Protec-a-Garage

Team Members

Collin Whitfield

Ryan Unroe

Trevor Schmit

Team Norms

- Treat each other with respect
- Trust each other
- Be open-minded
- Support each other, don't throw someone under the bus
- If you commit to something, do it
- No Zingers
- Inform other members when you are absent (before class starts)
- Communicate in the group chat

Semester 1 Gantt Chart

TASK	September				October					November				December			
	3	10	17	24	1	8	15	22	29	5	12	19	26	3	10	17	24
Project Management																	
Element A - Problem Statement					S			x									
Element A - Article Research					S			x									
Element A - Market Survey					S			x									
Element A - Expert Interview							S	x									
Element B - Documentation and Analysis on Prior and On-Market Solutions								S	x								
Element B - Patent Research								S	x								
Element C - Voice of the Customer									S	x							
Element C - Customer Requirements Document									S	x							
Element C - Similar Solution Matrix									S	x							
Element C - Product Design Specifications									S	x							
Element D - Thumbnail Sketching												S			x		
Element D - Solution Drawings															x	S	
Element D - Decision Matrix															x	S	
Element D - Final Design Solution															x	S	

S : Task has been started

x : Due date

: Started

: In Progress

: Finished

Semester 2 Gantt Chart

TASK	January				February				March				April				
	7	14	21	28	4	11	18	25	4	11	18	25	1	8	15	22	29
Project Management																	
Element D - Thumbnail Sketching																	
Element D - Solution Drawings																	
Element D - Decision Matrix																	
Element D - Final Design Solution																	
Element G - Introduction/Conclusion										x		S					
Element G - Weekly Updates										x	S						
Element G - Bill of Materials List										x	S						
Element G - Tools and Equipment list										x	S						
Element H - Introduction/Conclusion											S			x			
Element H - Testing Criteria / Plans											S			x			
Element H - Testing												S		x			
Element I - Introduction/Conclusion														x			
Element I - Test Plan 1														x			
Element I - Test Plan 2														x			
Element I - Test Plan 3														x			

S : Task has been started

x : Due date

: Started

: In Progress

: Finished

Element A

Problem Statement

79.4% of people have left their garage door open unintentionally. This can lead to valued items being stolen or damaged.

What: Leaving the garage door open unintentionally

Who: Garage owners

Where: Homes with garages

When: Varies based on person. Our studies show that most people usually leave their garage open one to two times a month

How Many People: From our research so far, this affects 79.4% of people

Article Research

Did You Remember to Close the Garage Door

This article states that as most people become older, they start to forget things more often. Many people struggle to remember simple things such as where they left their car keys, or if they forgot to close the garage. Older people tend to forget things, such as leaving their garage door open, more often than other ages.

Sharager, L. (2010, October 04). Did You Remember to Close the Garage Door? Retrieved from https://www.everydayhealth.com/columns/lynda-shrager-the-organized-caregiver/did-you-remember-to-close-the-garage-door/

Answers gained from the article:

What - Leaving the garage door open unintentionally

Who - This can happen to anyone, but it is more likely to happen to the older audience

When - The author, Lynda Shrager, says that she leaves her garage open very often. How forgetful you are can be affected by a number of disorders and traumatic experiences.

Why You Don't Want to Leave Your Garage Door Open

The article states that most people leave their garage door open from time to time. There are many risks to doing so. The biggest risk to leaving your garage open is thieves. Leaving your garage open allows anyone to take what they want. Many families use their garages as additional storage. Anything stored in your garage is at risk if the door is left open. Another problem that can arise from this is that you could be giving access to your home to anyone around. Most people have a door leading into their home from the garage and it's common for it to be unlocked during the day. Anybody around can walk through your garage and go straight into the home without a struggle. The next risk of leaving your garage door open is that wild animals can come in and nest in there. Your garage is most susceptible to birds, racoons, and wild cats. The last risk is that the contents stored in the garage can be damaged or destroyed by bad weather such as wind, rain, dust storms etc.

B.(2017, October 23). Why You Don't Want to Leave Your Garage Door Open. Retrieved from https://www.aplusdoors.com/archives/leave-garage-door-open

Answers gained from the article:

Who - Most people leave their garage door open. The consequences can happen to anyone

Why - You should not leave your garage door open for many reasons including thieves, weather damage, and wild animals nesting inside.

This is Why You Never Leave Your Garage Door Open Overnight

Your garage door is the first line of defense for your home. Even if you're in the garage working, leaving it open gives many pests, such as birds, bugs, and spiders, opportunities to make your garage their new home. Another issue that arises is the likelihood that things can be stolen out of your garage if it is left open, even if you live in the "nice part of town". Finally, leaving the garage open gives any would-be-intruders easy, unlocked access to your home. This not only puts your possessions in danger, but your life. The careless action of leaving the garage open can lead to many nasty consequences. These can include infestations by rodents or insects, items being stolen out of your garage, and home invasion.

This is Why You Never Leave Your Garage Door Open Overnight. (2016, August 26). Retrieved October 22, 2018, from https://www.ganaga.com/blog/never-leave-garage-door-open-overnight/

Answers gained from the article:

What - Leaving your garage door open can lead to bad consequences such as pest infestations, items being stolen, and home invasion.

Police Warn About Open Garage Doors

Once it starts to get cooler, people are out more often and can forget to close the garage door overnight. This simple mistake could cost you thousands of dollars according to the police. One man had his daughter's 3-wheeler stolen overnight after leaving the garage door open. Luckily it was only his neighbor that took it, as they were trying to teach him a lesson. Most people get to a point where they become lazy with closing their garage door.

Starling, N. (2016, May 18). Police warn about open garage doors. Retrieved October 24, 2018, from https://www.3newsnow.com/news/local-news/police-warn-about-open-garage-doors

Answers gained from the article:

What - Garage doors are left open overnight, making easy theft possible

Who - Police say that this is a problem

Where - This can happen anywhere to any home with a garage.

How Many People - "... they see so many garage doors left open." - La Vista Officer T.J. Jacik

Crime in Your Neighborhood: Open Garage Doors are Invitations for Thieves

You would not leave your front door open all day for burglars, but that is basically what people are doing. As it gets warmer, more people are going outside, including thieves. They are going out and looking for open garages. One couple stole from at least six garages. The thieves are not just stealing tools, they are going into homes and stealing valuable objects. This can be a problem even in trusting communities. Some people crack their garage open for their pets to come in and out and when they are in their backyards. Doing this can easily lead to your garage being robbed.

Corr, J. (2016, May 9). Crime in Your Neighborhood: Open garage doors are invitations for thieves. Retrieved October 25, 2018, from https://www.kspr.com/content/news/Crime-in-Your-Neighborhood-Open-garage-doors-are-invitations-for-thieves--378631241.html

Answers gained from the article:

What - Leaving garage doors open unattended or unintentionally can lead to it being robbed.
Who - Garage owner
Where - This can happen anywhere to anyone who owns a garage
How Many People - Many people leave their garage door open, leaving a good chance for thieves to rob it

Items Most Commonly Stolen From Garages

Open garage doors are very inviting for would-be thieves. Lots of the time, valuables are stored in the garage in plain view, especially if the garage door has windows. Bikes are commonly stolen as they double as a getaway vehicle and can be sold relatively easily on Craigslist. Power tools are often stolen as well, due to the fact they can be easily pawned and not traced. Power tools are very expensive to replace and their loss could be devastating if required for work. Guns are another common target for garage robberies. Guns have high street value and can be traced to you if used for malevolent purposes.

Vaughn, B. (2013, November 27). Totally Home Improvement. Retrieved October 26, 2018, from https://www.totallyhomeimprovement.com/other-rooms/garage/items-most-commonly-stolen

Answers gained from the article:

Who- Garage owners

What- Items that are commonly stolen from garages

How many people: Everyone is susceptible, and hundreds of families are victims every year.

Survey Results

Overview

We presented our survey in the way we did to gain real-world data on a variety of variables that pertain to our overall problem. Our questions were aimed to determine what age groups each specific sub-problem applied more directly to and enable us to more effectively aim our project in the direction most people were interested in.

Analysis

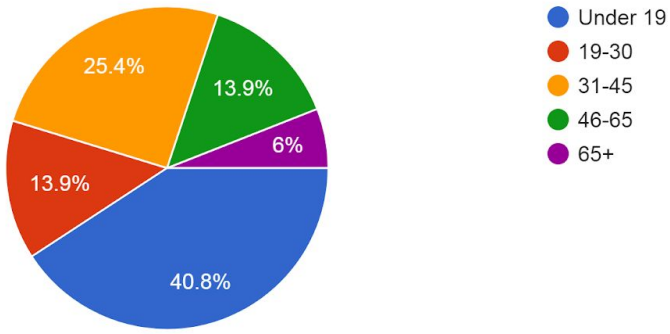
To gather 200 responses, we tried to post the survey wherever we could. We started by emailing it to students and putting it on social media. This resulted in around 160 responses. To get the last 40, we brought the survey to people out at lunch.

From our data, we can see that 91% of people with garages have an automatic garage door. Of them, 79.4% said that they have left open their garage door unintentionally. From the survey, 74.6% of garage owners have left their garage open during the day while 57.1% have left it open overnight. Most people, 66.1%, leave their garage open around once or twice a month, while 11.6% leave it open three or more times a month. 87.3% of people would like to be able to manage their garage door through their smartphone.

Survey Results (as of 11/26/18 -201 responses)

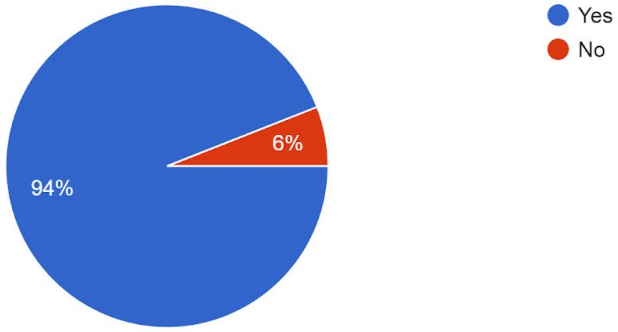
What is your age?

201 responses



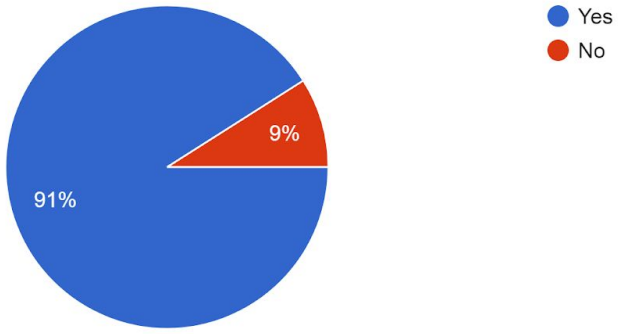
Do you have a garage?

201 responses



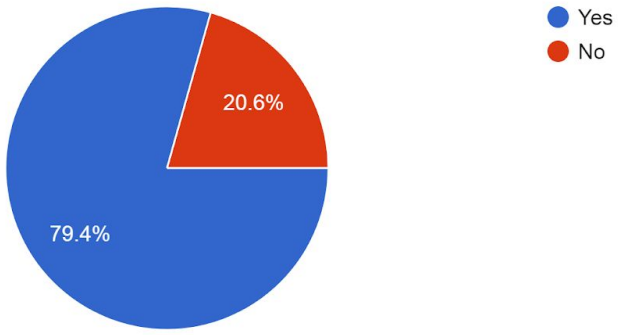
Do you have an automatic garage door?

189 responses



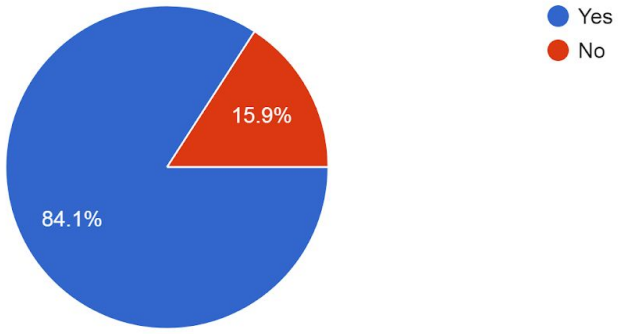
Have you ever left your garage open unintentionally?

189 responses



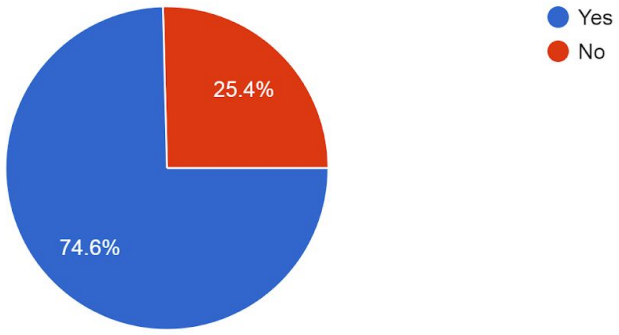
Have you ever been worried that you might have left your garage open?

189 responses



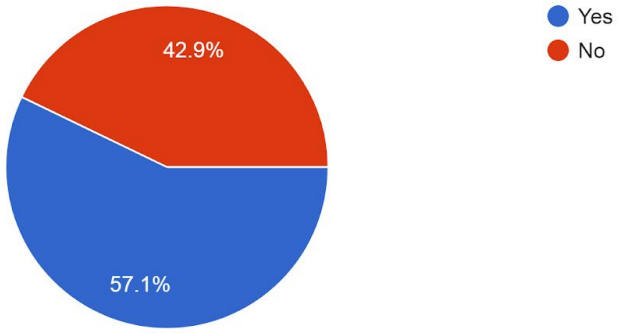
Have you ever left your garage open during the day?

189 responses



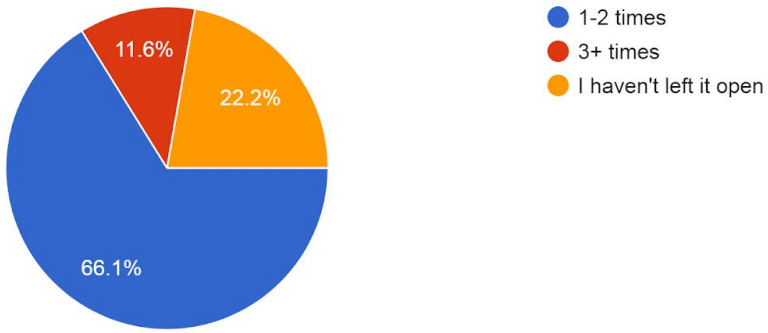
Have you ever left your garage open overnight?

189 responses



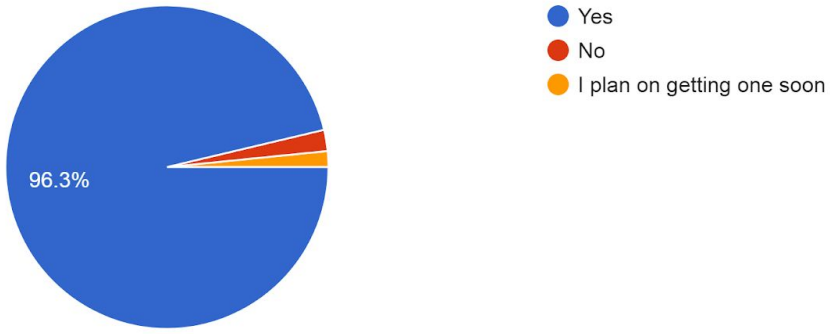
If you have left your garage open, how many times a month does it happen?

