Electronic Arduino Simple Yard

Jesus G. Zayas Rivera
Master of Engineering in Computer Engineering
Dr. Nelliud Torres
Electrical and Computer Engineering and Computer Science Department
Polytechnic University of Puerto Rico

Abstract *– Easy represents Electronics Arduino Simple Yard. Easy is a project that will intent to guide the user to understand the behavior of a plant environment. By using electronics guided environment indoors the plant will have the basic things that it need to grow. It will also give the user the viability of the integration of programming and electronics tools, in other to be used in agriculture. This will intend to make people aware of their environment not only physically but on the digital area also. It will help people to learn how to integrate this tools in other to help them grow an indoor plant. The projects, also uses a JAVA software that reads and writes signals to the Arduino. With the use of the Arduino input signals that are read by the sensor changes and generates an output to activate behavior .This to simplify the user experience. This JAVA EASY application will tell the user if there are problems in any of the input data and record the data in a data sheet.*

Key Terms *– Arduino: Microcontroller, Analog: any continuous signal that varies thru time, EASY: Electronics Arduino Simple Yard, JAVA: programming language expressly designed for use in a small application module. LDR: light dependent resistor, Plant, Electronics,* ***Baud rate*** *is a speed measurement for communication.*

INTRODUCTION

Puerto Rico is in a need of new business entrepreneurs that self-starts their own infrastructures. With the help of EASY we can wake up interest on the minds of Puerto Ricans to understand the concepts of programming, electronics and agriculture. This project intends to make it simple and affordable to include the programming, electronics and agriculture environment to help a plant growth.

MOTIVATION

Puerto Rico is passing thru an economic crisis, this is why I understand that we need to work hard to get us on the right track. Studies proclaim that education is the key to unlock a whole world of opportunities. More than helping others to growth I am motivated to help others understand the need of agriculture, the importance of harvesting, the need of having plants nearby, and also technology in our lives and indoors environments. With this on hand as we implement the existent technology to our environments we may have the opportunity to change the life style.

PROBLEM STATEMENT

There is a problem in now day in schools, houses and metropolitan areas. Many are not enthusiast with the agriculture anymore, because they may see it as an old way to get our own food. People rather go to the super market, than to grow their own crops. In a recent poll I made on twitter platform, most of the people does not have a preference on organics foods, although many of those persons interviewed does not have any crops on their houses [1] shown in figure 1

There is a study made by *Statista* platform from 2005 until 2015 almost 94% of the population lives in urban areas.[2] So that tells us that the most common Puerto Ricans does not have their own crops.

But a recent survey [3] shows that more than 50 percent today understand the need of the organic food because of their rich value of nutritious eating.

This tells us that there is a need of self-plant cares on the houses.

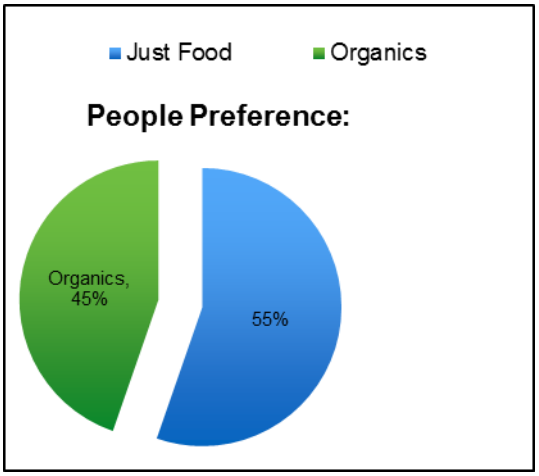


Chart 1
People Preference

APPROACH

I understand that Puerto Rico has, only specialize schools, in which only one is on science and mathematics [4]. I understand by this that the approach of today's educations is not based on technology as a strong teaching tool, by this we as time passes by the interest in technology just became a consumer thing. With this at hand we can tell that Puerto Ricans just consume electronics but the majority does not interact with it to help them as a tool.

The need of this tool in the home environment is a great way to regain the interest back in cultivating our own crops. This is why Puerto Rico needs to have instruments like EASY, on their hands and also we need to begin to integrate the deferent aspects of, analysis, programming language, agricultural science, and economics to each area of our lives.

