Smart Mousetrap

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I. Executive Summary

This report outlines the process of designing and creating a smart mousetrap that notifies the user when a mouse has been captured. In order to create a mouse trap that met the clients goals, an efficient battery life, cleanable trap, user notification, and main function of capturing the mouse had to be achieved. With these objectives in mind, mechanisms like a pressure sensor, automatic door, and wifi enabled message were developed.

At first the approach to designing the mousetrap seemed simple, but after many changes and failures throughout testing, a prototype that encompassed all the objectives from the client, but remained realistic to all constraints was created. The mousetrap loures the mouse into the trap with bait placed in the back of the trap in order for the mouse to trigger the pressure sensor. When the pressure sensor is triggered the door closes behind the mouse capturing it. The mousetrap notifies the user when a mouse is captured with a text message sent to the user through a messaging application called Telegram. Additionally the mousetrap is humane because it specifically captures the mouse, not killing it. The mousetrap has six air holes for the mouse to breath and food at the end of the trap. Another requirement was to have the mousetrap be battery powered, so rechargeable batteries were chosen for the prototype including easy access from the bottom for the owner to change the batteries as they wish.

The overall design of the smart mousetrap meets all the requirements from the client, but if a company were to pursue this product more efficient mechanisms would be implemented. With a larger budget and more time to perfect the product, a smart mousetrap could be commercially sold across households nationally.

II. Introduction and Problem Statement

When consumers think of a mouse trap they think of the classic wooden, spring load trap that instead of capturing a mouse, kills it. This is not necessary, as humane mouse traps can be made so that the mouse is released back outside. This idea is appealing as it does not kill the mouse, but one would have to check the traps routinely to to see if a mouse was captured. A smart mousetrap can notify a user when a mouse has been captured. This new smart mousetrap aims to be a humane way of capturing a mouse as well as being user-friendly.

The motivation behind creating a smart mouse trap is the wave of technology in society today. Humans are in constant use of their cell phones, computers, smart watches, and tablets. Creating a product that can notify an owner of a captured mouse via their phone is a successful way to release the mouse safely, and for the owner to not have to worry about constantly checking their trap for a mouse. Having the entire trap be electronically powered is another important aspect of the product because it aims to keep as little contact between the user and the mouse as possible. An owner of a trap wants to keep their captured mouse alive, they do not want to come in contact with the rodent itself. This is understandable because mice can carry diseases, so having the trap open the door electronically should solve this problem, which also exists with conventional mouse traps.

In order to create a successful prototype, objectives and metrics must me met, as well as constraints considered and followed. A design must be chosen from a variety of ideas and alternatives, while also considering cost constraints. This report will outline the process of creating a prototype to meet client's objectives.

III. Design Alternatives Considered

In order to determine how each function would be achieved, a function means table was created. On the left a column labeled function displays all the main functions of the prototype, and then the many ways one could achieve and create this working function are listed in each of the means columns.

Table 1: This shows the initial design space for the smart mousetrap. Green highlights which means were chosen for the prototype, yellow was second to be chosen, and red was decided as a definite no.

Function	Mean 1	Mean 2	Mean 3	Mean 4
Torsion force (to close door)	Spring torsion	Servo/motor	Magnetic door (induction)	
Detect capture	Weight sensor (load cells)	Laser Sensor (light interruption)	Ultrasound sensor	Motion sensor
	Switch button triggered by mouse	Sensitive pressure switch (microwave switch)		
Alert user	LED light	Text message to phone	App notification on phone	Sound/alarm
Identify location	Different color LED	A serial code?	Customizable in app	Bluetooth code
	Different sound	Button Selection		
Power supply	Rechargeable battery	Primary battery	AC 120 V outlet	

Release without contact	Push button Trigger on handle	Application control from phone	Remote control	
Humane	Air holes	No sharp edges	Mouse get food	
Control	Arduino	PCB		
Lock mechanism	Solenoid	Manual lock	Mechanically locks (one way door)	