189 responses



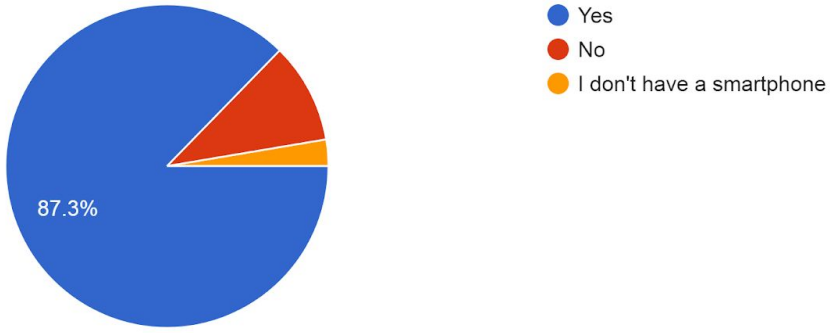
Do you own a smartphone?

189 responses



Would you like to be able manage your garage through your smartphone?

189 responses



Expert Interview

11-27-18

For our expert interview, we contacted Melissa Hagen of Legends Garage Door via email. She is the Director of Operations for this company, so we figured that she would be able to provide suitable advice for our research.

What is the automation system/device you install the most? Liftmaster Garage door motor

Why is this system the most commonly installed system? (What makes it desirable?) Warranty, brand recognition, WiFi built in.

How simple would one of these systems be to install by the end user? Similar version is Chamberlain sold at Lowe's, Home Depot- -Liftmaster is professional product not available to general public.

How are these systems wired to the garage door openers? Low Voltage or CAT-5 wires for wall control and sensors, plug

for main motor, remotes and keypad run off of batteries and synced with opener.

Are there any automation systems that communicate with the opener wirelessly? Or are they all hardwired?
Most have both options, but you have to have hardwired wall control and sensors due to being UL 375 Compliant (safety regulation that took effect in 1993)

Element B

Patent Research

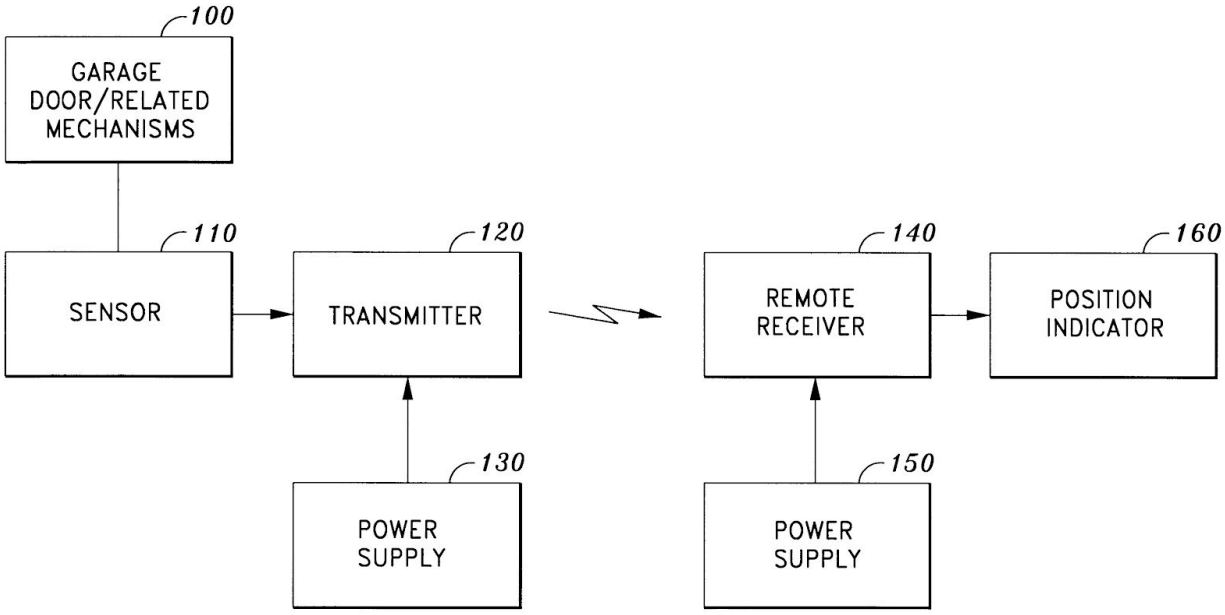
Garage Door Monitor - US6597291B2

Google Patents - Garage door monitor

Summary: This patent allows garage doors to be monitored from remote locations. A sensor detects the position of the garage doors and sends the information to a local transmitter. Infrared sensors are used to detect the garage door position while in another location, trigger switches detect the direction in which the door is moving.

Critique: This patent allows the monitoring of the state of the garage door and which direction it is moving. This can be accessed remotely. This is a feature that we would like to have in our final product, through our own app. A key feature in this patent is that it can send information to a remote location. This will be very important for being able to remotely control and monitor garage doors.

Ka Leung Tsui, G. (n.d.) US6597291B2 - Garage door monitoring system, Retrieved, October 26, 2018, from https://patents.google.com/patent/US6597291B2/en?q=monitor&oq=garage+door+monitor


100
GARAGE DOOR/RELATED MECHANISMS
110
SENSOR
120
TRANSMITTER
130
POWER SUPPLY
140
REMOTE RECEIVER
150
POWER SUPPLY
160
POSITION INDICATOR

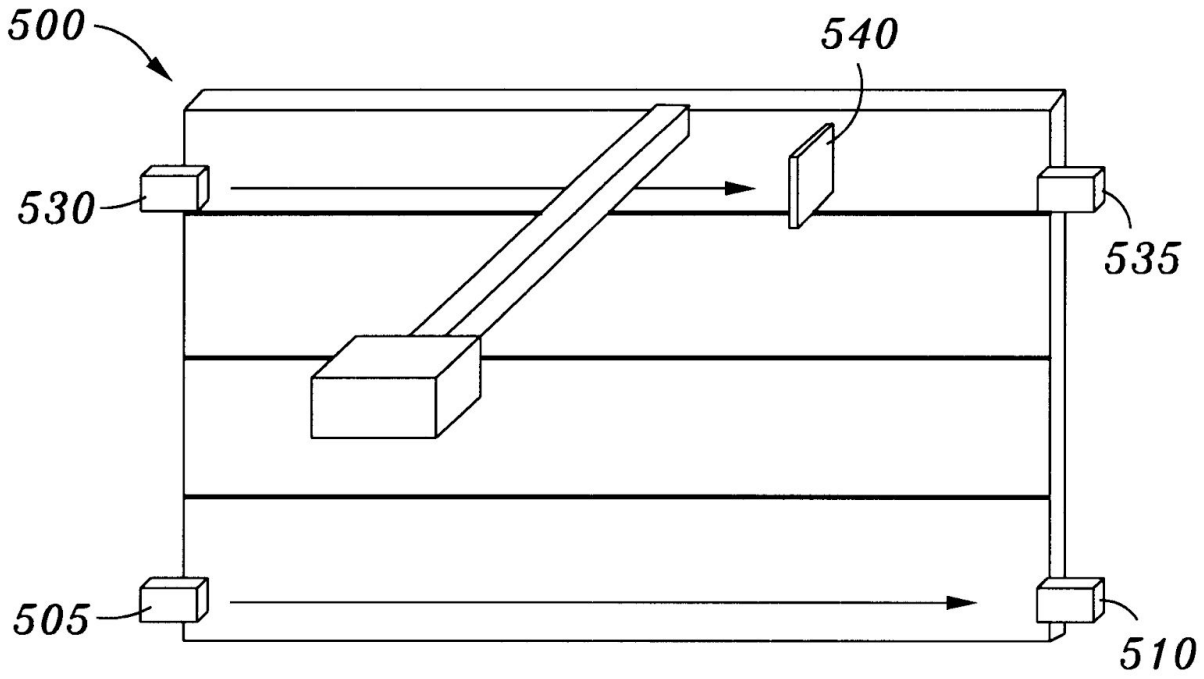


FIG. 7

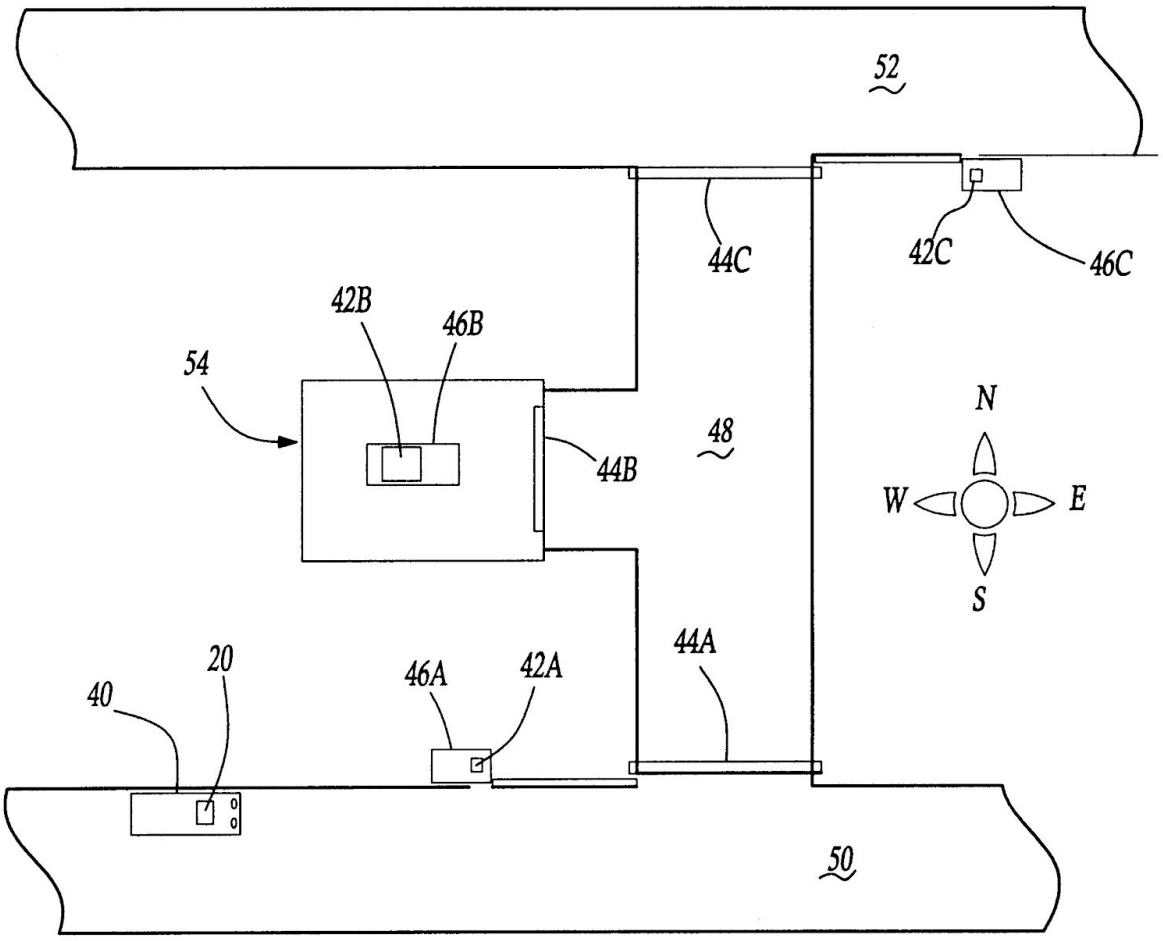
Passive Garage Door Opener - US6271765B1

Google Patents - Garage door opener

Summary: This patent presents an invention whose purpose is to passively monitor the position of a vehicle. The garage door is at a fixed, known position and sensors are placed along the driving path to determine the position and direction of the travel of the vehicle. The direction and the relative position is then processed by the transmitter and when predetermined conditions are met, the transmitter sends the open or close command.

Critique: This patent shows an implementation of an idea we had for our future product. This patent is for a system of sensors to detect when a car is approaching and receive the signal to open the door it's approaching. This attempts to solve our problem by closing and opening the garage automatically as the car reaches a specific distance from the house. This patent does the automation part well, but a downside would be the need for additional transmitters/receivers along the path of the driveway. This patent gives us an idea for how long we could supplement a location based opening algorithm.

King, J. D. (1998-06-02). U.S. Patent No. US6271765B1. Washington, DC: U.S. Patent and Trademark Office.
https://patents.google.com/patent/US6271765B1


52
44C
42C
46C
42B
46B
54
48
44B
N
W
E
S
44A
20
40
46A
42A
50

Remote control, cellular, WiFi, WiLAN, mobile communication and position finder systems - US7904041B2

Google Patents - WiFi remote control

Summary: A remote control capable of controlling a device from a distance. Transmitters operate in seperate radio frequency (RF) bands. The receiver has a radio frequency unit located at a remote location from a demodulator. The remote control can send signals over cellular data, wifi, lan, mobile communication, and position finder systems.

Critique: This patent will help solve our problem by allowing us to wirelessly control and monitor garage doors. This is beneficial because it can be accessed through cellular data and wifi. In our final product, we would like to be able to control and monitor garage doors remotely through cellular data and/or wifi. We want to make an app that will allow us to use a phone as a remote to be able to communicate with an arduino. We are hoping to be able to make it use cellular data so that we can monitor and control a garage door from any distance.

Feher, K.(2005, August 03). US7904041B2 - Remote control, cellular, WiFi, WiLAN, mobile communication and position finder systems. Retrieved October 29, 2018, from https://patents.google.com/patent/US7904041B2/en?q=control&oq=wifi+remote+control