I understand that by integrating the areas mention before, our future generations may have a better understanding of tomorrow's future. I created an easy Arduino yard that will help people to gain again the interest in the soiling and cultivating methodology with the use of technology as a tool. Expanding the use of programming and electronics we can ensure that people from all ages gain interest in the agricultural business again. This project works as follows on the diagram on figure 1.

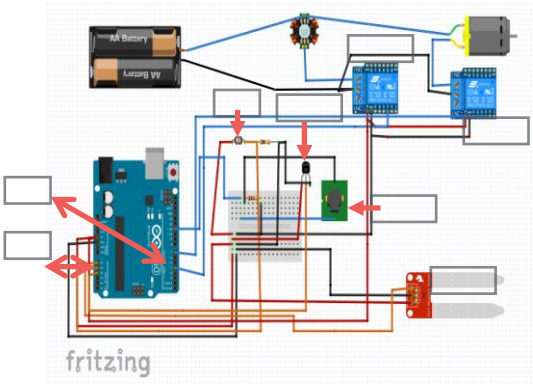


Figure 1
Circuit Diagram

EXPLAINING THE ANALOG INPUT SENSORS

The Project includes a series of analog inputs. The inputs are as follow:

Light Sensor (Voltage Divider) (1)

This is an analog sensor made out of a photo resistor or also known as light dependent resistor (LDR) that measures the temperature change and indices a voltage, that voltage is differentiated with the resistor in a voltage divider, as shown in the diagram.

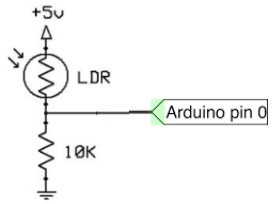


Figure 2
Voltage Divider

It works by passing current through the sensor by measuring the amount of heat passing thru the sensor and measuring the voltage change across. The equation for the voltage divider will be [5]:

$$Vout = Vin * (\frac{R2}{RLDR + R2}) \quad (1)$$

As we can see if there is a change in the resistance value RLDR the arithmetic function will provoke a change in the voltage output. We need to have the LDR variable in other to have an effect on this divider. Then we use the analog to digital converter, to read the readings of this conversion. In this case we use the microprocessor from the Arduino with the code mentioned below. The relation between the voltage changes in the photo resistor goes as this graph. As the light is more intense the voltage on the divider drops and the resistance in the photo resistor.

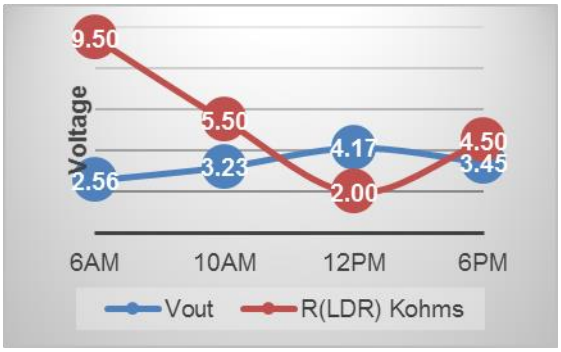


Chart 2
Resistance vs Output Voltage

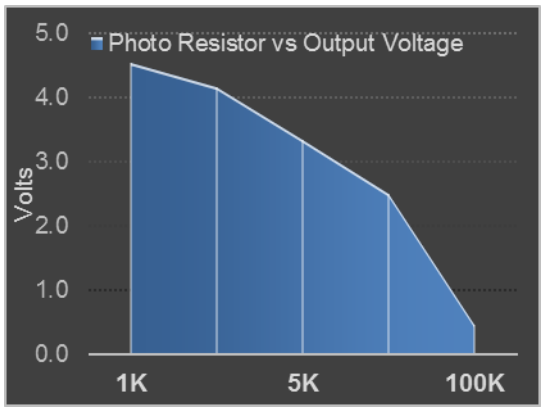


Chart 3
Photo Resistor vs Output Voltage

The Light is measured in the Arduino by:

1. This code first enables the serial com, in other to check the input interaction on the JAVA code.
2. Then value is read thru the:
   - $val = analogRead * (analogLight)$ (2)
3. The voltage is converted from the raw value in other to get the analog to digital:
   - $voltage /= 1024.0$ (3)
4. Makes an arithmetic value to convert to millivolts.
5. The conditions of the light turning ON or OFF to activate the relay are determined.
6. Writes to the Voltage Pin on Arduino to give an action.

