online web interface provides the same functionality with a more interactive approach. With the simplicity provided by these features, this product is able to meet the goal we initially had.

It is recommended to engineer a different circuit for the supplemental board, as the YL-40 maximum input voltage is 8 volts, if you intended to use a solar cell with greater output voltage. With the current design, this product is designed solely for indoor testing. If you intended to operate the product outdoors, a weather proof case design is highly recommend, as weather elements may damage the product. If manufacturing this product on a large scale, it is recommended that the two provided circuit board designs are further developed and condensed into a single board without redundant space and function. As a result, the will also affect the size of the case containing the hardware internals thus making it smaller and more affordable.

[8.] Bibliography

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