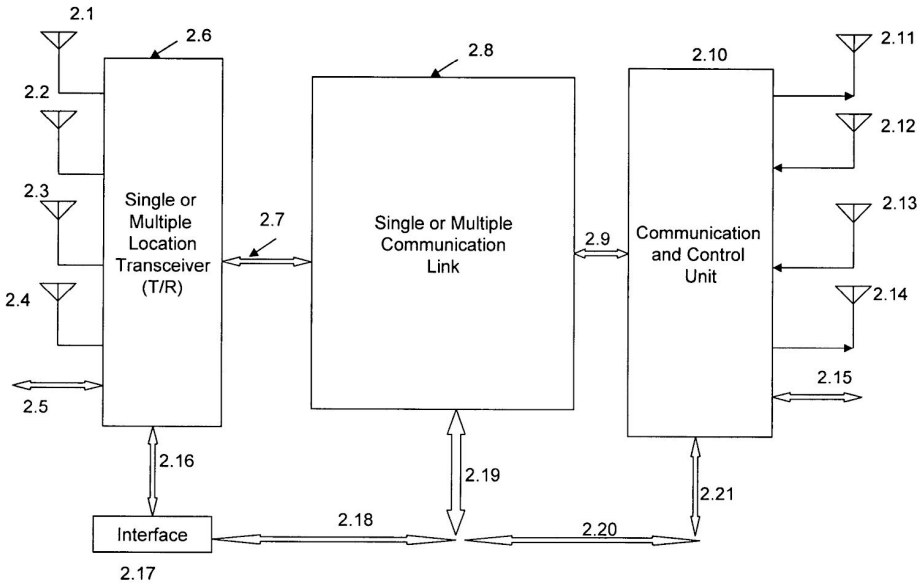


FIG.2

0 MED Feher,Aug.3,05

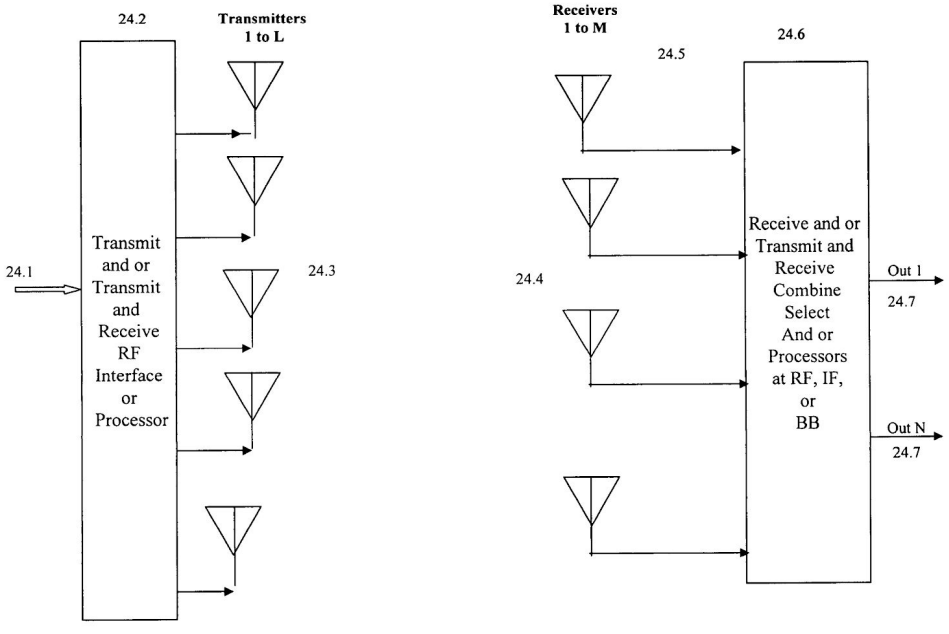


Fig24

0 MED Feher,Aug.3,05

Garage Door Security Device - US6437527B1

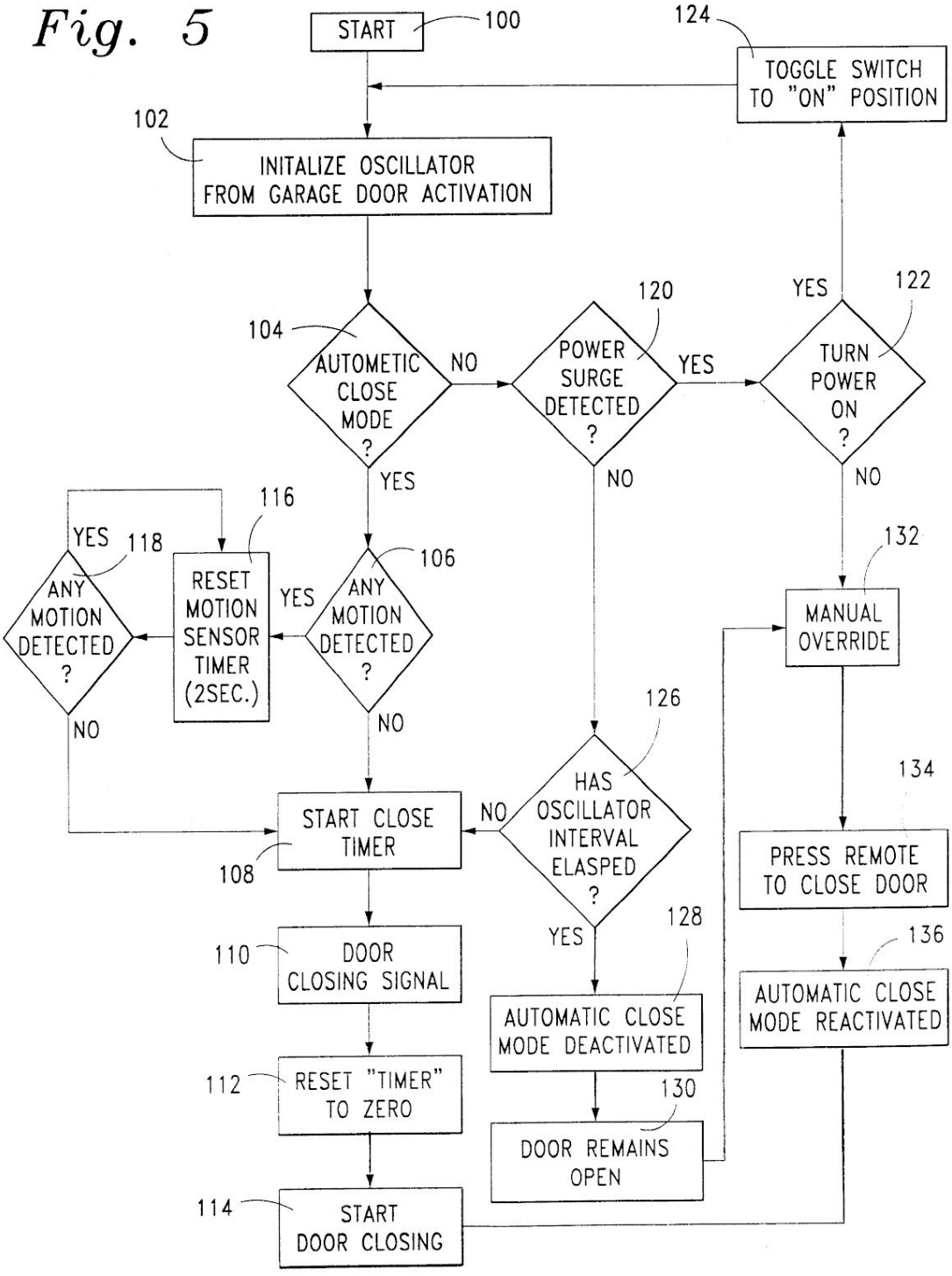
Google Patents - Garage door control

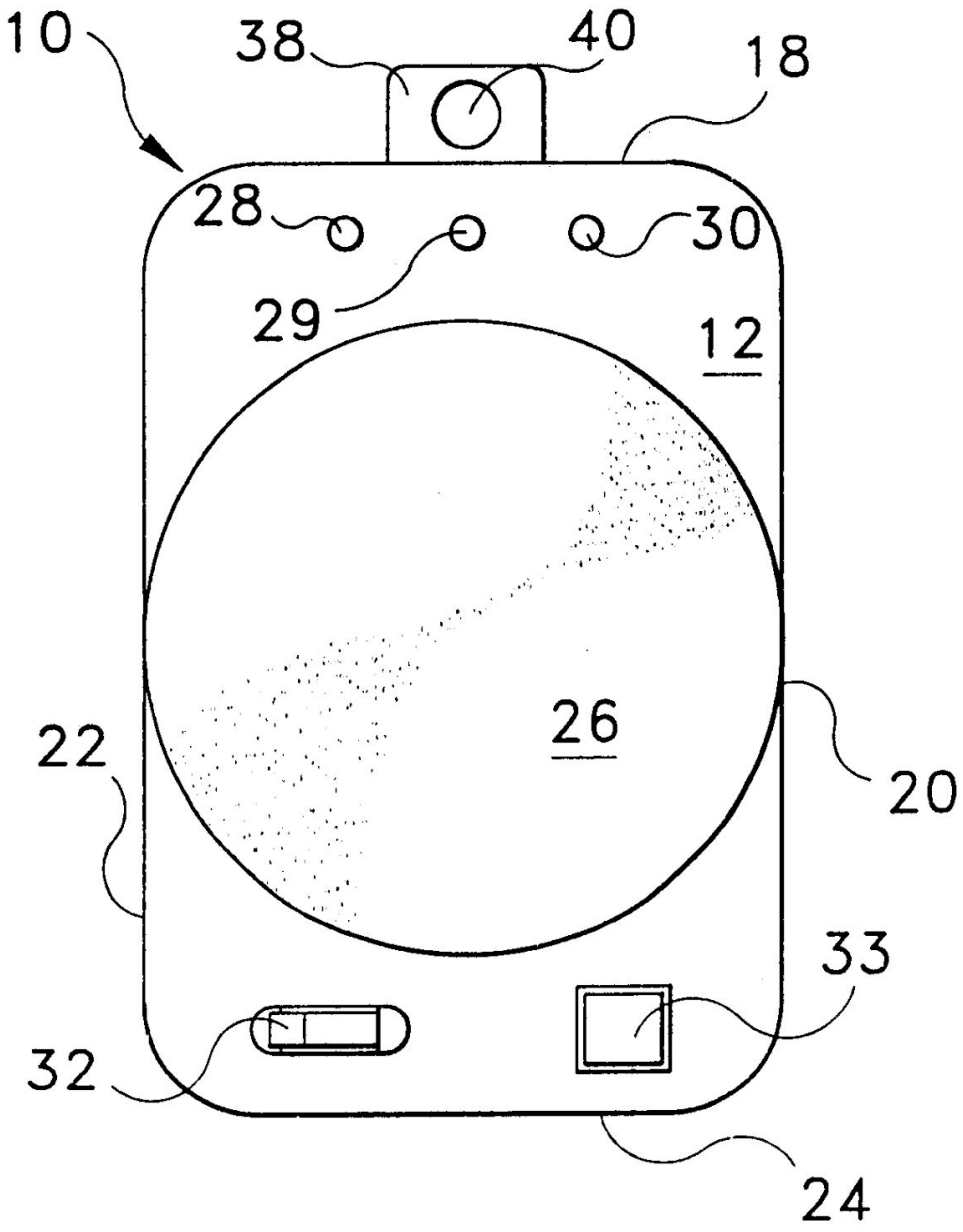
Summary: It is a garage door security device. This device automatically closes the garage door if left open for 45 seconds. It sends a signal to the garage door system to close it. The device has a 25 second timer before starting the 45 second countdown. If there is any motion detected, the 25 second timer gets reset.

Critique: It solves our problem by closing the garage after a certain amount of time. A good thing about it is that it automatically closes a garage after a certain amount of time. A flaw with this is if someone leaves the garage door open to go do something quick, it will still shut if they take too long.

Rhodes, S. (June 18, 1999). U.S. Patent No. US6437527B1. Washington, DC: U.S. Patent and Trademark Office.

Fig. 5


START
100
TOGGLE SWITCH TO "ON" POSITION
124
INITALIZE OSCILLATOR FROM GARAGE DOOR ACTIVATION
102
AUTOMETIC CLOSE MODE ?
104
NO
POWER SURGE DETECTED ?
120
YES
TURN POWER ON ?
122
YES
NO
YES
NO
ANY MOTION DETECTED ?
YES
118
RESET MOTION SENSOR TIMER (2SEC.)
116
ANY MOTION DETECTED ?
106
YES
NO
NO
MANUAL OVERRIDE
132
HAS OSCILLATOR INTERVAL ELASPED ?
126
NO
START CLOSE TIMER
108
YES
PRESS REMOTE TO CLOSE DOOR
134
DOOR CLOSING SIGNAL
110
AUTOMATIC CLOSE MODE DEACTIVATED
128
AUTOMATIC CLOSE MODE REACTIVATED
136
RESET "TIMER" TO ZERO
112
DOOR REMAINS OPEN
130
START DOOR CLOSING
114


10
38
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18
28
30
29
12
26
22
20
33
32
24

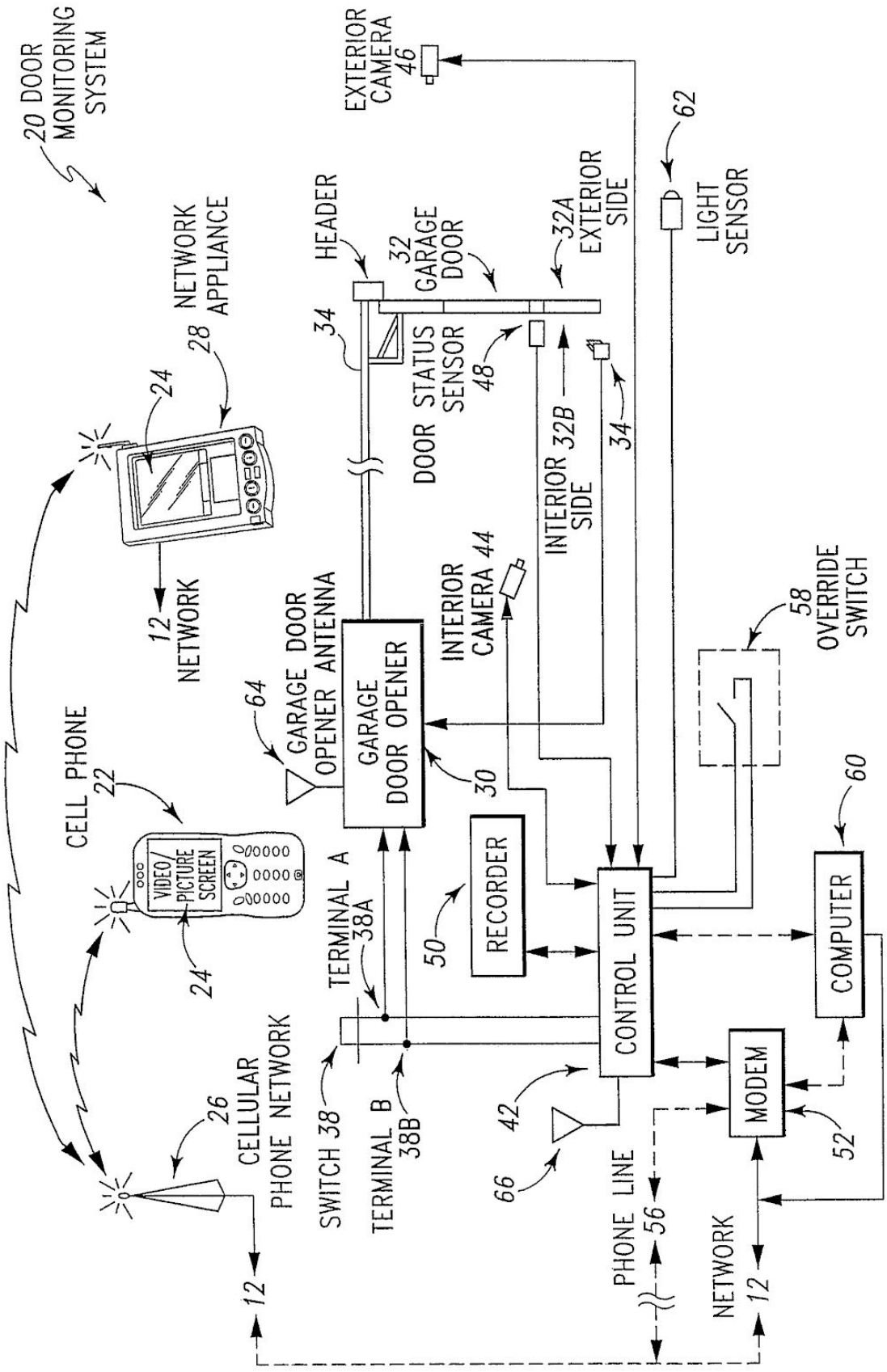
Remote Garage Door Monitoring System - 7,468,676

United States Patent Office - Garage door control

Summary: This patent is for a device that can monitor and control a garage door via network connection. It monitors it through an app, which sends video feeds of the interior and exterior of the garage door. It also has a sensor that can detect the open/close state of the garage door. You are able to set different timers for different times of the day.

Critique: The good thing about this patented item is that it allows you to monitor your garage door wirelessly. A bad thing about it is that it might be trying to accomplish too much for one device.

Styers, J. R. (February 4, 2005). U.S. Patent No. 7,468,676. Washington, DC: U.S. Patent and Trademark Office.