The Sensor has three pins (facing the sensor, pin 1 is the most left):

1. VCC - 3 to 5V power DC
2. A0 = Analog Read Data in
3. 10k Ohm Resistor to ground

Once the sensor is installed at Arduino, the sensor is coded in order to test the sensor [6].

The Importance of the Light Control

Controlling the light on a plant grow is essential to its development, to nutrient absorption. The intensity of light the plant receives is determined by the wattage of the light source and how close this source is to the plant. Plants have different need of lights thru the year, this is important when you want a plant to grow in any season. You need to create the proper environment in other to grow healthy.

SOIL MOISTURE SENSOR

The HL-69, is a digital relative moisture sensor. It works by passing current through the soil and measuring the resistance. As shown in figure 3.

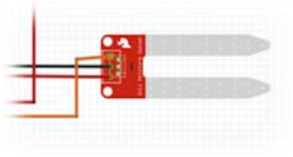


Figure 3
Moisture Sensor

According the readings made by experiment, the sensor should be powered between 3.3V and 5V with an accuracy of +/-2% for relative Humidity. Its average 2 seconds (minimum time between readings).

Once the moisture exceeds the threshold indicated on the code, the Arduino will send an output signal to the water pump to activate the watering in order to add water to the soil until it has the right moisture amount. The moisture is measured by measuring the maximum amount of water the soil has, and comparing the voltages. The findings on this experiment, was that the more water the soil have the higher the voltage gets, this is because of the resistance in the terminals.

As water and particle in the soil are a conductive material the relation of the electrodes that pass thru the terminals increase as we add more water. This interaction of water and soil makes the sensor react and add a change in voltage reading thru the circuit.

The HL-69 has Four Pins (Facing the Sensor, Pin one is the Most Left):

1. VCC - 3 to 5V power DC
2. A0 = Analog Data out
3. D0 = Digital Connection out.
4. GRN = Ground

Once the sensor is installed at Arduino, the sensor is coded in order to test the sensor. [7] Once you reload your Arduino IDE, the "Humidity Sensor Test" should be installed. Run the code to verify that everything is running OK. Once run you may see the reading change on the Serial Monitor in the Arduino selecting the 9600 communication baud rate.

TEMPERATURE SENSOR

This sensor is the TMP35GT9Z [8], an analog sensor that measures the temperature change and indices a voltage, that voltage is differentiated with the resistor in a voltage divider, as shown in the diagram.

According to the data sheet the minimal operation voltage is from, 2.2 volts. Indicating that has a 10 mV/°C scale factor. The specified temperature are −40°C to +125°C, this makes it perfect to determine the right temperature for a plant.

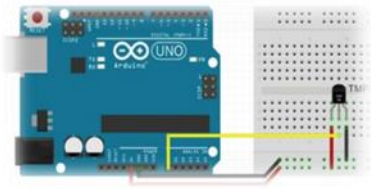


Figure 4
Temperature Sensor

This sensor works by passing current through the sensor by measuring the amount of heat passing thru the sensor and measuring the voltage change across the voltage divider inside the sensor. Then these millivolts are then pass thru a series of transistors to determine the voltage.

The output voltage measure following the data sheet reference is of 250 millivolts by 25C. The graphical relation of the voltage measured and the thermistor circuit looks like chart number four.

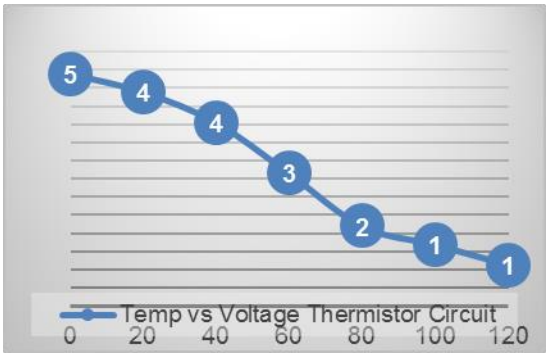


Chart 4
Temp vs Voltage Thermistor Circuit

The temperature is measured as follows:

1. The temperature is read thru the analog 2 input of the arduino board.
2. The voltage is read from a raw value then is from analog to digital
   - $500mV/1024 = .48828125$ (4)
3. Makes an arithmetic value to convert to millivolts.
   - Float Celsius = Temperatureval * 0.48828125 (5)
   - Convert the Celsius in Fahrenheit
   - $Tempvoltage = Celsius * 9/5 + 32$ (6)
4. Adds the condition parameters.

