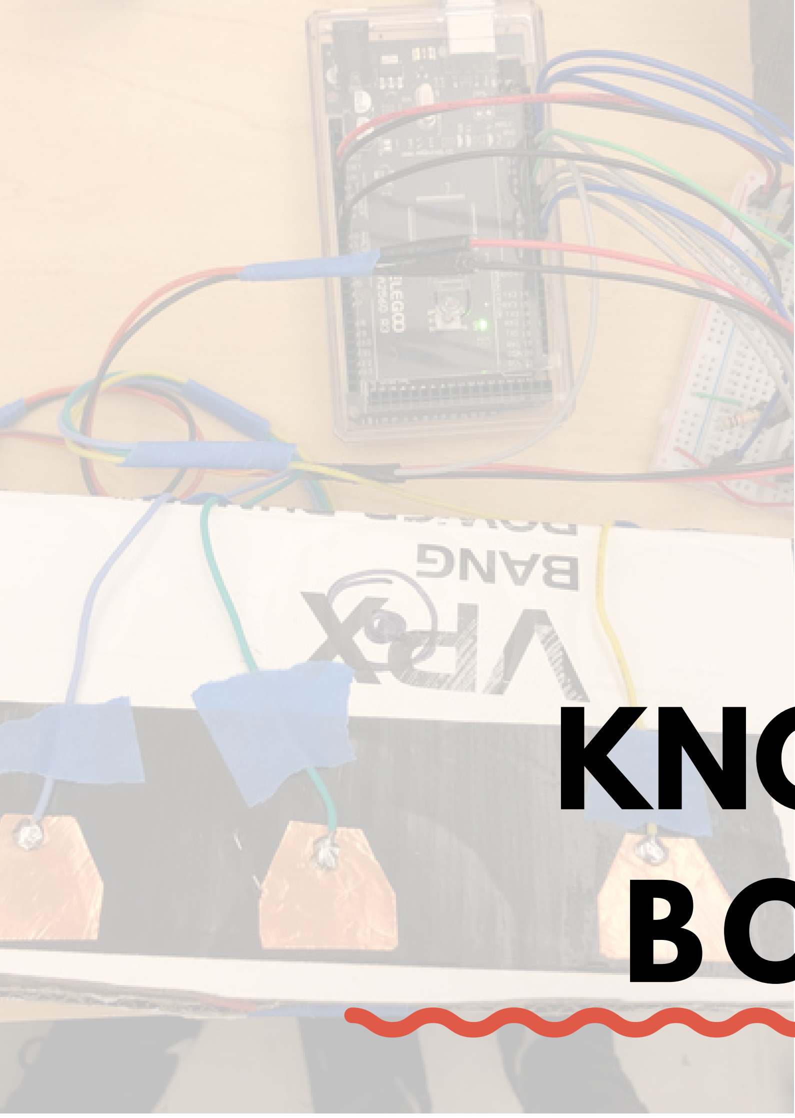

ELECTRO INFINITY

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ENGR 10: INTRO TO ENGINEERING

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SUBMITTED TO:
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OBJECTIVE

Our goal is to become familiar with the Arduino microcontroller through a guided project lesson. To further challenge our skillset, we added supplementary characteristics to our project that we each found interesting. Obtaining success by self-efficiency and accessing resources from our current environment, i.e. our network, friends, and/or professors.