20 DOOR MONITORING SYSTEM
EXTERIOR CAMERA 46
62
LIGHT SENSOR
NETWORK APPLIANCE
28
24
HEADER
34
32 GARAGE DOOR
32A EXTERIOR SIDE
DOOR STATUS SENSOR 48
INTERIOR 32B SIDE
34
12 NETWORK
64
GARAGE DOOR OPENER ANTENNA
INTERIOR CAMERA 44
58 OVERRIDE SWITCH
CELL PHONE
22
GARAGE DOOR OPENER
30
VIDEO/ PICTURE SCREEN
24
TERMINAL A 38A
50
RECORDER
CONTROL UNIT
60
COMPUTER
26
CELLULAR PHONE NETWORK
SWITCH 38
TERMINAL B 38B
42
66
MODEM
52
PHONE LINE
56
NETWORK
12
12

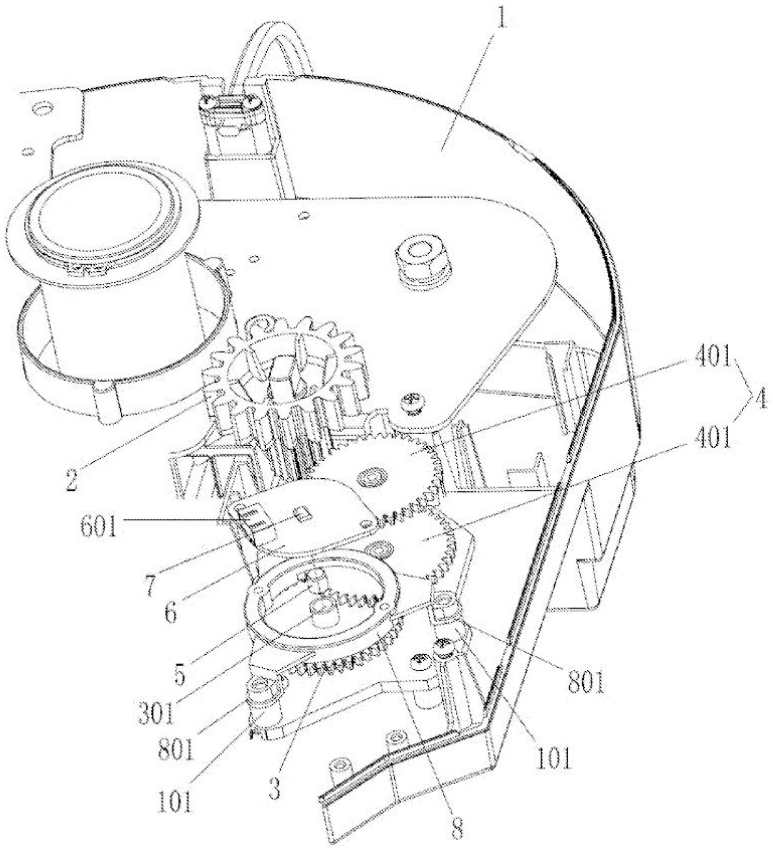
Door Position Detection Device for Electric Door Opener - 201720091493.3

United States Patent Office - Garage Doors

Summary: This patent is for a garage door position detector. This device detects the position of the door and outputs it. Magnets and magnetic angle sensor chips are used to determine its position.

Critique: With the device, we will be able to monitor the position of the door remotely. We can take the door position output and send it to our WiFi/cellular data enabled arduino. We can then send it to the to whatever device harbors the mobile application. The benefit of this device is that we can easily read the position of the garage door. Another benefit is that this will be adaptable and easy to use in our project. We will use the output of the built in position detector to notify the user about their garage door.

Ming Shao, J.(2017). U.S. Patent No. 201720091493.3. Washington, DC: U.S. Patent and Trademark Office.


1
401
4
401
2
601
7
6
5
301
801
101
3
801
101
8

On Market Solutions

Liftmaster - www.liftmaster.com

Model and Price: 821LMB myQ Smart Garage Hub for $79.99

Specs: Weight = 1.6oz ; Dimensions 2.2 x 0.8 x 2.6 inches; Requires Batteries; 1 Year Warranty

Summary: This product allows the user to monitor and control a garage door. It also allows the user to preset days and times for when the lights go on and off. Liftmaster uses cellular data to communicate with the garage, allowing the garage to be monitored and controlled from anywhere. To install, you must have the model 821LMB myQ Smart Garage Hub. This is only compatible with a limited number of garage door opener brands and it must be connected to WiFi.

Critique: This product is similar to the solution we were thinking of. It is an additional piece that you hook up to the WiFi and sync to your garage. You can then send a signal through a phone app to open or close the garage door. The app also allows the user to monitor the state of the garage door . The downside to this product is that the user instantly gets notified. If you are coming home and open

the garage, you will receive a notification, which can be distracting, letting you know that you opened the door. Instead, we plan to notify the user if the garage has been open for too long or if it is still open at night. Our product is targeted toward helping users remember to shut their garage door when necessary. Another downside of this product is the cost. I think that 80 dollars is a bit too much for this product. This Liftmaster gives us an idea of which garage door opener brands will be compatible (Chamberlain, Liftmaster, Craftsman, Genie, Overhead Door, Linear, Stanley, Wayne Dalton). The average rating on this product is 5 starts on the Liftmaster website, and a 3.5 star on Amazon.

Chamberlain - www.amazon.com

Model and Price: Chamberlain CLDM1 Clicker Garage Door Monitor for $239.99
Specs: Weight: 12oz; Dimensions 8 x 8.5x 3.5 inches; Batteries Not Required

Summary: This monitor comes in two pieces, the sensor and the receiver. All you have to do is hook up the sensor in the garage and the receiver will light up different colors based on whether the garage is open or closed. The receiver is wireless and can be taken anywhere in the house. The sensor is battery operated while the receiver has a charging cord. This product was rated a 4 star on Amazon.

Critique: This product allows simple monitoring of the state of the garage door. This is a key element that we would like to have on our product. Instead of the remote being constrained to the house, we plan to make ours accessible from anywhere with cell service. We will also monitor the garage through an app instead of a physical remote. This product helps us with learning how we will connect the sensor wirelessly.

The part on the left is the receiver. The colored leds on it indicate whether the garage is in an opened or closed state. The part on the right is the sensor that is installed in the garage. This part transmits data to the receiver, telling it whether the garage is opened or not.

Nexx Garage - www.nexxgarage.com

Model and Price: Nexx Garage NXG-100 for $99.99

Specs: (Taken from Amazon) Weight: 8.2oz; Model Number NXG-100; Dimensions 3.5 x 1 x 1.5 inches; No Batteries Required

Summary: Nexx Garage is an addon device for existing garage doors. It allows the users to open, close, and monitor their garage doors from anywhere through the use of a mobile app. The app has a lot of built in security and allows multiple users to control the same garage. The app uses the phones built in "push notifications" feature to alert the user. Nexx Garage also is compatible with the Amazon Alexa voice activation. In addition, it keeps logs of all of the times when the garage has been opened and closed.

Critique: This product has a lot of similar features as the ones we wanted to include in our product. It also has some features that we did not even think of, but might want to include such as the logs of the garage door activity. There are a lot of good aspects of this product, but we had a slightly different direction for our product. We plan to notify the user if the garage has been left open for X amount of minutes (chosen by each user), and if the garage is still open at a certain time of night (also chosen by each user).

One part of the phone application that I did not think of is that we will need to configure it to be able to use the phones ‘push notifications’. Along with this, we will need to store data for the logs and will need to set up a user login. I think that I will need to have a running server holding all of the encrypted login information to verify each login. This product received a 4 star on their Nexx Garage website and a 4.5 star on Amazon.

Aladdin Connect - www.amazon.com

Model and Price: Aladdin Connect ALKT1-R for $79.72

Specs: 11” x 6” x 2.5”, no other specs were given

Summary: This product allows you to monitor your garage through the app. You are able to create “keys” that you can give to friends or family through the app, so they can have access to your garage temporarily. You can also set it to close at a specific time, and have it close after a certain amount of time.

Critique: This product has the ability to monitor if the garage door is open or closed, and open or close it with their app. This is something we need to have, but we also want to be able to set timers and set certain times.

Garadget - www.garadget.com

Model and Price: Garadget for $99 but its on sale for $89

Specs: Weight - .5 lbs, dimensions - 2.5” x 2” x 1.5” Batteries not required/uses a power adapter

Summary: You are able to control and monitor your garage from IOS, Android, or web browser. It can send a notification if your garage is open as you drive away, or if it is open after a certain amount of time. It will also tell you if it is opened at an unusual time, and you can see when it was last opened or closed. It has a simple installation.

Critique: This product solves our problem, and some good things about it are being able to monitor it on your phone or computer, having a timer or se time, and telling you if the garage door is open as you are leaving. A unique aspect it adds is the notification if the door is opened at an unusual time.

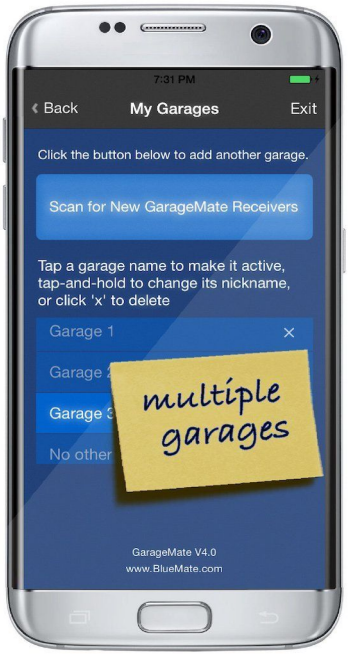
Garage Mate - https://amzn.to/2DkOpYB

Model and Price: GM2540-W $53.95

Specs: Bluetooth 4.0 - Pairs up to 8 phones; weight: 3.04oz; Dimensions 2.5 x 1.5 x 0.5 x inches; Color:white; Power Source: 100-240VAC 50/60Hz North American Plug

Summary: Garage Mate installs directly into the opener motor itself. You use an app which connects to 1 or multiple Garage Mate devices over Bluetooth. A local Bluetooth connection offers security at the sacrifice of some functionality, and ease of use. Garage Mate works with all openers made before 2011 and certain openers after 2011.

Critique: This product is solving our problem of losing a garage door opener remote. It accomplishes this by using your phone as a bluetooth remote to control the opening of the garage. This is opposed to using a WiFi/internet connection like many other solutions on the market, creating a more secure, localized connection. However, this device is unable to determine the position of the door. This would require using a secondary device such as a webcam.



Element C

VOC - Voice of the Customer

Research

- Homes are most commonly robbed through open garage doors.
- Leaving garage doors open can lead to weather damage and animals nesting inside.
- Most people do not lock their door from the house to the garage, giving extremely easy access to intruders.
- Bicycles and tools are most commonly stolen out of unattended garages.

Survey

- 79.4% of people have left their garage door open unintentionally.
    - 74.6% of people have left it open during the day.
    - 57.1% of people have left it open during night.
- 66.1% of people leave their garage open 1 to 2 times a month.
- 87.3% of people would like to be able to monitor and control their garage through their smartphone.

CRD - Customer Requirements Document

List of Customer Requirements

1. Low Cost
2. High Security
3. Internet Connectivity over wireless/cellular
4. Activity Log (Opening/Closing)
5. Simple app design for easy use
6. Easy Installation
7. Reasonable Size
8. Powered from the wall

Summary

The customer would ideally like a product that is low cost, easy to install, has high security, and can be accessed from anywhere through the use of cellular data. Along with this, it would be nice if the app was simple and easy to use, a log was kept of the garage opening and closing, and if the part was a reasonable size. High security is one of the biggest concerns and must be done properly to ensure safety, making this the highest priority of the requirements.

SSM - Similar Solution Matrix

On-Market Solutions from Element B ranked against CRD (above) from 0 to 5, higher being better. (Highest total can be 40)

	Customer Requirements								
Similar Solutions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Liftmaster 	4	3	5	0	4	4	4	5	29
Chamberlain 	1	4	0	0	0	4	5	0	14

Similar Solutions	1	2	3	4	5	6	7	8	Total
Nexx Garage 	2	5	5	5	3	3	5	5	33
Aladdin Connect 	4	3	5	0	2	3	5	0	22

Similar Solutions	1	2	3	4	5	6	7	8	Total
Garadget 	3	4	5	5	4	2	4	5	32
Garage Mate 	5	5	0	5	4	5	5	5	34

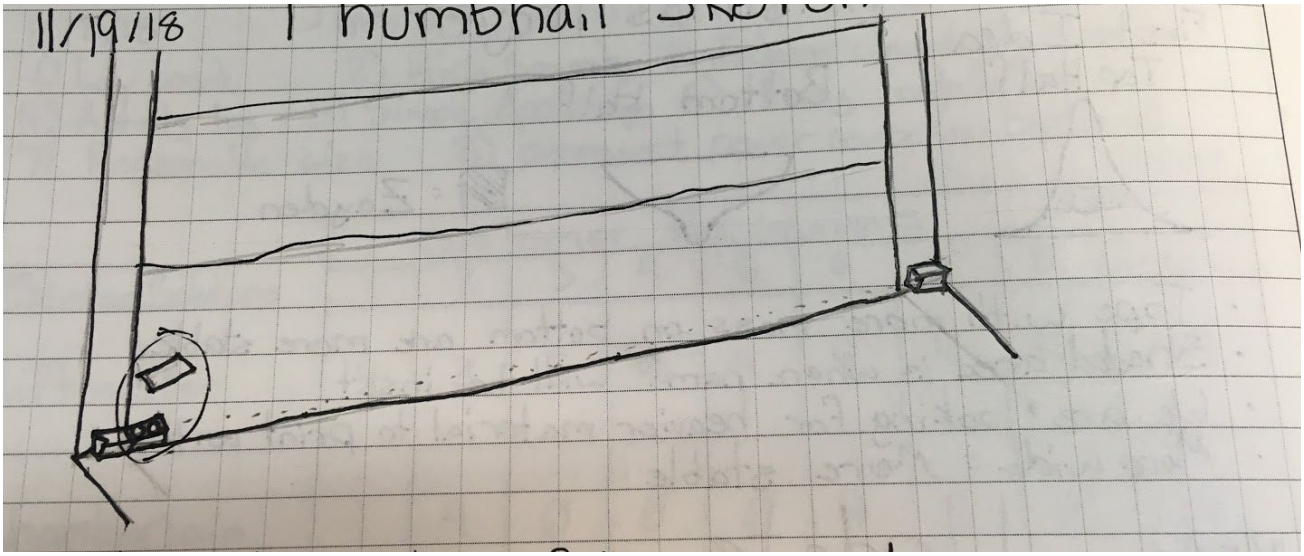
PDS - Product Design Specifications

- Product should be no larger than 5” x 5” x 3”
- Product should weigh no more than 20 oz.
- Product should use a power adapter
- Product should cost no more than $80
- Product should have a simple app design
- Product should have access via cloud
- Product should have high security

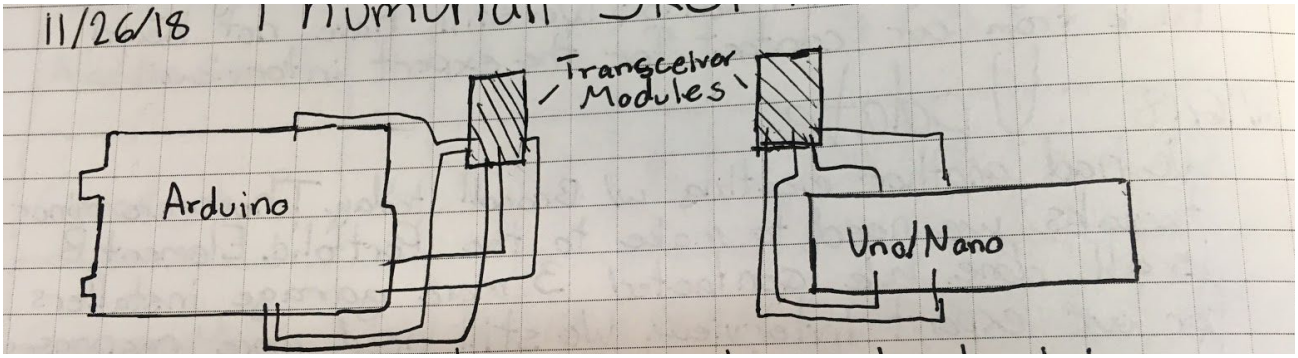
Element D

Our team originally planned to not have a physical interface with our prototype, instead planning to create a phone or web app to remotely alter the settings desired. As we began the prototyping process, we discovered that we would not have enough time to learn how to create a phone app and implement it. We instead chose to use a touch screen attached to the raspberry pi. Ryan later learned how to send data from the Pi to a webpage. We used this as a way to display the data to the user.