5. Writes to the TEMP Pin on Arduino to give an action.

The LM-34 has 3 pins (facing the sensor, pin 1 is the most left):

1. VCC - 3 to 5V power DC
2. A2 = Analog Read Data in
3. GRN = Ground

Once the sensor is installed at Arduino, the sensor is coded in order to test the sensor [9].

The Importance of the Temperature Control

Resent research done in the US by the CDC [10], showed that although the good concentration on CO2 can affect the plant growth in a good way, the changes in the right temperature the plant should receive, can cause bad absorption of nutrients in the plant digestive process producing a low production on the corps. The research showed that extreme temperatures also can cause crops not to grow the right way. Also another study showed that the expansion of rural areas may increase the damage in plant propagation [11]. This is some of many reasons to control the temperature the plant is receiving.

EXPLAINING THE ANALOG OUTPUT RELAYS

The Project includes a series of analog outputs. The outputs that where included is explained as follows:

Lamp ON/OFF

The lamp will turn on when the user wants to or when the Arduino light sensor detects low light intensity. The threshold values where experimented and explain in the light sensor section. Then it will send a character in byte to the Arduino, this characters will be interpreted by the Arduino, with a precompiled code in the integrated development environment (IDE).

This buttons will activate the light, once pressed the JAVA code will have a listener waiting for the response. The figure 5 will introduce how the run code will show the user the interactive screen of the Arduino controller.

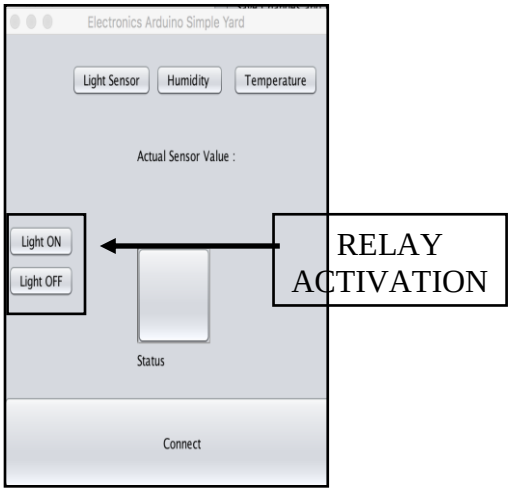
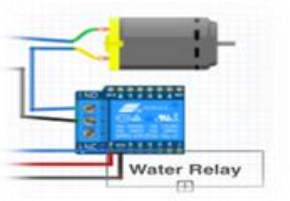


Figure 5
Light Controlling Buttons

Water Pump ON/OFF

Once the moisture sensor indicates water is not present in the soil, the water will be added on the soil until it reaches the experimented good levels of voltage on the sensor



Fidget 6
Water PUMP Circuit Diagram

JAVA SOFTWARE INTEGRATION

This section will explain the system overview and related usage for the java code that reads and writes to the Arduino.

System Overview [12]

The EASY application is a user tool to simplify the readings on the sensors. The program will give status and information in a user friendly manner. Also may store text so that user can integrate this data in any other application for further analysis.