After creating this first function and means table the design space continued to change. One of the big changes was the decision to use a servo motor to close the door as opposed to a spring loaded hinge actuated by a solenoid. The reason for this was that the power the solenoid would need to put on the door to keep the hinge open continuously would be too much and would require an enormous battery. The overall shape of the mousetrap was changed to a tube with a space underneath in which the electronics are housed. This decision came about after Acrylic was ordered for the overall casing of the mousetrap and realizing it was easier to keep this geometry. A servo motor was chosen as the mechanism with which to open and close the door due to its reliability and simplicity. A sensitive pressure switch was still used in the final prototype because of its sensitivity. The way all the mechanisms work together is by using a central wifi module with a built-in microcontroller. Placing the sensor by the back of trap ensures that a mouse is lured in by bait, then stepping on the ramp the sensor is triggered. Next, the microcontroller indicates to the servo to close the front door. The Wifi module additionally sends a message to the user alerting that a mouse has been captured.

Deciding how the user will be notified was difficult because a text message seemed to be the simplest way, but it proved to be more costly as the user would have to pay for monthly data for the GSM chip installed in the mouse trap. There are many messaging applications like facebook messenger, groupme, and whatsapp that allows a user to “text” message with people strictly due to wireless internet connection. There is an application called Telegram which allows customized bots to send message to Telegram users.

Users can easily set up mousetrap with a few taps of commands in Telegram. Users may select one of three pre-selected locations: kitchen, bedroom, garage to name their mousetraps. The wifi module was able to control when the opening through command from users over Telegram and closing of the door based on the pressure sensor being triggered, and then the application telegram will send the user a message informing them a mouse was caught in their trap. From the command “/open” with the mousetrap the user is able to send to the bot, which allows the trap door to release the mouse in a desired location of the users. This was important because if the mousetrap tried to keep as little contact between the user and mouse as possible it was important to be able to open the door and releasing the mouse from a distance.

Table 2: This shows a new function and means table that matches the present prototype. Green cells represent which means were used for the function.

Function	Mean 1	Mean 2	Mean 4
Torsion force (to close door)	Spring torsion	Servo/motor	Magnetic door (induction)
Detect capture	Weight sensor (load cells)	Laser Sensor (light interruption)	Motion sensor
	Switch button triggered by mouse	Sensitive pressure switch	Lever Switch
Alert user	LED light	Mobile Application	Sound/alarm
Identify location	Different color LED	A serial code?	Bluetooth code
	Different sound	Button Selection	Mobile Application
Power supply	Rechargeable battery	Primary battery	
Release without contact	Push button Trigger on handle	Mobile Application	
Humane	Air holes	No sharp edges	Mouse gets food
Control	Arduino UNO	PCB	NodeMCU
Lock mechanism	Solenoid	Manual lock	Servo Motor

IV. Evaluation of Results

The final design chosen for the smart mousetrap proved to effectively meet the objectives required. Overall, the mousetrap captures the mouse by sparing his/hers life while at the same time notifying the user when a mouse has been caught and having the mousetrap be controlled completely remotely.

Despite the objectives and metrics being met, there was still room for improvement. Notifying the user of a mouse being captured does send a text message, but this also first requires the owner to download the application Telegram. Consumers will probably not be a fan of going through the process of downloading an application. Another objective that was met but could still use some improving was detection of the mouse. The group chose a sensitive lever pressure sensor, that ideally would signal to the servo to close the door of the trap when stepped on by a mouse. After testing the trap, a motion sensor or an extremely easy to trigger sensor would be better if this prototype ever went to the market. In the prototype for the mousetrap to work as expected a mouse must walk up a ramp that may not be wide enough for a real-life situation.

Despite needing a few improvements, some objectives were exceedingly met. The battery life for the smart mousetrap was required to be one month or approximately thirty days. After calculating the power budget, it was discovered that the batteries purchased could last up to 3.75 months before being changed - the calculations for the power budget can be referred to in Appendix II. This would be a great advantage for consumers because if they can spend less time changing the batteries, they will be more interested in the product. The servomotor also exceeded expected capabilities as it had a factor of safety of slightly over 10 on the output torque required - the calculations done to obtain required torque are in Appendix V .

To make the smart mousetrap as great as it can would be unachievable provided the limitations this prototype has. With a budget of only 400 dollars and a time constraint of about four weeks to complete the prototype, the final project was not what the group envisioned in the design stage. Accepting that the mousetrap was just a prototype and the abilities of four young engineering students can only go so far was difficult, but creating a working prototype was achieved, and there is only room for improvement from that point.