DESCRIPTION

The project is a lockbox designed with a number of features to customize capabilities based around the consumer. The main feature of this box is its ability to lock, and remain locked, until a specific knock sequence has been tapped on the box by the user. Additionally, the box has been programmed with a side game similar to the “Simon Says” game. The addition of the game is meant to be a brain game that helps with memorization while also serving as a break during the user’s work time. If the box has been opened while the program is in the lock setting, an alarm will sound. Also, the next feature is a tamper sensor in the form of an accelerometer, which feels acceleration in all directions. If the accelerometer registers continuous acceleration in a 3 second period, an alarm will sound alerting the user to possible tampering. The goal of the lockbox is to increase productivity for the user by being a way to lock away distractions, like a phone, during a work period. The significance of the project lies in the fact that many need a way to get rid of distractions, as shown by the market research, but currently there is no effective method to achieve this. Seeing a need that could be filled by our project, we proceeded to plan out a method to achieve the features desired. The main challenges that occurred during the assembly phase lied within the programming of each component. Creating a program that could correctly interpret analog signals from the piezo, capacitive and accelerometer sensors proved to be a significant challenge. Upon completing the interpretive portion of the program, creating a function that could consistently perform the actions desired with the interpreted data received from the Arduino was an even greater challenge because it forced the team to create methods for simplifying the program in a way where the features of the lock box would perform well under any situation. While these challenges proved to be difficult, the impact of a fully functional lock box would be immense, not only by filling a need for many students and professions alike, but also because of the box’s versatility and many possible applications.

THE DESIGN FIGURES

Mechanical Design:

- The container is a wooden box about the size of a jewelry box with electronic sensors, wires, and a microcontroller augmented for the user to interact with. On the outside, touch sensors, and LEDS can be observed. Upon opening the box, a close inspection of the lid reveals the top lined with copper tape as well as a latch hook to catch the servo latch and close the lid.The box is lined with a layer of copper tape that allows a faraday cage effect thereby shielding mostly FM signal. A false bottom is placed to obscure the electronics below that operate it. An extended rod from the servo runs through false bottom to allow the servo latch to reach the hook. The electronic components are mounted in place through a mixture of permanent adhesives and carving out wood for emplacements.

Circuit Design/Control Algorithms:

- The Knock Lock's circuit design is an extended design of the Knock Lock from chapter 12 in the Arduino Projects Book. In our design, we added an additional two piezos, replaced the mechanical button with capacitive sensors, and included high pass filters to help control received data from the piezo sensors. The Knock Lock receives user input from either the Capacitive Sensors, Piezos, or the contact plates. For output, the user reads cues from the light sensors, hears tones from the speaker, and waits for the servo motor to unlock. All of these inputs and outputs are managed through an Arduino Mega 2560 Microcontroller.
- Each Capacitive Sensor is a copper plate with a soldered wire that connects to two things: a resistor which then connects to a digital input port on the Arduino, and connected to a line that grounds all connected capacitive sensors back into one digital input port. The Capacitive Sensor, carries a charge that is disturbed when an object touches or comes close enough. This disturbance is measured through the digital inputs while the tethered line supplies voltage through a 1 MΩ Resistor before connecting to a Capacitive Sensor.
- Each Piezo Sensor takes 5V input and branches into the analog port as input and into a 1 MΩ Resistor that is connected to ground. The Piezo Sensor A sensor that utilizes the piezoelectric effect, to measure changes in acceleration, strain, pressure, and force by converting them into electrical charge is called as a piezoelectric sensor. This generated piezoelectricity is proportional to the pressure applied to the solid piezoelectric crystal materials. The contact plate is a means to detect whether the lid is opened or closed. A 5V plate waits to come into connect with the other plate that branches: to a 10 KΩ Resistor to ground, and to a digital input port on the arduino. Once a signal of voltage is read in the input port, microcontroller locks the lid or sounds the alarm depending on the state of the box.
- The servo motor is a PWM motor supplied with a 100 μF capacitor. The servo takes 5V input as power and waits for a signal sent out from the arduino digital port to determine degrees of rotation. Both servo motor and capacitor are connected to ground.The whole system is supplied by a 6V power supply comprised of 4 1.5V AA Batteries in series. The battery supply's positive lead goes into the VIN port of the Arduino and connects to ground.

