Marcellin Nshimiyimana
The University of the South, Dept. of Computer Science
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Power of Arduino

It is summer and you are coming out of work. You enter inside your car, and suddenly feel like you have just been placed in a fire container because of the 100 degree Fahrenheit temperature. Now, imagine how convenient it would be if your car knew when you were going to drive it, and 5 minutes before you needed to drive it, it could start cooling down by itself. This machine intelligence of knowing things ahead of time is achieved through the use of embedded systems [(1)]. They are a hardware-software combinations that provide real-time responses with or without human interaction, and they are provided as part of a bigger system. For example, a car cruise control system contains an embedded system that replaces a person in maintaining the constant speed of a car. Some embedded systems are formed with microprocessors [(2)] to perform general purpose tasks, and others use microcontrollers to perform specific functions. Arduino [(3)] falls into the microcontroller driven embedded systems category. Arduino is basically an electronic device that is used to "create interactive objects or environment". The main part, Microchip [(4)] performs a particular task until it is reset. These tasks range from weather control to sound control, and of course one can also perform multiple tasks with Arduino by connecting shields [(5)] to the Arduino board. Arduino shields are also electronic devices that add more capacity to the Arduino. As being able to interact with the environment, Arduino can have a big impact on our society as it provides an easy way for people to communicate or understand the world around them.

Although Arduino is easy to use, it requires some tools to function properly. Controlling arduino requires a user to put instructions [(6)] into the microchip so that arduino can execute them. These instructions are called programs, and one uses an Integrated Development Environment (IDE) software [(7)] to write and download the instructions into the Arduino microchip. These programs are often designed to collect and send data or perform a task depending on what data is collect and how variable is compared to a particular value. So, to achieve this data collection, Arduino uses different sensors, such as sound

sensors, light sensors, temperature sensors, and chemical sensors. Besides sensors that are used to collect data, Arduino uses shields to perform tasks that include sending data on remote server or through Bluetooth connection, processing image based data, turning motors back and forth, and receiving a telephone, GPS, or WIFI signal. After knowing all these good things that Arduino does in combination with Arduino shields and sensors, one may wonder how they are interconnected for a good performance.

Light Emitting Diode and Potentiometer [(8)] were used to understand the basic use of Arduino. In electronic field, visible light is the best tool for checking the effectiveness of a device because it ensures the user that electrical current is passing through. So, for Arduino, an LED plays such a role of confirming the successful download of a program into the microchip and/or easily showing which pin is providing the power. The LED also indicates the power/voltage variation on a particular pin caused by sensors or other voltage modifying devices such as photo-resistors or pushbuttons. These voltage modifying devices play an important role in our daily life. For example, everybody knows that automatic doors open when one gets in front of them. One can achieve this technology by placing a big pushbutton under a carpet in front of the door so that whenever a person steps on the carpet, they would push that button and open the door for themselves without noticing. For my case, I used a photo-resistor that turned the LED on at night and off during the day, and I think many street lights use this light detector to save time and energy. Nevertheless, not only are streets lights controlled by sensors, but decoratio- based lights are too.

Music and lighting system are very important parts of our celebration. Weddings, graduation parties, and birthdays require some type of entertainment which include acting, dancing, or singing. Moreover, the place in use has to distinguish itself from normal place by the types of decorations that cover it. Some of the modern decorations are laser lights and/or disco mirror balls (spheres that shine with different colors) [(9)], and one feature that makes these devices special is the ability to automatically change

the light color and point it into different direction. It is hard to say if these lighting devices use any electronic system to control them. But, one good thing a person can do is somehow connect them to a radio or any other audio playing system [(10)] so that they can give off light of a particular color depending on what type of music is played and how loud it is. With Arduino, I was able to try this process. In my project, I used 10 LED's of different light color and a microphone to detect the sound. In fact, after the microphone detects a sound, Arduino would produce a value out of the sound and then after, this value was compared to every single value assigned to each LED. Any LED with assigned value smaller than the sound value, was lit. Since the sound value was changing over time, this made a good variation of light color on the array of ten LED's. The sound value change also can be used in studios as part of a noise cancellation process [(11)] because by detecting a sound, one can easily manipulate it in any way they want. Moreover, this detection and manipulation process is important in big machines that rely on very sensitive electronics, to function. A good example here would be an airplane.