The group realized that there was a lot of design improvements that could be made. Simple ideas like having the casing be a solid color versus transparent would be more pleasing to the eye because all the electronics would be hidden from view. A four inch acrylic tube was ordered to be cut in half and act as a roof for the mousetrap, but it came to the group's attention that the tubing will not hold its shape if cut into. This setback changed the mousetraps design completely. From having a “mailbox” shape for the trap, it was decided to use the tube itself for the actual trap. A round mousetrap is a bit of an interesting look, but it could appeal to consumers looking for a more contemporary design. To reach a consumer base more interested in just the basics, a rectangular box shape would be a more effective design for the mousetrap, but either design still achieves the basic goals of capturing the mouse and keeping it contained in the trap until released.

Creating a humane mousetrap while also making it “smart” is definitely useful in society. Although, not every household or business has a mice problem in their house or building, but for those who do this product could become very useful for such a technologically advanced society humans live in. Mice are a problem, and people want the easiest and quickest way to get rid of them, and that is why traditional mouse traps have been so effective throughout the years, but now this prototype aims to have a humane way of catching a mouse that is just as easy and effective.

V. Appendix

Table 3: This is the bill of materials for the Mousetrap Prototype

Team Names: Colleen Twomey, Hin Lui Shum, Carla Sheridan, Reyn Saoit				
Emails: catwomey@bu.edu; jshl@bu.edu; sheridac@bu.edu; reyns808@bu.edu				
Project Title: Smart Mousetrap				
Section: Thursday 1:30 - 315				
Part Description	**Supplier**	**Quantity**	**Part #**	**Cost**
Arduino WiFi Shield - ESP8266 module	Amazon	1	esp8266 NodeMCU	$8.39
3.3v Voltage Regulator MCP1700-3302E/TO	Mouser	1	MCP1700-3302E/TO	$0.38
Quimat Arduino Uno R3 ATmega328P CH340 Development Board Compatible Arduino IDE Development Kit	Amazon	1	UNO R3	$7.88
Zehhe Copper Foil Tape with Double-Sided Conductive (1/4 inch)	Amazon	1		$5.88
Acrylic Tube Translucent (1 ft)	McMaster	1		$57.31
Acrylic Sheets translucent (2 ft)	McMaster	3		$15.18
5-minute epoxy (2 pack)	Amazon	1		$9.49
AA High-Capacity Rechargeable Batteries (AA 4-Pack) and Ni-MH AA Battery Charger	Amazon	1	AA 4 pack with charger	$26.98
Generic 4 X AA Battery Holder Case Enclosed Box OFF/ON Switch With Wires	Amazon	1		$3.69
Spring hinges	McMaster	2		$1.70
Handle (grey)	McMaster	1	1950A5	$10.42
Screws to mount handle	McMaster	1	91772A545	$7.76
Nuts to mount handle	McMaster	1	95505A601	$3.90
Lever Switch (6 pack)	Amazon	1		$7.39
Servomotor	Digikey	1	1528-1501-ND	$3.50
			Total Cost:	$169.85