Program:

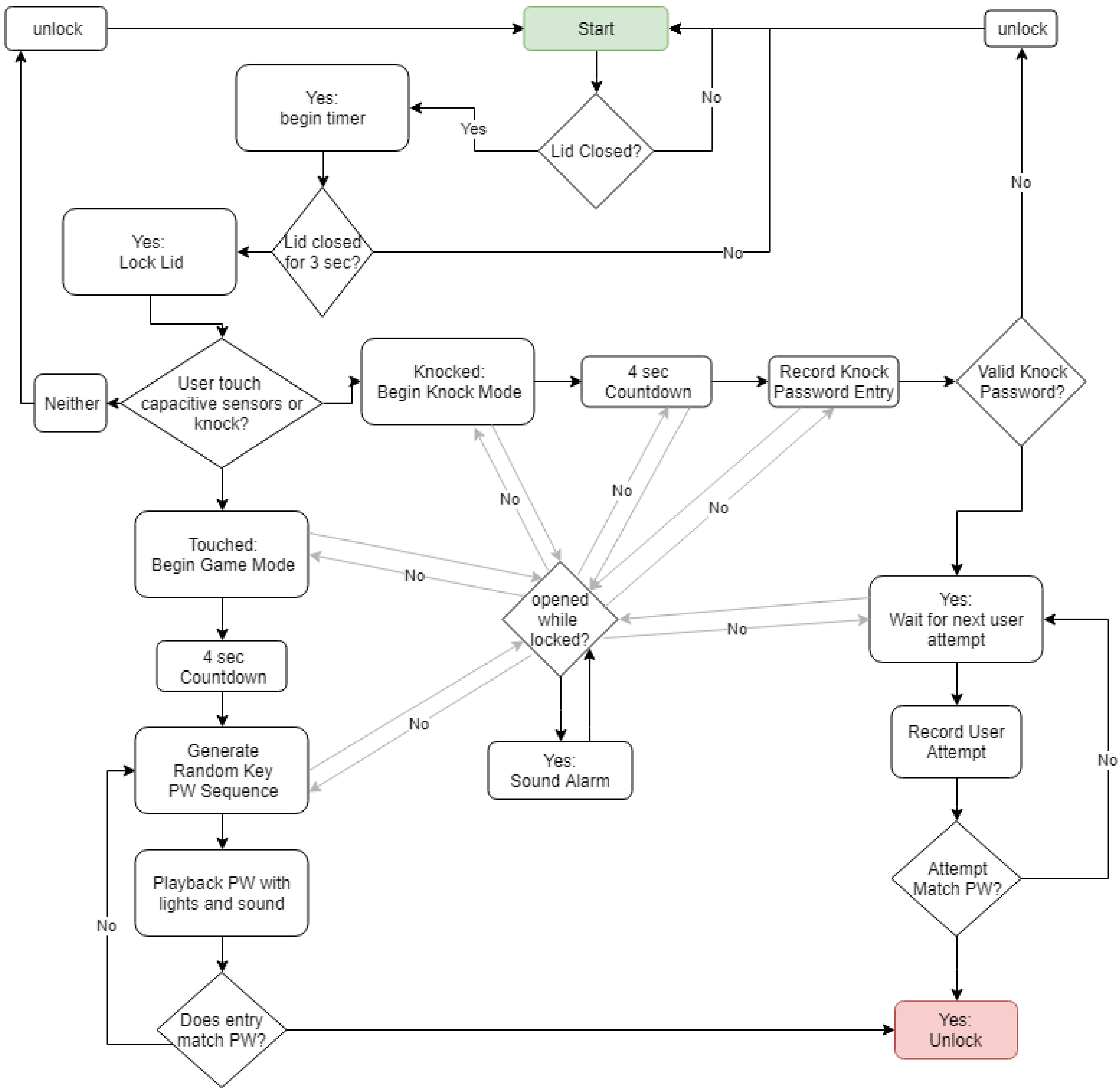
- Since the microcontroller governs the interactions between the user and the box, a state machine programming method was applied. Because this device relies on time keeping such as locking the box after the user closes the lid for three second, a state machine methodology will provide the box the ability to perform time sensitive. The arduino is not able to multitask (multi thread) so in order to perform physical and digital operations the machine will continuously keep track of time and in each iteration check if tasks were scheduled then perform them.