Electromagnetic Interference (EMI) [(12)] causes a lot of problems if not taken care of. Once I was playing with my calculator (HP-28S) near a small FM radio. Whenever, I would perform a large algebra problem with this calculator, I would hear a "ssshh" sound from the radio until the calculator spits out the result to my question. I asked my Math professor and he told me that the current passing through the electronics inside the calculator produce a variable magnetic field. This field, in turn, produces small variable current in the radios wires that create a sound in the radio's speakers. At that time, it was hard for me to understand exactly what he was saying, but after playing with Arduino, I realized that that was an Electromagnetic Interference from the calculator that created external sound in the radio's speakers. The same and common phenomenon happens when a person uses a phone near a radio or a computer. In fact, apart from the main signal which is send on a specific frequency, a phone also emit "low energy electromagnetic waves" [(13)] that are detected by speaker wires and that creates a sound. Besides, this Interference doesn't only produce a sound in a speaker, it also interrupt communication in airplane

systems and other lower energy wireless based communication systems. So, to avoid this interruption, engineers have created a shielding system [14] that prevents a device to transmit extra electromagnetic waves or takes away all outside waves that can interfere with the device. So what I did with Arduino was not making the Electromagnetic interference shield, but an Electromagnetic interference detector that would help an engineer know where to put their shielding system.

This Electromagnetic interference detector was composed of an EMI sensor, Arduino board, and a speaker. The EMI sensor, which is just a combination of a wire and a resistor, would send a detected signal to the Arduino board to be interpreted in a useful way. The information that is collected from the signal include the signal strength and the sound created. I did not get to display this signal strength because it requires a 4Char display [15]. However, I got to play the annoying sound caused by the detected EMI. This device can be useful in planes to track people who do not turn off their electronic devices during flight takeoff and therefore increasing safety. Beside Arduino safety role in a plane, Arduino can also enhance safety in homes and offices.

Security systems are handy for stores, offices, and homes where every member spends time away. Most of us know how convenient garage door remote openers are. Imagine now the same technology, but advanced enough to allow a parent of careless kids to lock the door from their office after all of their kids have just left the house and open it when they come back. With Arduino, this technology is achieved by use of Ethernet shield, servo motor shield, and camera shield. In theory, a camera with motion detection capability would take a picture when a motion is detected and then the picture would be sent by the Ethernet shield to a smart phone of the house owner. If the picture is of a known person, the owner would send a “door unlocking” message to Arduino through Ethernet shield. After all that, the Arduino would trigger the servo motor to put the locker in unlocked position. My project was not this sophisticated because I had no camera shield, but I was able to construct an internet based door opener. I used a smart

phone, but one also can use a computer because I was using a webpage to send information to the Arduino board. The room that I was working has a motion detector inside, so if a person is about to leave the room, their presence triggers the detector which releases the magnetic lock on the door. So, when Arduino received information about opening the door in that room, it would trigger a servo motor to swing a small stick in front of the motion detector that released the magnetic lock in turn. That is, I would be able to use my phone to enter the room instead of my school ID card. The ability of arduino to connect to internet is very useful not just in house security, but also in physics experiments and weather control.

Predicting the weather is very important in our everyday life. Online travel information, such as directions or nice places to visit, has been improved so much that people are able to get real time data about the traffic as well as the weather condition of the place where they are going. This information helps a person better plan ahead their trips because they would not go in a city if it is raining heavily and flooding everywhere, for example. This weather-based information also helps farmers grow crops that are resistive to the current climate and time conditions. Companies that provide this information [(16)], use very sophisticated devices and sensors to collect and process them. However, Arduino, with its sensor connection ability, holds the very basic, but almost complete functionality of these "sophisticated devices." One of sensors used with Arduino in weather prediction and control is the Humidity and temperature sensor – RHT03 [(17)], which is the one I used in my project. I had this sensor connected to the Arduino board, which would send all collected data to the "cosm.com" data sharing website and/or to my smartphone.

The use of this sensor was more challenging and very educational than other sensors. In fact, all other sensors that I used, send data in a digit-based form to Arduino board, but RHT03 sensor was sending byte data which is converted into readable data (digit form) by use of a library [(18)] that came with the sensor. So, to correctly use the sensor, I had to understand how this library works. That is, know

which methods provide what data in which units. After getting readable data, sending them to an external device or a remote server was not easy. The Ethernet shield attached to Arduino, acted as a server that was using a Local Area Network (LAN) [19]. So the server would send information fine, but it could not get request from a device or a client connected to a different LAN because of firewall blocking some connections outside of LAN. Therefore, I created an intermediary connection, a public server [20] that was on the LAN as the Ethernet shield's server, and accessible by everybody. A request of data from an external client would be send to this public server, which would transfer it to Ethernet shield's server, retrieve response, and then send it to the client.