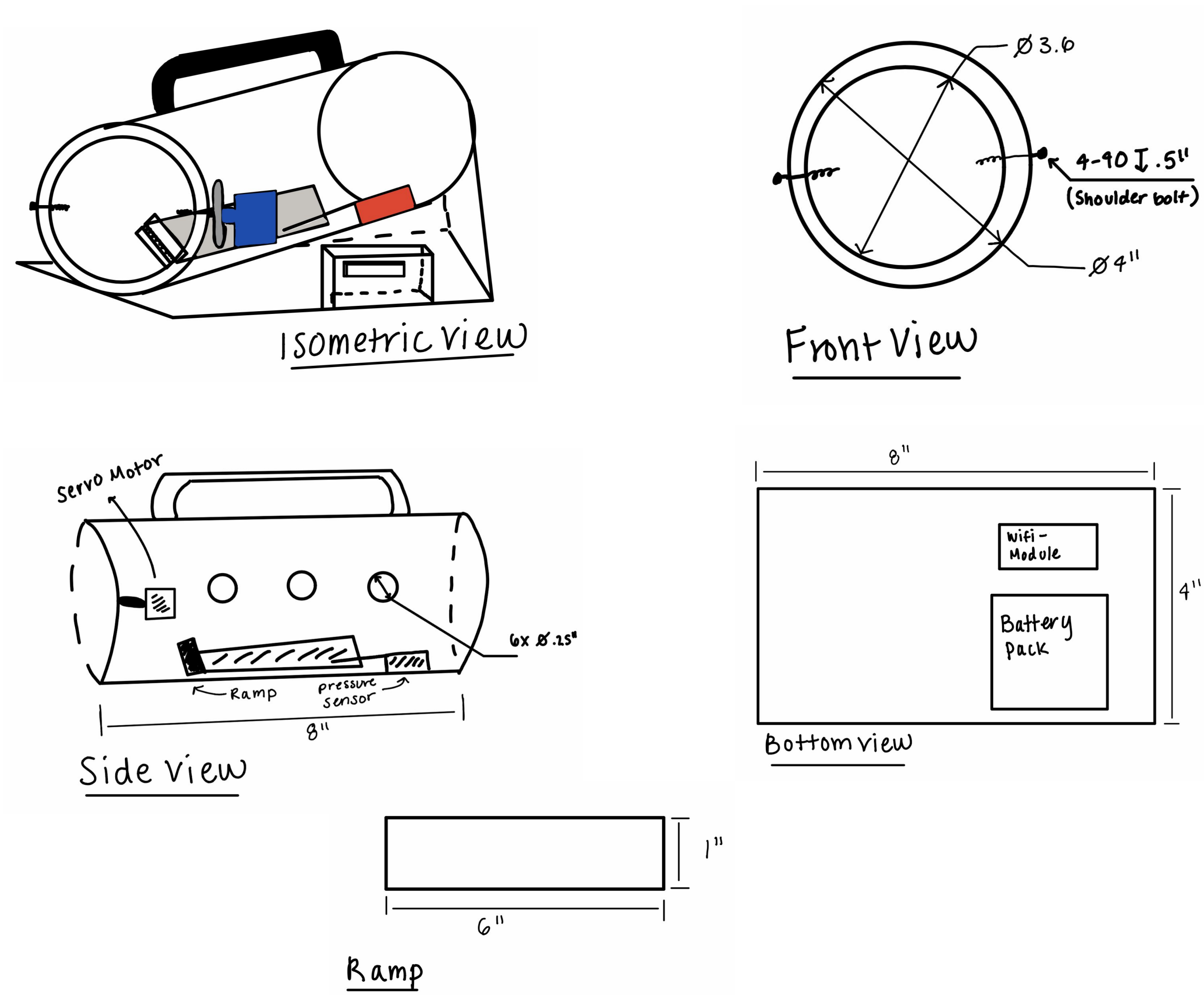
Appendix II

Table 4: This table displays the power budget

Electronic	Current	hours/day	Total Current draw
Wifi Module: NodeMCU	320 mA 45 mA 0.1 mA	1 minute X 20 Startup 1 minutes X 20 Normal Function 24hrs/day X 30 days mode	106.67 mAh 15 mAh .08 mAh
Pressure Sensor	600 mA	24 hrs/day X 30	480 mAh
Servo Motor	120 mA	1 Minute X 20	40 mAh
		Total:	**642 mAh**
		Battery rated to:	**2400 mAh**