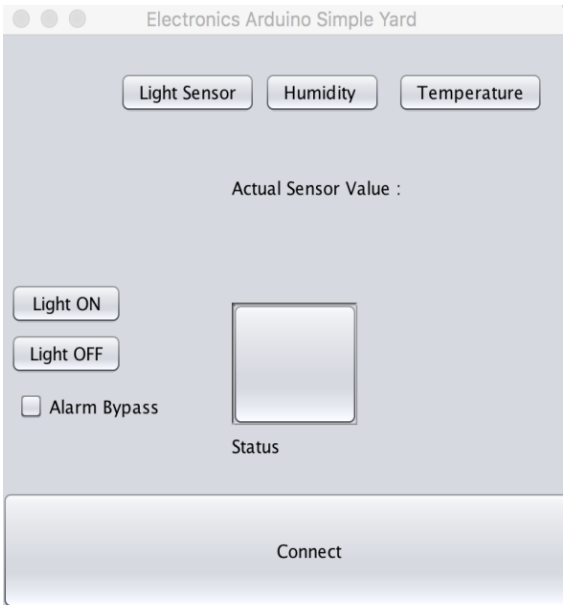


Figure 7
EASY Application

Design Considerations

As the software is designed to work with an Arduino, it was needed to add a serial communication [13] between the app and the Arduino. This serial communication will provide the byte reading handshake between the computer and the Arduino itself. The purpose is to guide the client easy understanding the values introduced by the Arduino analog read. The Arduino as explained in detail above, it will read the analog inputs and convert the values in volts.

Goals and Guidelines

The main goal of this project is to help the indoor plant owner on their plant grow experience. This project can be also intended to research purposes since it can read values from these inputs and stored in a text file. This file can be used as a telemetry.

System Design

Easy project will have as we speak before, an Arduino microcontroller [13], a Java source [14] code, and serial communication available between the peripherals. The system will consider the light, water, air and temperature. The Arduino will then process this information through a serial communication, then the Arduino will read the analog inputs, in order to show write data on the JAVA software as requested by the client. This byte value will be evaluated and tested by the software, by doing a series on pre done experiments about the high and low values of the sensors. This values can be found on the codes provided by each sensor. The system was design taking into consideration indoor plant owners, since they may need to do some research and know certain behavior in a plant or a crops. The EASY can be powered by one 12 volts power supply that controls the Arduino unit, and the other to control the relays current. It was separated, in order to isolate the power consumption of the relay and the light from the Arduino current.

Responsibilities

The EASY application has a class that calls a *JFrame* [13], where has the initial components of the application. Automatically it opens a file, ready to save the selected values in an organized manner. The primary responsibility of the application is to connect to the Arduino. The application can connect on any USB port and provide a serial communication in 9600 baud transmission rate. The serial port sends and receives bytes of information one bit at a time Also it has the ability to read the input form the analog Arduino interfaces and give a relative voltage on the input. Those values are saves on the EasyOutput.txt file created at the start of the software, as shown in figure 8.

This component is added, to have a chronology of the data reported by the Arduino on the computer and then have a file saved with those findings. There are some constraints in the data recollection, since the data receive is in byte, but every input has a voltage.

I managed to control the input as a voltage divider (1). I find that the value read in byte changed constantly meaning that the value in the input changes according the voltage. As this was noticed I used a voltage divider in the reading of the analog inputs, with a variation.

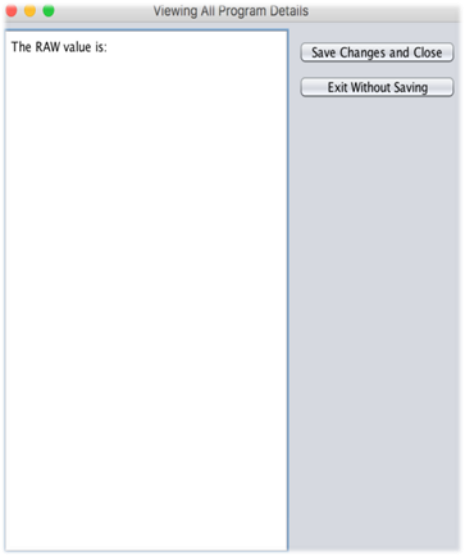


Figure 8
EasyOutput.txt File

As you may appreciate there is a class called 'serialEvent' shown in the *Code 1 figure 9* which listens to the port and get the event values. This value is then called in a buffer which will add values received from the analog input. Then that value is the coveted into float in order to calculate the voltage divider (1) to have a relative voltage value.