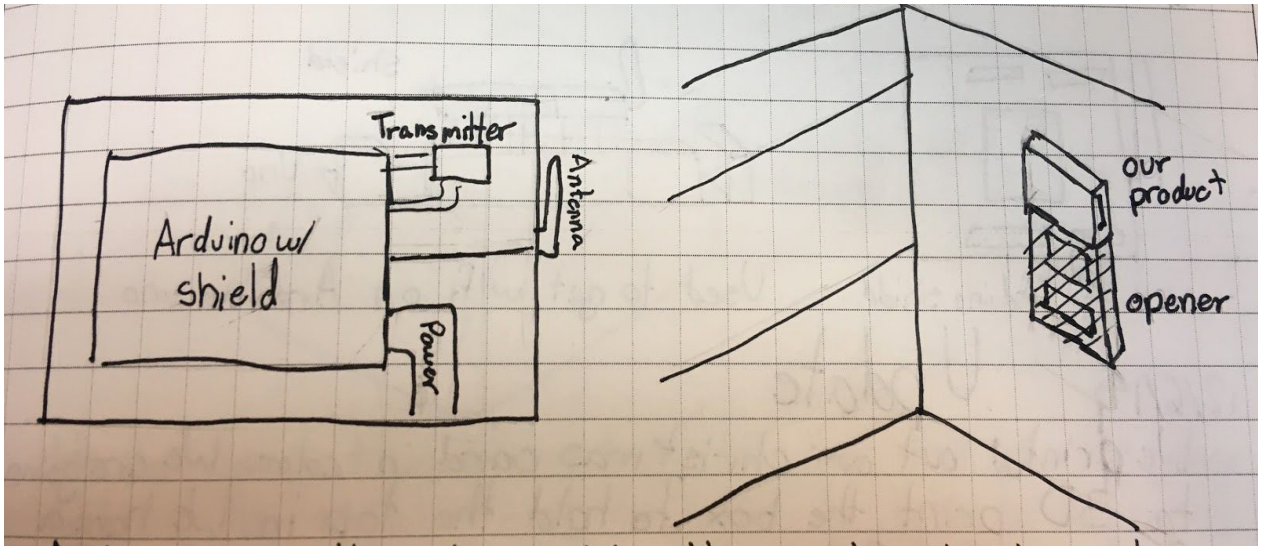
Thumbnail Sketches



To detect the position of the garage door, we can use an ultrasonic sensor. To increase accuracy of the sensor, there can be an extra 'sheet' above for detection.

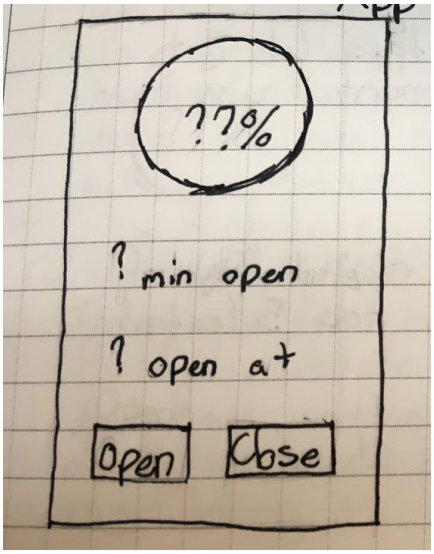


We can use transceiver modules to allow wireless communication between an arduino and an arduino nano. This can be used to connect the sensor to the main module. From here, we would only need to communicate wirelessly with one arduino.

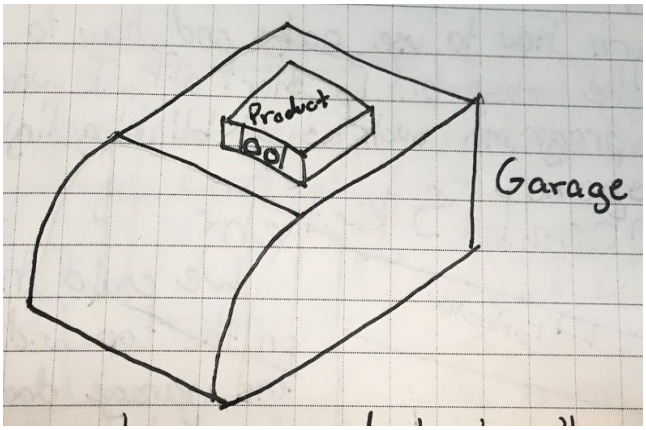


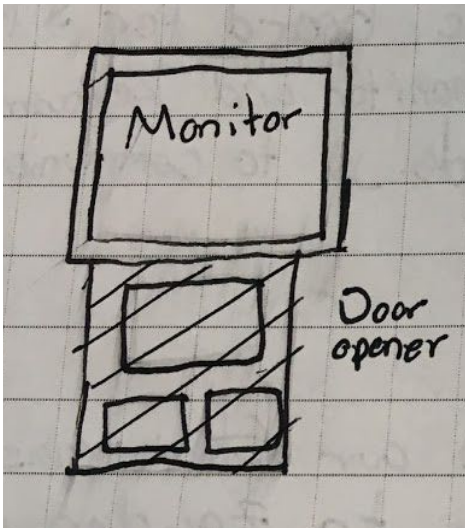
Arduino uses ethernet shield attachment with an antenna to connect to the users wifi. The transmitter talks to another arduino to detect the garage door position (sketch above).

At this point in time, we planned to have a phone app that would display the data. This sketch is how we planned to format the app interface. The top circle would output the garage door state, while the two lines under would show the data set by the user. The bottom two buttons could be used to remotely control the garage door.



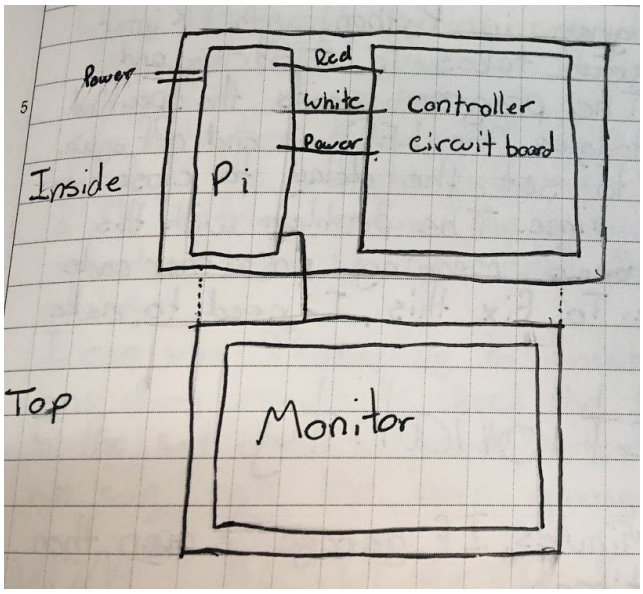
We can mount our product to the top of the garage and use the signals from the door to talk to the button. Our product would be able to detect the position of the garage door from above without having other objects in the way.

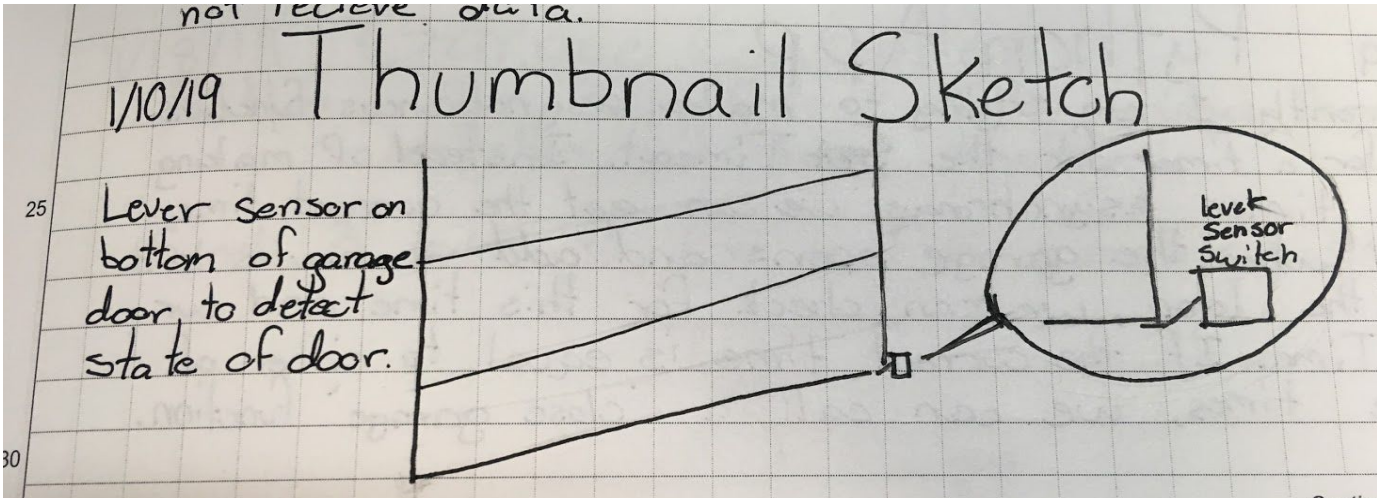




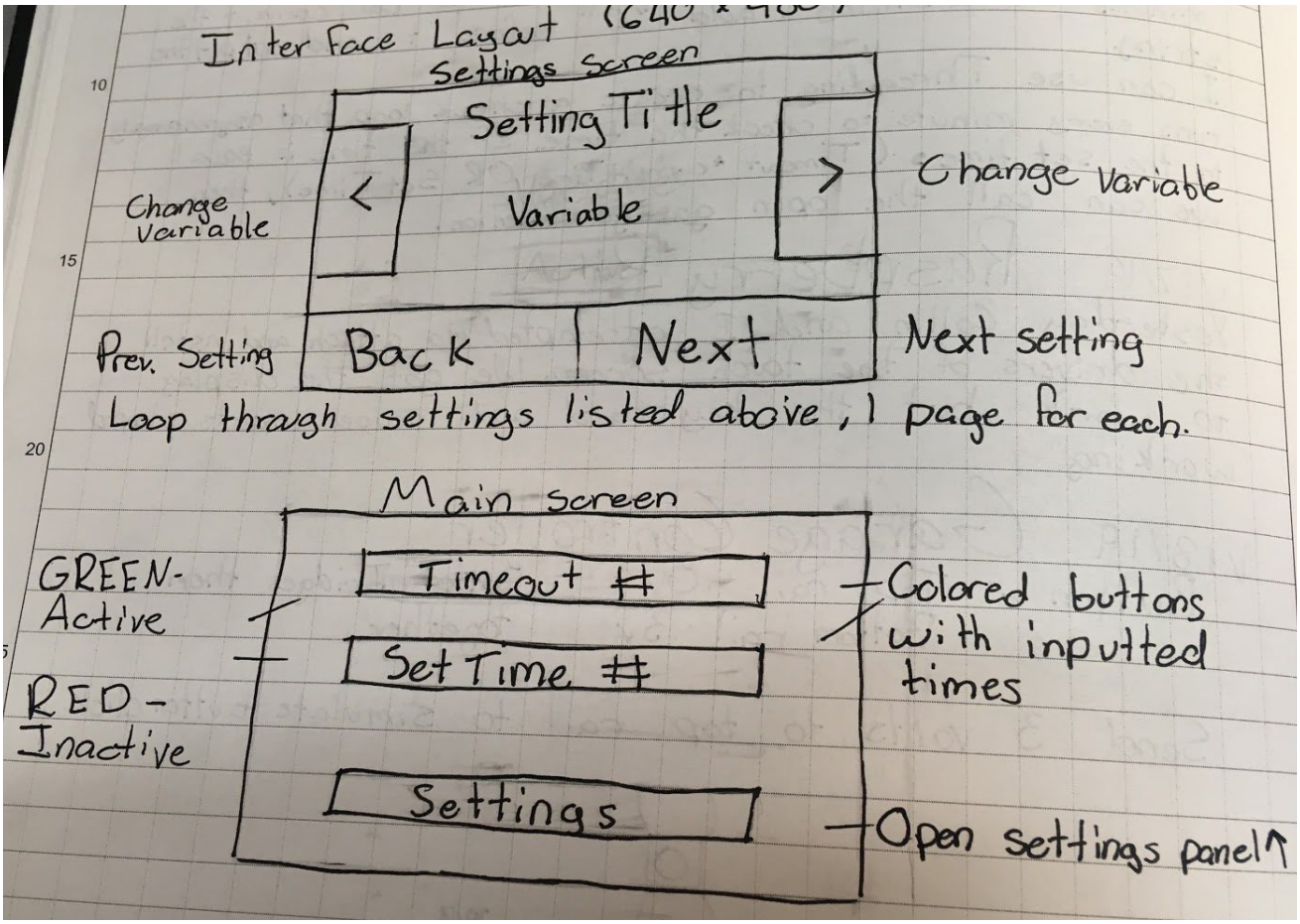
Instead of controlling the garage through an app, we can control it through a display mounted above the opener. We can control when the garage auto closes and the set time to close.

We can buy the garage door controller and use it to connect to the garage door. This would allow the product to wirelessly connect to the garage and can be taken anywhere throughout the house. The Pi will store the time inputs and use them to remotely close the garage.