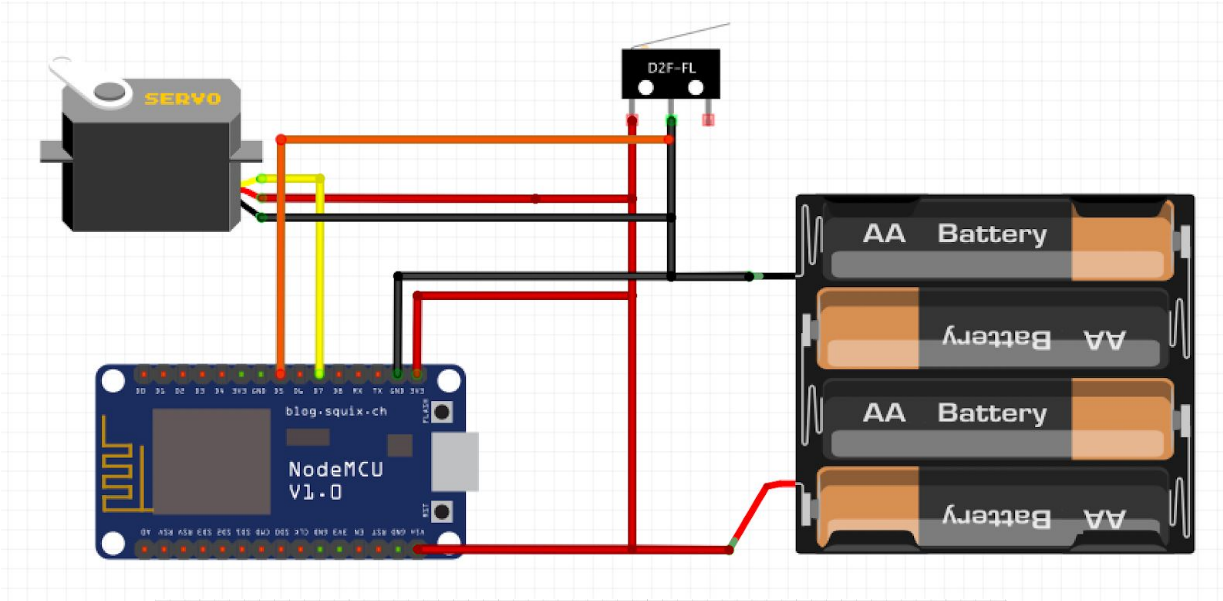
Appendix III

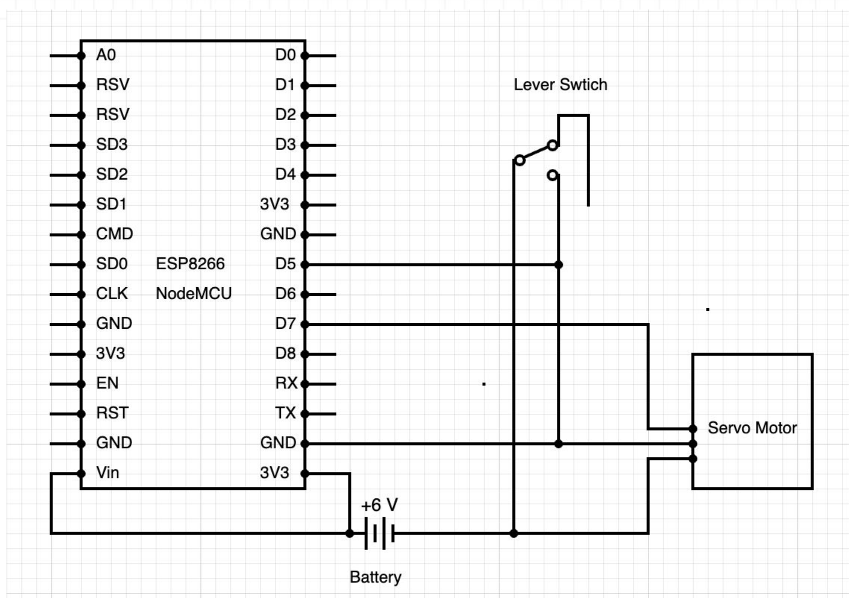
Figure 1: drawings with different views of the mousetrap



Appendix IV

Figure 2: Electric circuit schematic of Mousetrap electronics
Figure 3: Circuit Diagram of Mousetrap electronics





Appendix V

$$T_{\ required} = l \cdot F\ = (2in)(0.063lbf) = 0.126\ in - lbf$$

$$0.126\ in - lbf\ \ =\ \ 2.02\ oz - in$$

$$20.86\ oz - in$$

$$Factor\ of\ Safety\ \ =\ \ 10.33$$

VI. References

"The Animal Welfare Act." *National Anti-Vivisection Society*, www.navs.org/what-we-do/keep-you-informed/legal-arena/research/explanation-of-the-animal-welfare-act-awa/#.XMZ01i_Mw1I.

"Density of Materials." *Psyclops*. http://www.psyclops.com/tools/technotes/materials/density.html.