This value can be a constraint since is a value to indicate voltage on the analog input, however the user can interpret that signal and calculate any differential, to generate their own analysis of how the plant is behaving. The rest of the application is composed by public class Easy that has 7 methods. The first class to explain is the components initialization that will create the format and calls all the buttons functions to it. Then once the 'connect' button is pressed the will begin the serial event listener in other to read the *buffer* values interchanged by the Arduino and the code. As you may see in the Code 1 table this serial event, not only reads the buffer but also injects and convert the value received in their respective strings and integers. This conversion then is posted in the program so the user can interact with them.

The program will show the values in labels and also enter into conditional statements to determine good values of each button previously analyzed in their respective experiment.

```
public class SerialPortReader implements SerialPortEventListener {

 public void serialEvent(SerialPortEvent event) {
  if (event.isRXCHAR()) { //If data is available
   if (event.getEventValue() > 0) { //Check bytes count in the input buffer
    //Read data, if 10 bytes available
    try {
     //String receivedData = serialPort.readString(event.getEventValue());
     byte buffer[] = serialPort.readBytes(1);
     System.out.println("Received " + buffer[0]);
     value = buffer[0];

     string = ("Value recieved:" + String.valueOf(value));
     //string = ("Value recieved:" + receivedData);
     string2 = String.valueOf(value);
     //jLabel.setText(string2);
     System.out.println(string);
     //Converting to float to calculating
     integerValue = (Float.valueOf(buffer[0])).floatValue();
     System.out.println("The Int Value ABS is:" + integerValue);
     //calculation of Voltage divider
     //multipling the integer value by 30 to increase the
     //resistance change
     readValue = abs((1000 / (1000 + (integerValue) * 30)) * 5);
     //recieve data after arithmetic function
     receivedData = String.valueOf(readValue);
     System.out.println("The Calculated Integer is:" + readValue);
     jLabel.setText(String.valueOf(abs((1000 / (1000 + (integerValue) * 30)) * 5)));
     /*out = new PrintWriter("EasyOutput.txt");
      out.println("The values you requested are:");
      out.println(string);
      out.close();*/

    } catch (SerialPortException ex) {
     System.out.println("Error in receiving string from COM-port: " + ex);

    } //catch (FileNotFoundException ex) {
    //Logger.getLogger(Easy.class.getName()).log(Level.SEVERE, null, ex);
    //}
   }
  }
 }
}
```

Code 1 Figure 9
Java I/O Serial to Arduino

RESULTS

EASY, Electronics Arduino Simple Yard, this hydroponics, electronically controlled system will be not only an intractable tool in indoor planting, but it also may break the barriers of soling, since the idea is to harvest inside the urban areas of Puerto Rico and the world, without the proper environment EASY will introduce the proper environment for a plant to grown, and then be transplanted. A research made by EPA.gov founded that most Americans eat non organics foods [15]. I found in a recent pool I made on twitter platform, of 20 people I found that most of them does not owned their own crops as shown in chart 4, which means, they always buy the same food, and also they eat outside, incrementing the chance of not getting a good health according to another research made by EPA. [15]

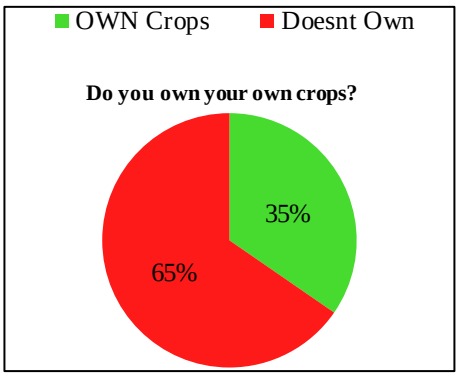


Chart 4
Own Crops vs Doesn't Own [16]

CONCLUSIONS

This software, hardware and physical planting integration it going to change the world of indoor planting since the Arduino will control the growth .With today's rush sometimes we cannot have the time to nurse the plants, this will be a significant "win "for specialized schools, since can be a nice hack to the class room and great motivations for new students. This work responded to the need of many of our today's life style, it responds to a growing generation with a need of change in the way the use technology. Also it will be a challenge to research more in other environment.