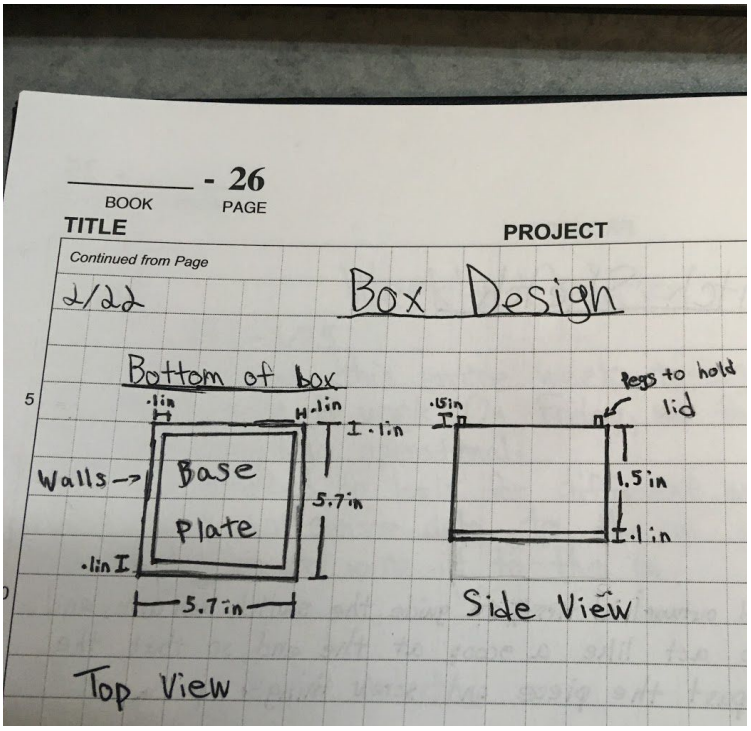




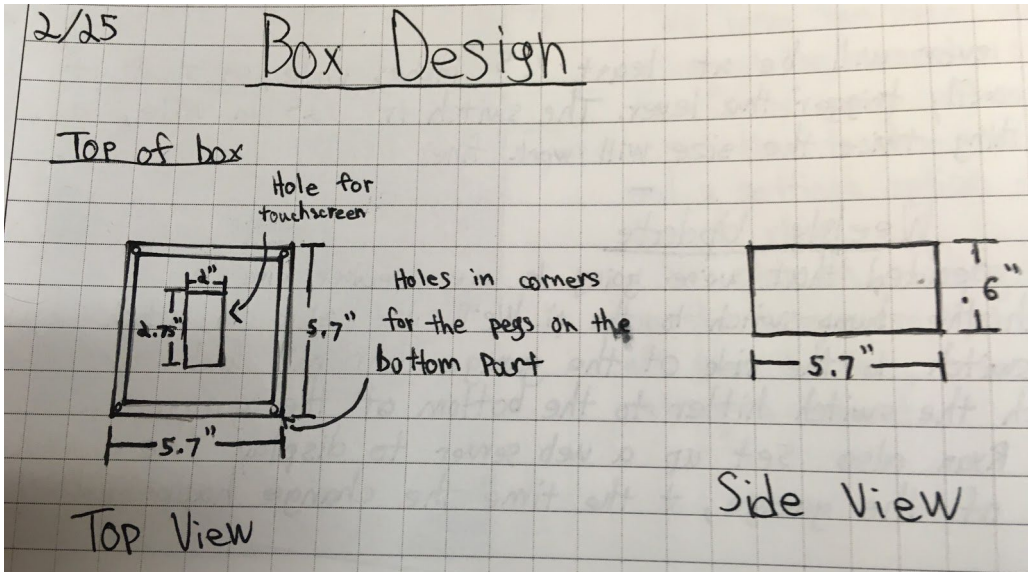
We can use a bump switch at the bottom of the garage door to detect the state of the garage door (closed or open).



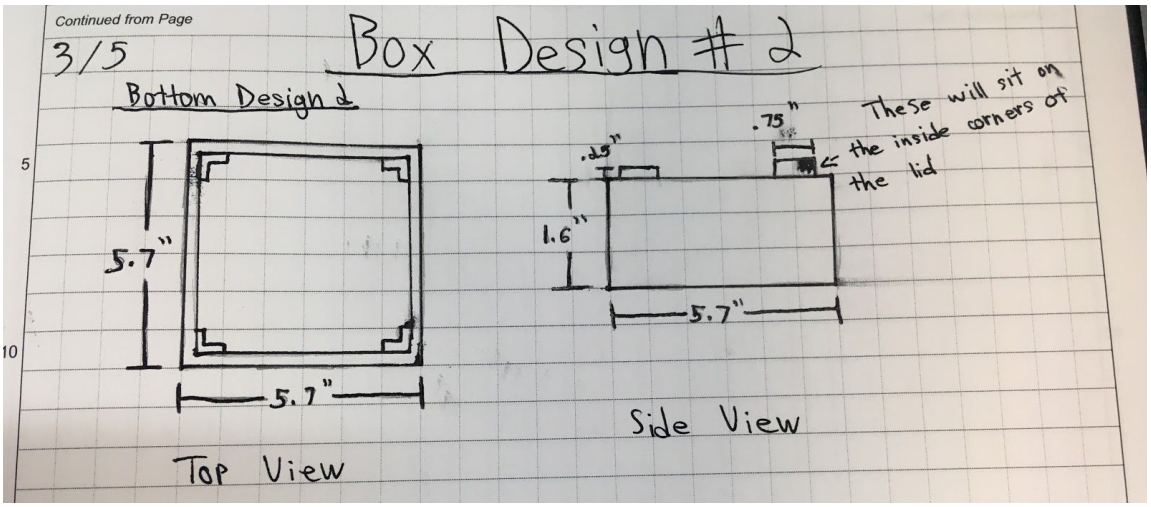
This is the design for the app interface of the python program running on the raspberry pi. The bottom drawing is the layout of the main screen. It allows the user to toggle whether the settings are active or not. From the main page, the user can edit the settings. The top drawing is the layout for each setting. The buttons on the side allow the user to change the value of the setting, such as changing the timeout 30 minutes. The bottom buttons bring the user to the next setting. This program removes the mouse from the screen and is locked in fullscreen, making it more touch screen friendly.



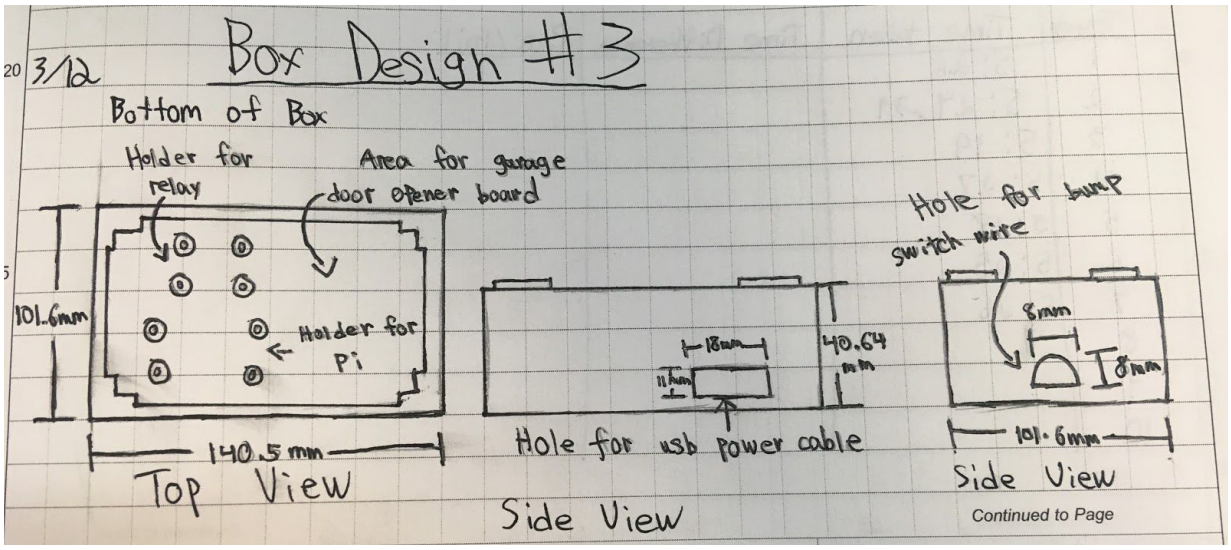
This design is just a basic cube to make sure that we have the right size box for all our electronics. The corners have pegs that will connect to the lid.



The lid is the same length and width as the bottom of the box, and has small holes in the corners to hold it in place and keep it connected to the bottom of the box.

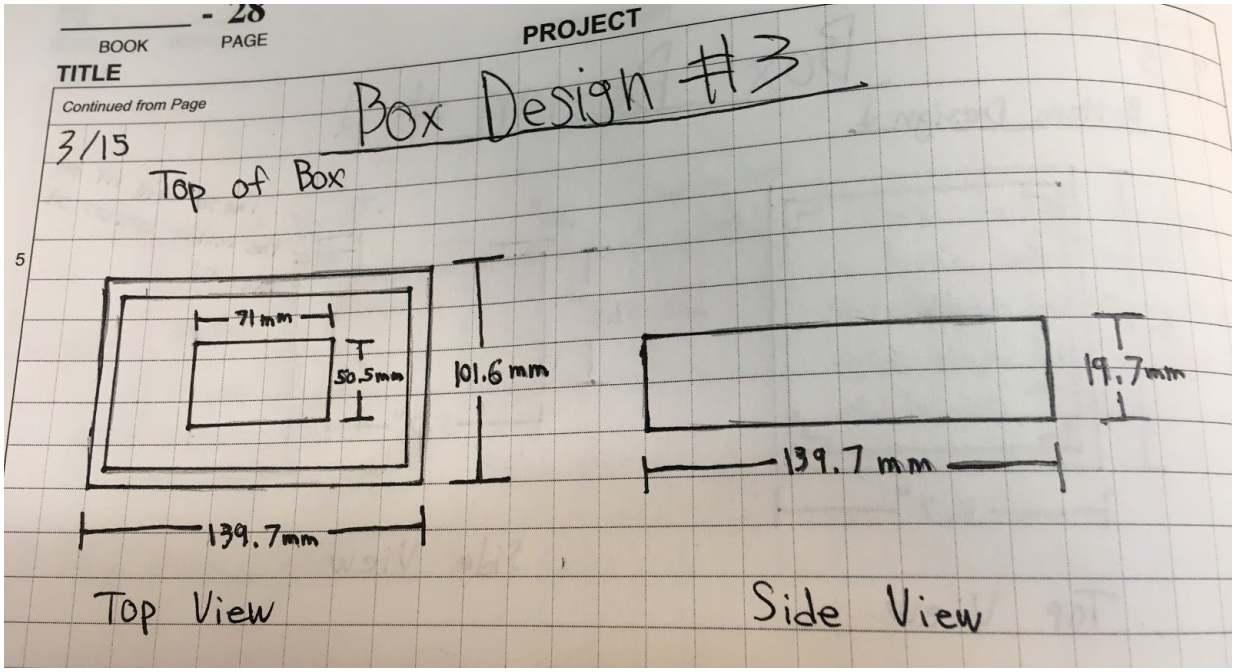


The previous pegs to hold the lid were way too small, so we changed them to a staggered corner so that the lid will rest around the corners. The design of the lid remained the same.

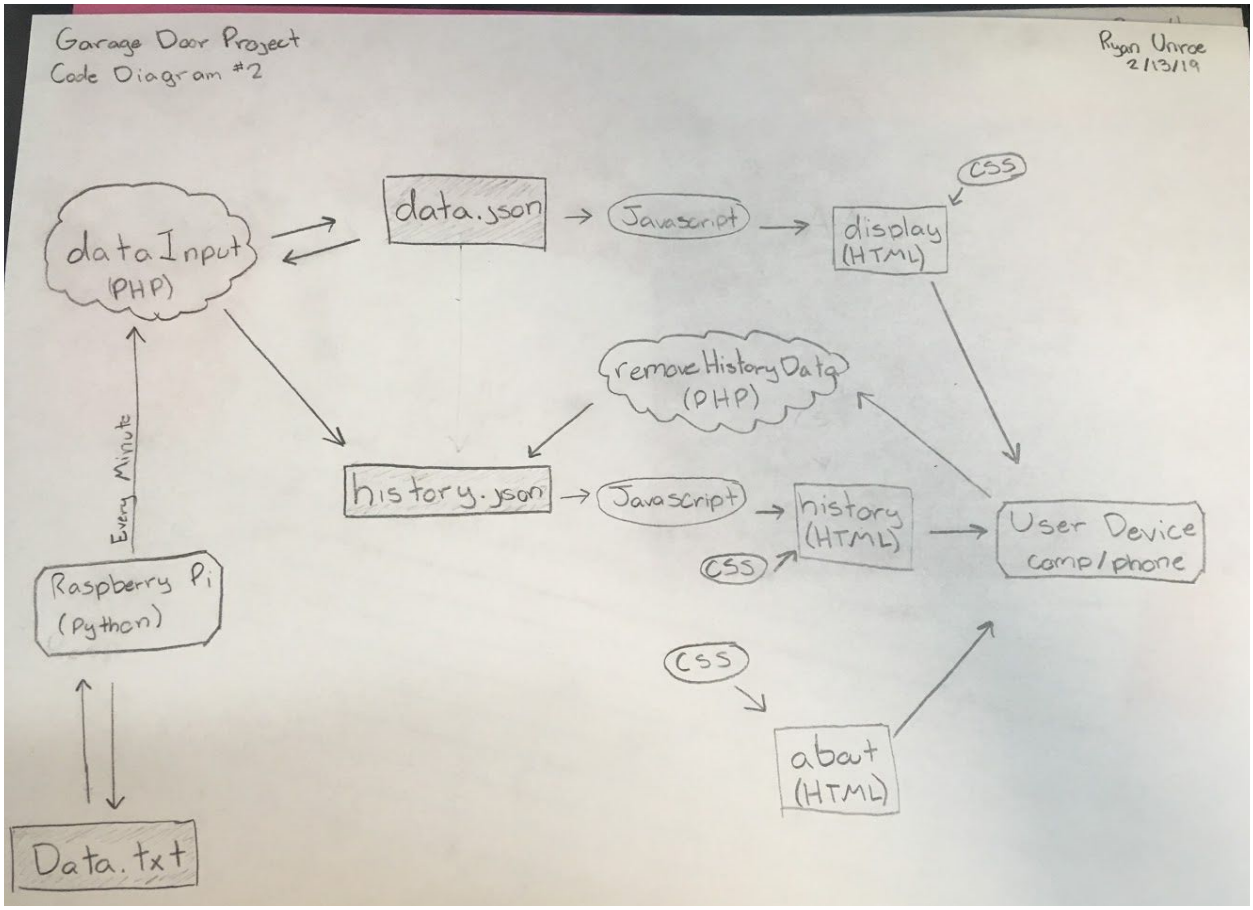


We changed the design of the box to a rectangle, because we were able to reduce the amount of materials in the box, so less space was required. We added pegs to the inside of the box to hold the raspberry pi and the relay in place. There was also an area left open for the garage door opener board to sit. We added a hole to the side for the usb power cable to fit through,

and on the other side we had a hole for the bump switch wire to go through to connect to the pi. We also changed the units of measure to metric, so that the 3D prints would be more accurate.

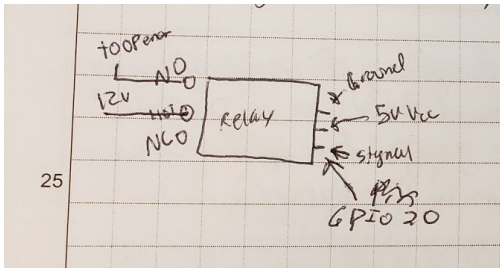


We changed the dimensions of the lid to match with the bottom, but made the length a little smaller so that the lid would have a snug fit to the bottom and not wobble around while attached. We also adjusted the location of the hole so that it would be in the center of the lid again.

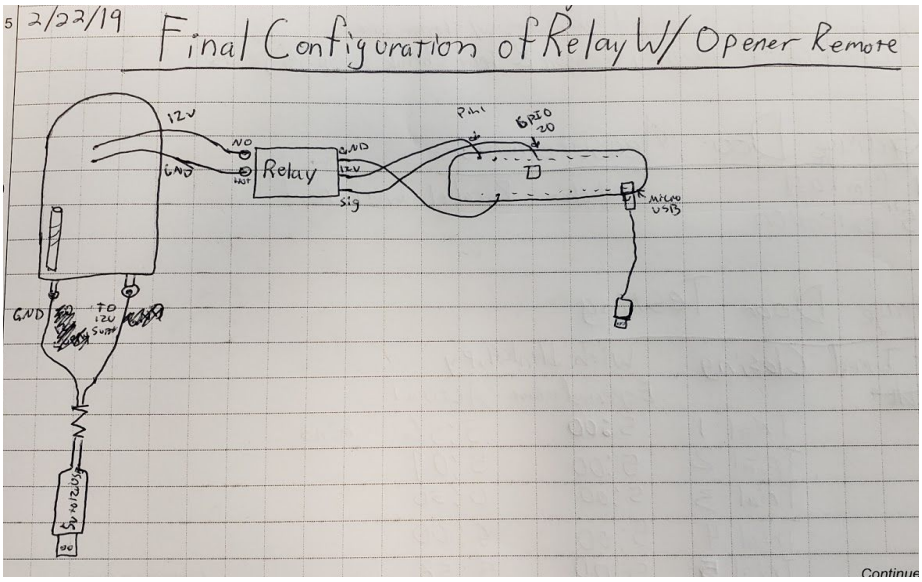


When the raspberry pi runs the program, it will gather the previously saved data from the Data.txt file stored locally. Every minute the program sends data to the web server. If the new garage state data is different from the old garage state data, the dataInput.php will write it to the history.json.