Code:

- The code is an extensive 1800 lines (45 pages worth).

For a view of the code visit this github site:

https://github.com/Kalimachus/KnockLock/blob/master/KnockLock.ino



PERFORMANCE & ADVANCEMENT

The Knock Lock does serve its purpose for storing one's cellphone to manage distractions by locking the device away from the user and blocking signals. One interesting moment experience was the focusing of our attention when developing and debugging the Game Mode. One could not hold a conversation while remembering the touch password and playing it back which proved box's intent of providing focus and managing distraction.

The use of a microcontroller allows us have sensing capabilities and the response time of the Knock Lock is as fast we programmed it to react to user inputs. Its so fast that we had to program delays and sleeper functions to stop the sensors from triggering undesired responses. For example if we did not program a delay on the alarm response, shaking the box could disconnect the contact plate for milliseconds. The disconnect in circuit would then signal the Arduino to set off the alarm. There was also an initial performance issue during development where printing statements to the computer that was programming the microcontroller would slow the processing speed of the microcontroller. Unaware of that performance issue, the microcontroller was programmed to operate slower than its optimized speed thus creating weird timing issues involving playing lights and sounds.

Notable weakness is that the box is wooden. The servo latch hook is wooden and the servo latch is plastic. If someone wanted to break open that box, it would be very easy, but noisy due to the alarm. By removing the batteries or letting them die, the power turns off and the box's microcontroller resets to an unlocked state. However, after our market research, we learned that with this device, there was not an emphasis on security, rather it was on fun.

The merits of this box is in the complexity of the code for the microcontroller. While it is unable process inputs simultaneously, it process input, logic, and output in a sequential fashion thousands of times per second that provides near real-timed response indistinguishable to the user.

CONCLUSIONS & FUTURE WORK

Kyle

“Being the programmer in the project, the amount of hours invested were proportionally high in order to implement the functionalities and features of the knock lock. Learning about electronic theory, the arduino, it’s software capabilities, and the sensor hardware with it’s software too provided a steep learning curve that I had to overcome. I learned to better document my team’s expectations of the project in terms of functionalities in order to avoid going back into the code in order to implement a functionality that was expected to be there that I did not recall while developing. If had to undergo this project with what I learned, I would have at least spent more time understanding each component or went with components that had more documentation. I would also have requested more components in the initial stages in order to rapidly prototype without needing to reconvene in class to share parts.”