Briefly, learning how to program electronic devices such as Arduino so that they can do any physical task for me, was my goals for the summer. However, with time, I have realized that there are more one can do with Arduino other than giving it instructions to follow, such as interacting with the environment and securing population. Of course, programming was the basic core of my work, one needs to understand what the world wants so that they can create instruction that allows Arduino to help people instead of ruining their life. For example, in security system, knowing that Arduino can send a picture of thieves robbing your house over the internet, which can be accessed by all people, is the same as knowing that it can also send a picture of your husband/wife taking a shower. So, a programmer has to provide some ways to send this picture in a private way. After this thought came to my mind, I started enumerating real life examples of what I can with any project that I would be working on. This real life example include displaying music generated lights, crops farming control, avoiding airplanes information transfer failure and so on. I have posted almost all projects online at http://arthur.sewanee.edu/marcen0/HTML5T/arduino/index.php and http://dokuwiki.sewanee.edu/doku.php?id=arduino_project .so that anybody can check it and hopefully get inspired.

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Resources and definitions:

(1) Embedded systems: Specialized computer systems that are part of a larger machine. Embedded systems, *Webopedia*, Retrieved August 20, 2012, from http://www.webopedia.com/TERM/E/embedded_system.html

(2) Microprocessors: A silicon chip that contains a Central Processing Unit. Microprocessor, *Webopedia*, Retrieved August 20, 2012, from http://www.webopedia.com/TERM/M/microprocessor.html

(3) Arduino: open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. Retrieved August 20, 2012, from http://arduino.cc/

(4) Microchip: a small piece of semiconductor material carrying many integrated circuits. Retrieved August 21, 2012, from http://www.thefreedictionary.com/microchip

(5) Shields: boards that can be plugged on top of the Arduino PCB extending its capabilities. Retrieved August 21, 2012, from http://arduino.cc/en/Main/ArduinoShields

(6) Instructions: computer programs (written in C++ programming Language for Arduino)

(7) Integrated Development Environment (IDE) software: A special text editor designed for writing and installing programs on Arduino board.

(8) Potentiometer: a simple knob that provides a variable electrical resistance. Reading a Potentiometer. *Arduino.* Retrieved August 21, 2012, from http://www.arduino.cc/en/Tutorial/Potentiometer

(9) Disco mirror balls: a large revolving ball covered with small pieces of mirror glass so that it reflects light in changing patterns. Retrieved August 21, 2012, from http://www.thefreedictionary.com/mirror+ball

(10) Audio playing system: this can be a person singing or playing drums.

(11) The original project (in the book) was designed as noise detector.

(12) Electro*m*agnetic interference: a naturally occurring phenomena when the electromagnetic field of onedevice disrupts, impedes or degrades the electromagnetic field of another device by coming into proximity with it. EMI. *Webopedia.* Retrieved August 21, 2012, from http://www.webopedia.com/TERM/E/EMI.html

(13) Why am I not allowed to use my cell phone in airplanes or hospitals? *Howstuffworks.* Retrieved August 21, 2012, from http://www.howstuffworks.com/question230.htm

(14) Shielding system: a system of controling an Electronic Field in order to prevent undesired responses or degradation of performance in electrical or electronic equipment. This is achieved by coating specials

material around an electronic device. EMI Shielding. *Central Coating.* Retrieved August 21, 2012, from http://www.centralcoating.com/emi-shielding.html

(15) 4Char display: A system of four seven-segment LED displays that show, natch, four characters of data at a time. E. Gertz, P. Di Justo (2012). New Component: 4Char Display. *Environmental Monitoring with Arduino.* O'Reilly Media, Inc.

(16) Companies that provide this information: Google, Bing…

(17) Humidity and temperature Sensor-RHT03. *SPARKFUN Electronics*. Retrieved August 21, 2012, from https://www.sparkfun.com/products/10167

(18) Library: A collection of instructions that are designed to execute a specific task. How to write libraries for the Arduino? *Arduino Playground.* Retrieved August 21, 2012, from http://arduino.cc/playground/Code/Library

(19) Public server: every computer science major has an account on “arthur.sewanee.edu” webserver.

(20) Local Area Network (LAN): A computer network that spans a relatively small area (ex: a school facility). local-area network. *Webopedia.* Retrieved August 21, 2012, from http://www.webopedia.com/TERM/L/local_area_network_LAN.html