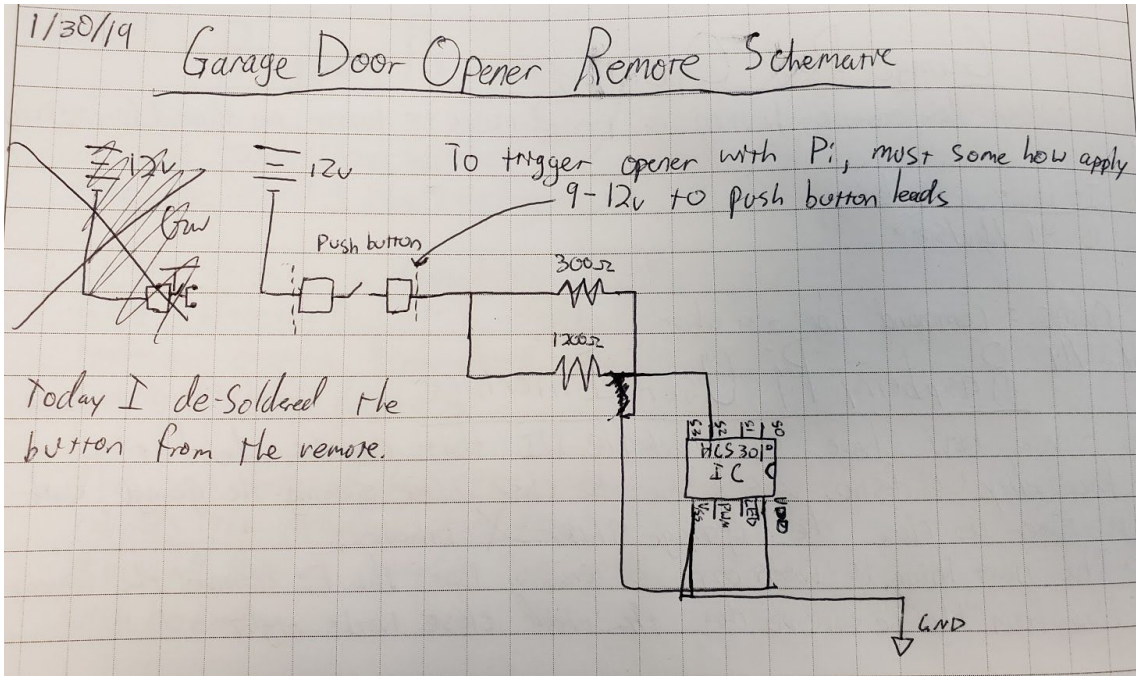
On the webpage, the main page, display.html, shows if the garage is opened or closed, when the door is scheduled to close, and when the data was last updated. The 'history' page shows the date and time of every time the garage opened and closed.



This is a pinout of how we originally intended to utilize the relay to activate the garage door opener. This relay is set up to pass 12v to the opener remote instead of just bridging the circuit, as we did not yet understand how the remote controls worked. This diagram also designated GPIO 20 as the signal input.

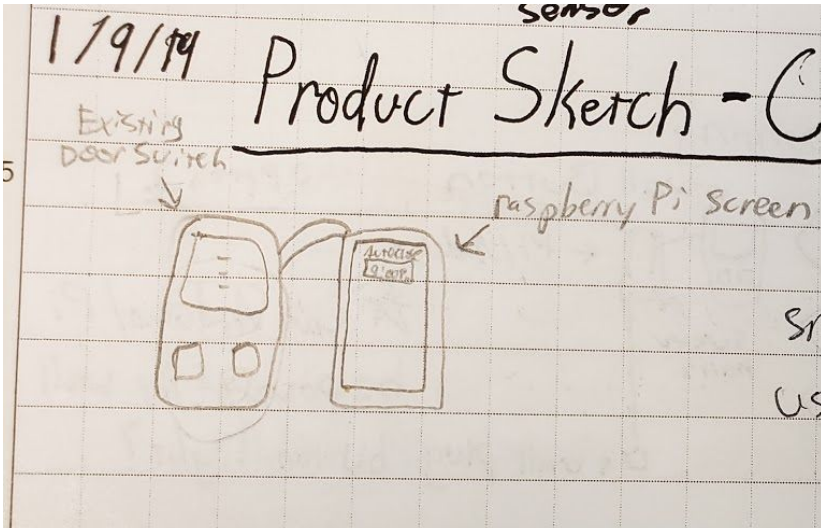


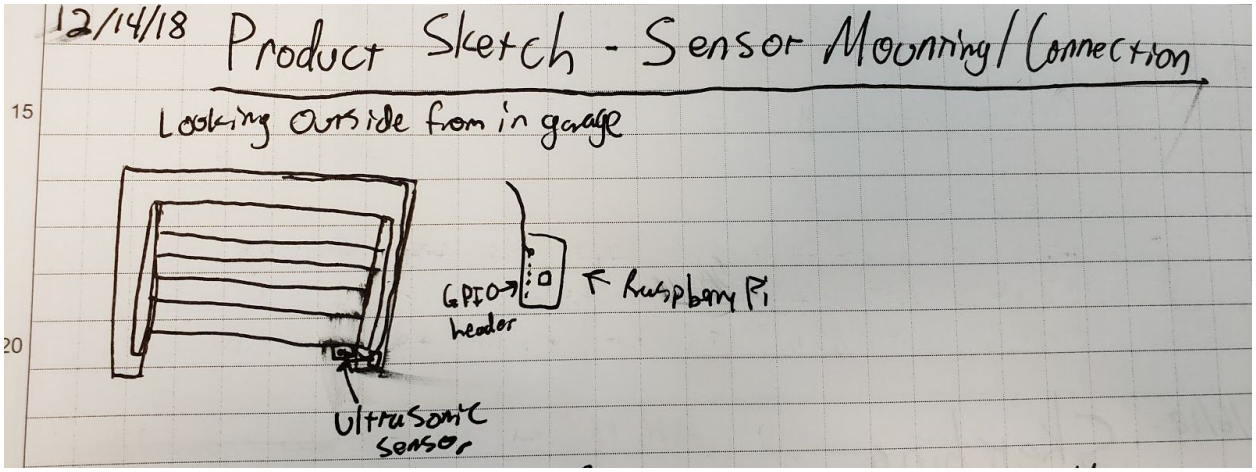
This diagram shows how we intended the final configuration to be set up. This included the connections between the Pi, Relay, Garage door remote, and 5v USB power.



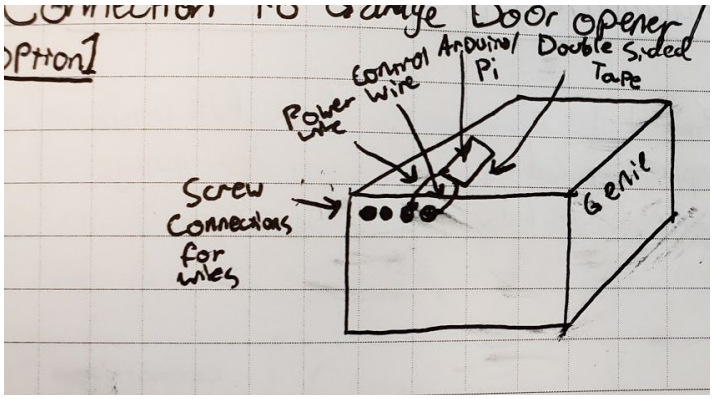
To close the garage, we can simulate clicking the button on the garage door remote. We can simulate this by sending 9 to 12 volts to the other side of the button. Collin removed the button and soldered in wires to replace it.

Instead of controlling the product through an app, we can use a Raspberry Pi touch screen. The touch screen, Raspberry Pi, and garage door opener can all be wired together to be able to create our prototype.



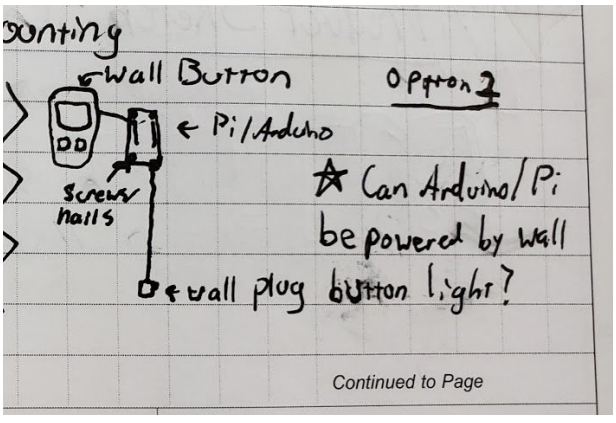


A way to detect the position of the garage door is by having an ultrasonic sensor secured at the base. The sensor can read the exact position of the door, which could be used to display an 'door open' percentage.

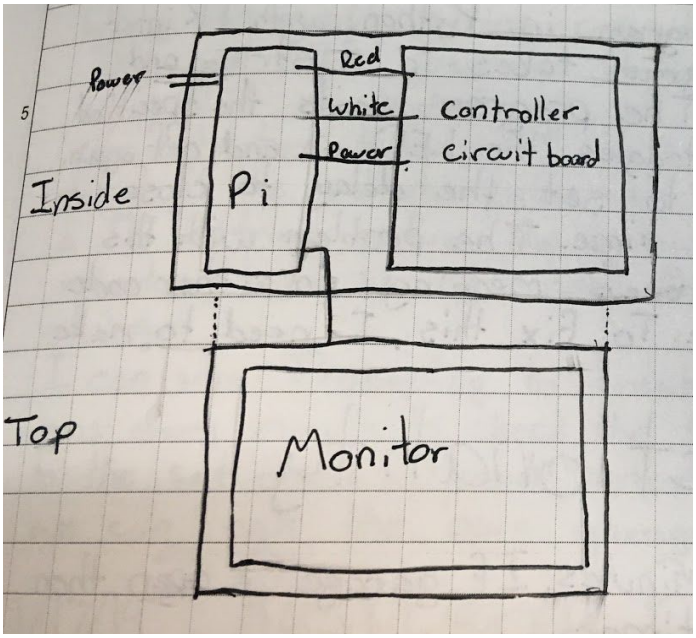


We can mount our product onto the top of the garage door opener and hardwire it directly into the opener. We can also have the sensor (ultrasonic) at the top to detect the garage state.

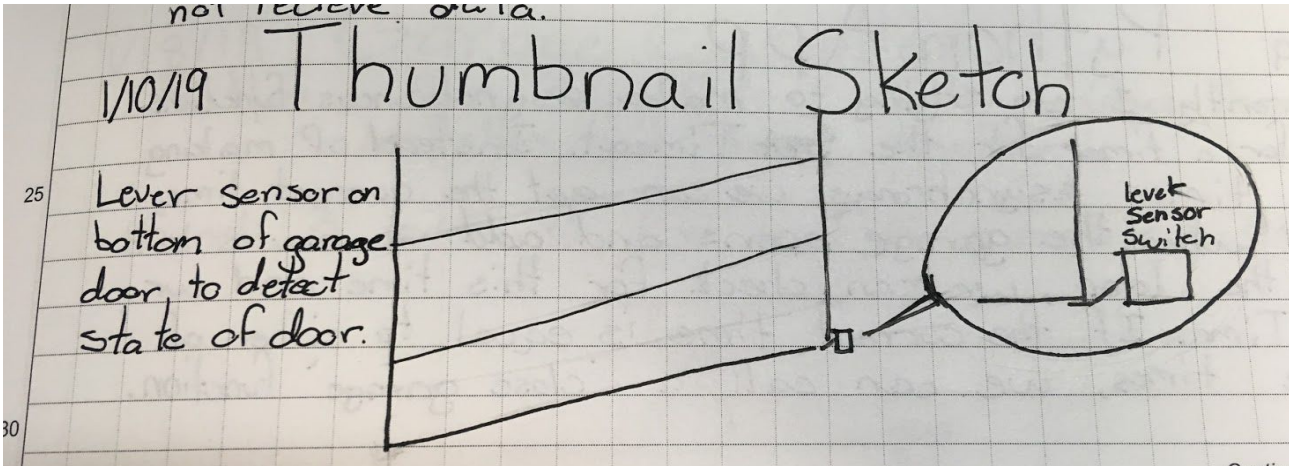
Another option we had was to mount the device next to the wall button. We could then hardwire the product in through the wall button and power it from the nearest outlet.



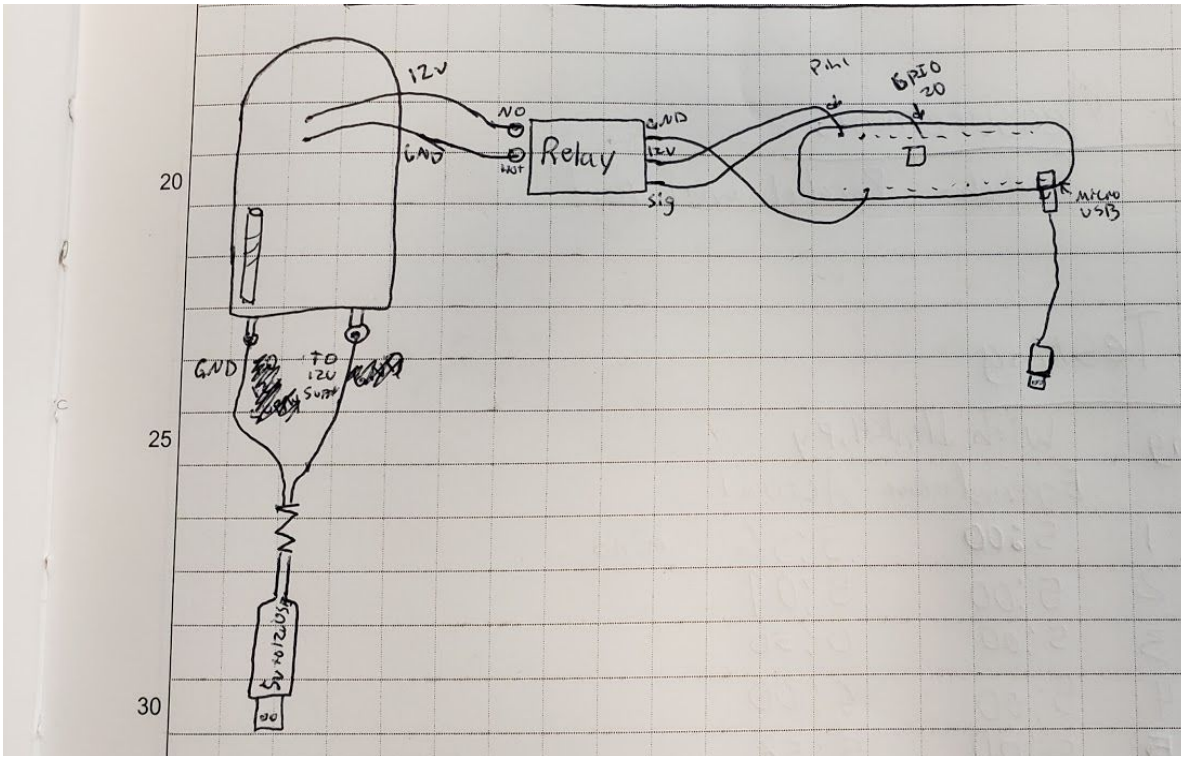
Potential Solution Designs



The touch screen will be attached to the raspberry pi through the GPIO pins and will be centered inside of the housing. The raspberry pi will send a data signal to the garage door remote to close the garage when specified. The whole product will be powered through one cable from the side of the housing.