FUTURE WORK

There is more work to do, the science and technology is expanding even day. There are other projects out there that uses similar technology with similar results. This project can advance in wireless communication between the hardware and the software. It can also be added a database where the Arduino can communicate thru PHP a series of values and interact them with HTML on a web server. This internet of thing integration can be practical not only for indoor use but also to bigger scales as to research projects on plant grow in other planets, spaces or atmospheres

ACKNOWLEDGEMENT

First of all I wish to give thanks to God. I also would like to express my sincere gratitude to all the Polytechnic university professors, that leadership us on their courses. I sincerely thank Prof. Nelliud Torres for his guidance on this process, I thank Raquel Martinez for her perseverance with me on this. I also thank Prof. Cruz for his guidance on the selection of this master's degree. Special thanks to everyone that participated on the polls, and thanks for all the advices that I received during the process.

REFERENCES

[1] J. G. Zayas, "Help me on my project, please retweet :) do you have your own crops?" in Twitter, Twitter, 2016. [Online]. Available: https://twitter.com/IZayasI/status/811781986662621185. Accessed: Jan. 6, 2017.

[2] Statista, "Puerto Rico - urbanization 2015 | statistic," Statista, 2017. [Online]. Available: https://www.statista.com/statistics/396016/urbanization-in-puerto-rico/. Accessed: Jan. 11, 2017.

[3] CDC, "Healthy eating for a healthy weight," CDC, 2016. [Online].Available:https://www.cdc.gov/healthyweight/healthy_eating/index.html. Accessed: Jan. 11, 2017.

[4] Gobierno de Puerto Rico. Directorio de Escuelas Especializadas [Online]. Available: http://www.de.gobierno.pr/files/Directorio_Escuelas_Especializadas_2012-2013.pdf. Accessed: Jan. 11, 2017.

[5] R. L. Boylestad, Introductory circuit analysis, 11th ed. United States: Pearson Education (US), 2006.

[6] Zayas 89, "Zayas89/Arduino-Analog-1-3-Read," GitHub, 2017. [Online]. Available: https://github.com/Zayas89/Arduino-Analog-1-3-Read/blob/master/test2_light.ino. Accessed: Jan. 11, 2017

[7] Zayas 89, "Zayas89/Arduino-Analog-1-3-Read," GitHub, 2017. [Online]. Available: https://github.com/Zayas89/Arduino-Analog-1-3-Read/blob/master/Test_Moisture_Sensor.ino. Accessed: Jan. 11, 2017.

[8] Analog Devices. (1996–2015). Low Voltage Temperature Sensors [Data Sheet]. Available: http://www.analog.com/media/en/technical-documentation/data-sheets/TMP35_36_37.pdf.

[9] Zayas 89, "Zayas89/Arduino-Analog-1-3-Read," GitHub, 2017. [Online]. Available: https://github.com/Zayas89/Arduino-Analog-1-3-Read/blob/master/Test_Temp_Sensor.ino. Accessed: Jan. 11, 2017.

[10] U.S. EPA, "Climate impacts on agriculture and food supply," 2016. [Online]. Available: https://www.epa.gov/climate-impacts/climate-impacts-agriculture-and-food-supply#crops. Accessed: Jan. 6, 2017.

[11] T. del Mar López, T. M. Aide, and J. R. Thomlinson, "Urban expansion and the loss of prime agricultural lands in Puerto Rico," AMBIO: A Journal of the Human Environment, vol. 30, no. 1, Feb. 2001, pp. 49–54.

[12] D. Maxwell, Java Bootcamp, *Learning the Basics of Java Programming*, 1st ed. KindleBookSpot.com: David Maxwell, 2016.

[13] J. Patterson, JAVA: A Beginner to Expert Guide to Learning the Basics of Java Programming (Computer Science Series) Kindle Edition, Kindle ed. Amazon, 2015.

[14] J. Nussey, *Arduino for dummies*. United States: Wiley, John & Sons, 2013

[15] R. Preidt, "Americans divided over organic, GM foods: Poll," *HealthDay*, 2016. [Online]. Available: https://consumer.healthday.com/vitamins-and-nutrition-information-27/food-and-nutrition-news-316/americans-divided-over-organic-gm-foods-poll-717280.html. Accessed: Jan. 6, 2017.

[16] J. G. Zayas, "Help me on my project, please retweet :) do you prefer?" in Twitter, Twitter, 2016. [Online]. Available: https://twitter.com/IZayasI/status/811781181045882880. Accessed: Jan. 6, 2017.