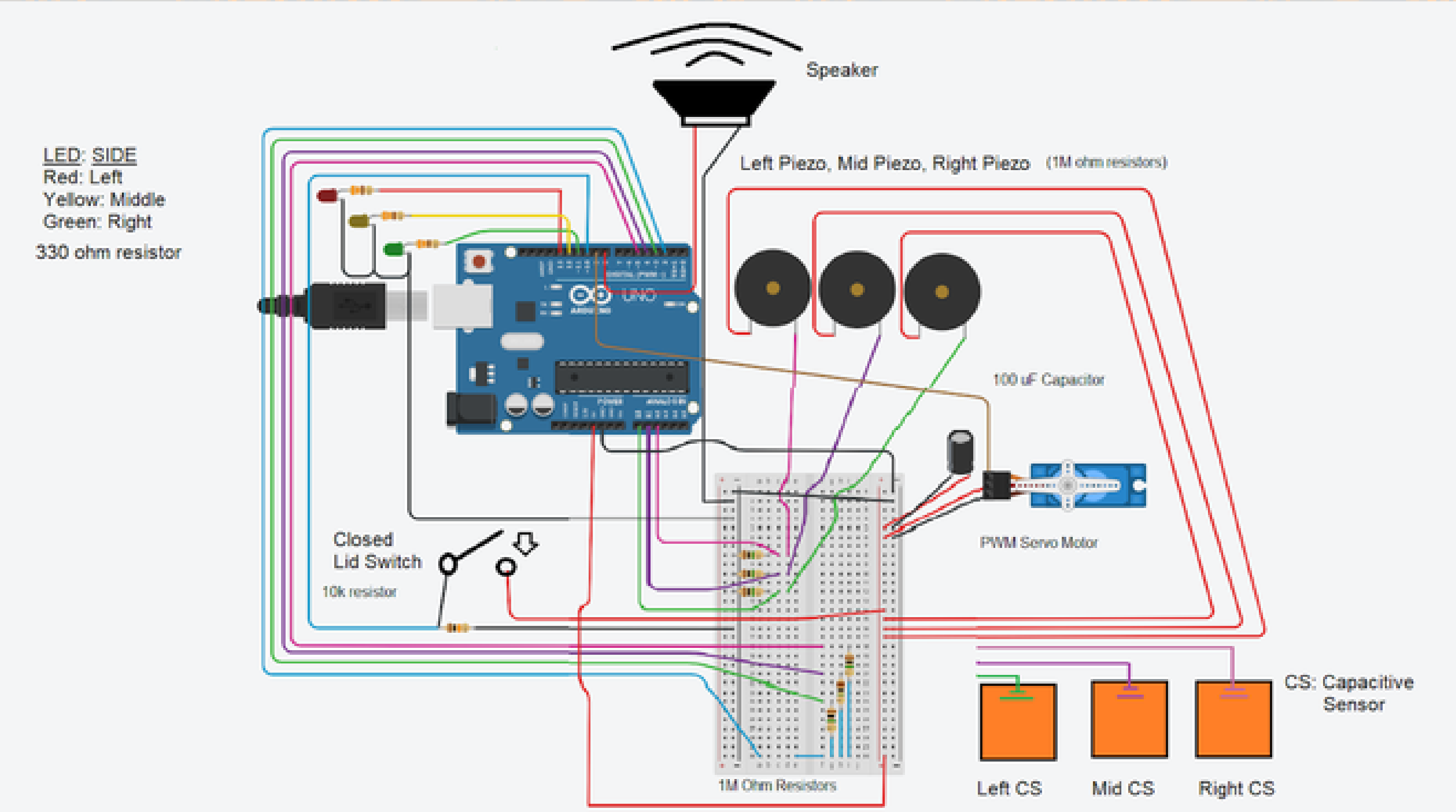
Marvin

“There were a variety new skills that needed to be learned while working on the project. One of the most important skills that I did not think would come into play for an engineering project would be communication skills. Being able to effectively communicate what each individual desires to add to the project and the challenges encountered was an invaluable skill. Another skill was learning how to apply the many physical concepts discussed in theory, to real life situations such as Ohm’s Law, Kirchoff’s Laws, and properties of electrical components when assembling the circuitry. If it was possible to restart the project with the knowledge acquired, more time would have been spent learning the programming aspect of the project, instead of heavily focusing on the physical and electrical aspects.”

Savannah

“For our project, I mainly worked on the circuit design for the capacitive sensors and the piezoelectric components. I learned how to do electronic design, the process of breadboard, and electronic debugging. The capacitive sensors worked really well as touch button for our game module. The piezoelectrics were very sensitive and created a lot of noise during the the knock sequence module. To limit the noise and optimize the code, I added a high pass filter that only allows high frequency waves to pass. Our design worked well with the code, but we had a little problem with the assembly. Our Team did not set strict deadlines within our timeline that we did not account for extra time needed for assembly. Looking back on our product development, it is clear that project management is a huge part of success. Effectively communicating with your team is crucial to save time on designing the circuit and writing the code. There was a point when we realized that we had different views on the concept of our product and what we wanted to showcase. It took some time to solidify the idea of our product as a team, which caused us to backtrack and alter our the code to fit what envision.”

APPENDIX & REFERENCES



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