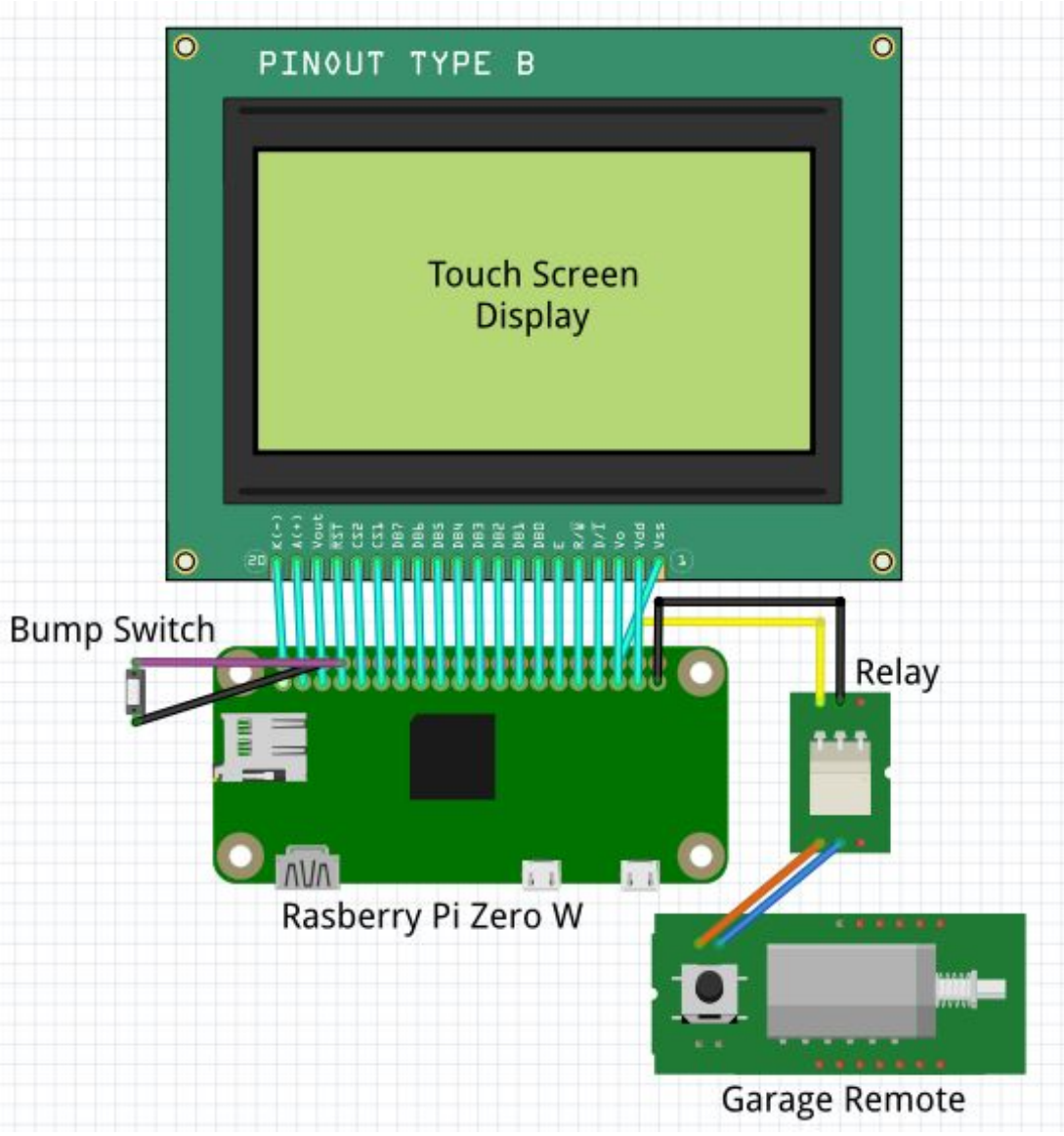


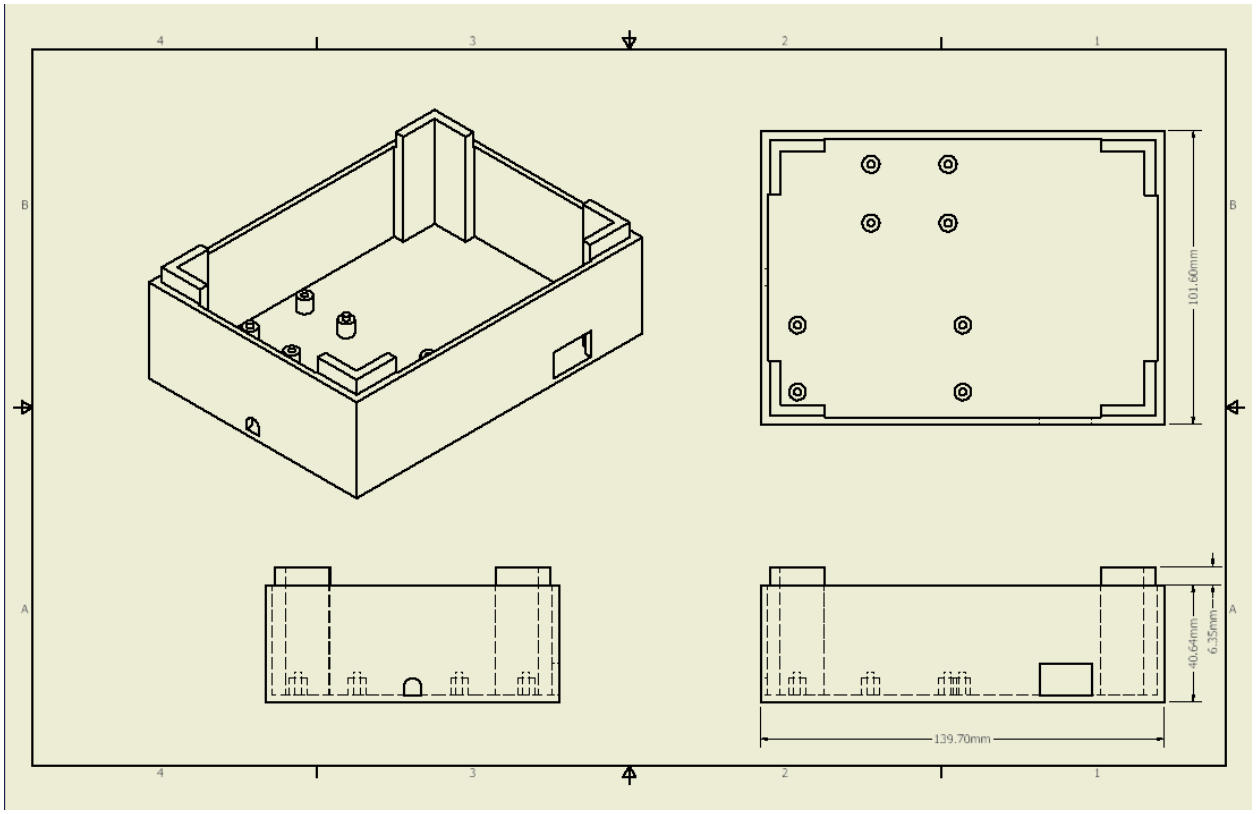
This bump switch can be used to detect the state of the garage door. This will allow us to only close the garage door when it is open and will ensure that it stayed closed overnight.

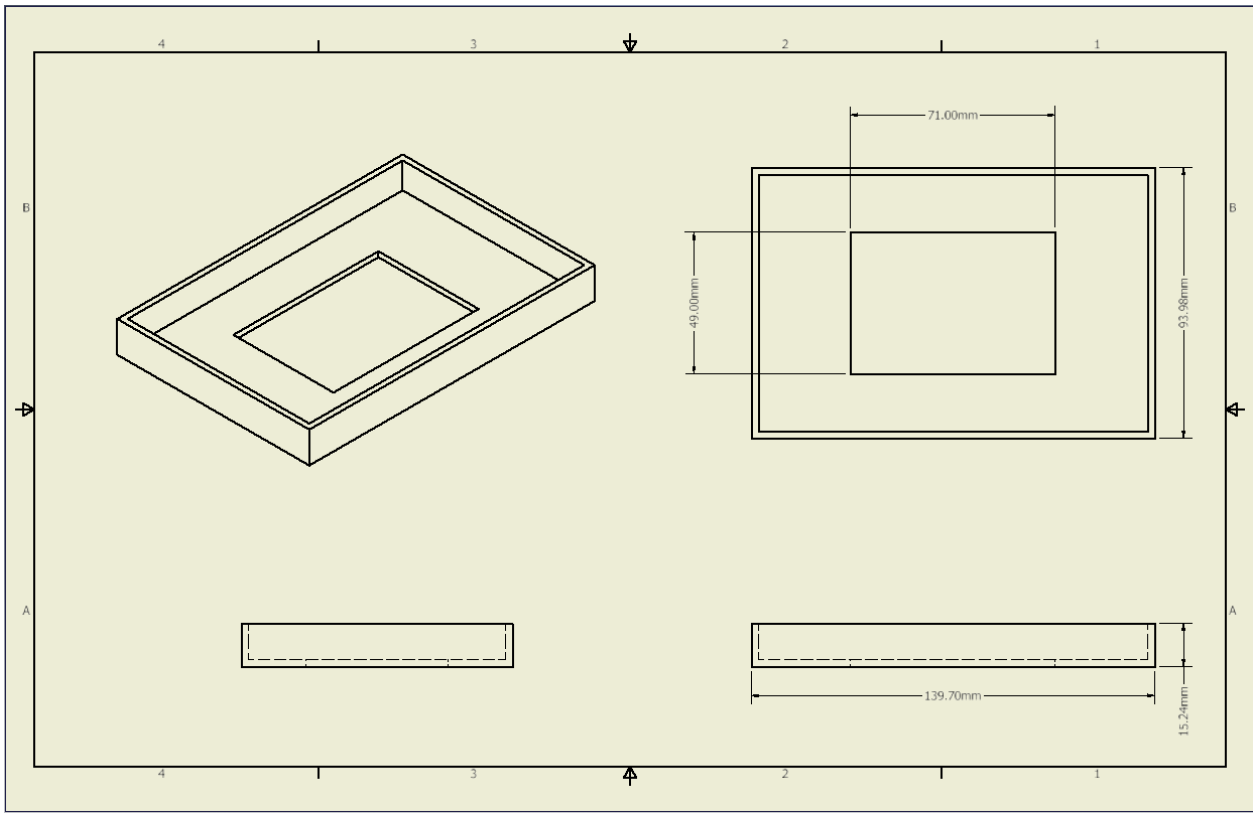


The garage door remote requires 12 volts while the raspberry pi can only output 5 volts max. To fix this, we added a relay that uses the raspberry pi signal to toggle the connection in the remote (same as pushing the remote button). The remote is powered separately with 12 volts.

Final Design Solution




101.60mm
40.64mm
6.35mm
139.70mm


71.00mm
49.00mm
93.98mm
139.70mm
15.24mm

Conclusion

The aspect of the design that we were most concerned with was the human interface with the electronics. We originally wanted to utilize a mobile application to control our Raspberry Pi and set parameters for when the garage closes. We quickly realized that we did not have the means to create an app so we started looking for other options. A touchscreen was decided on being the simplest to implement and easiest to use, and a Python based UI was easy to create on the Raspbian OS that is running on the Pi. Our group discovered that a wireless control would be easier to implement as opposed to a wired control as wired systems can vary between manufacturers and are not documented well, but manufacturer specific remotes or universal remotes can be utilized in a easier manner.

Element G

When we began the prototyping process, we knew that we wanted to utilize a Raspberry Pi in some way, but we did not know how we wanted to interface with it. We first entertained the idea of communicating between the user's phone and the Raspberry Pi through an app. When we started the build process, we found that this option was going to be too difficult to pursue without prior knowledge of creating mobile applications. Our alternative was to create an interface on a touch screen attached to the product. When the basics of the interface were completed, we implemented a webpage for viewing data sent from the Pi. At this point, we were done with most of the project. We just had to continue to tweak the code and housing until everything was how we wanted it.

Build Process

Week 1

(1/6 - 1/12)

On the first week back from winter break, we generated ideas about how we would detect the garage door state. We decided that we were going to use a bump switch at the bottom of the door, allowing us to see if the door is closed. We also decided to use a touchscreen display physically attached to the Pi instead of trying to create an app. Collin researched touchscreens for raspberry Pi's and found one for around $23. Instead of connecting directly to the garage, we decided that we will hook the Pi up to a garage door remote. Ryan started off trying to use node js to code the app in javascript, but then switched over to Python. He imported TKInter to create a GUI.

Week 2

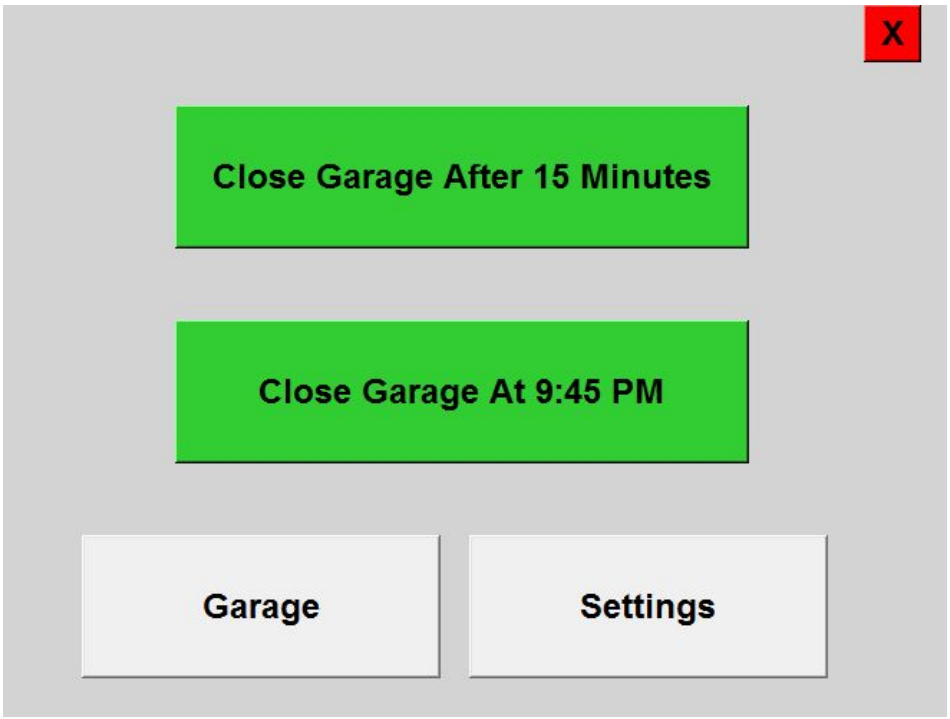
(1/13 - 1/19)

On the second week, we received our touch screen, but had problems with the drivers. We could only get the display working while both the touch screen and mouse/keyboard inputs stopped working. Collin found that when trying to install the drivers, not all of the packages were installing. He installed the ‘offline mode’ version of the drivers, and then updated them. Ryan found out that instead of running a timer asynchronously, we can add the timeout to the current time. We can then compare the current time to the new time. This is also how we detect when to close the garage for the set time. Ryan used the Python Threading library to run a check against the close time and the current time once a minute. Trevor ordered the wrong garage door controller, so we had to get a different one.

Week 3

(1/20 - 1/26)

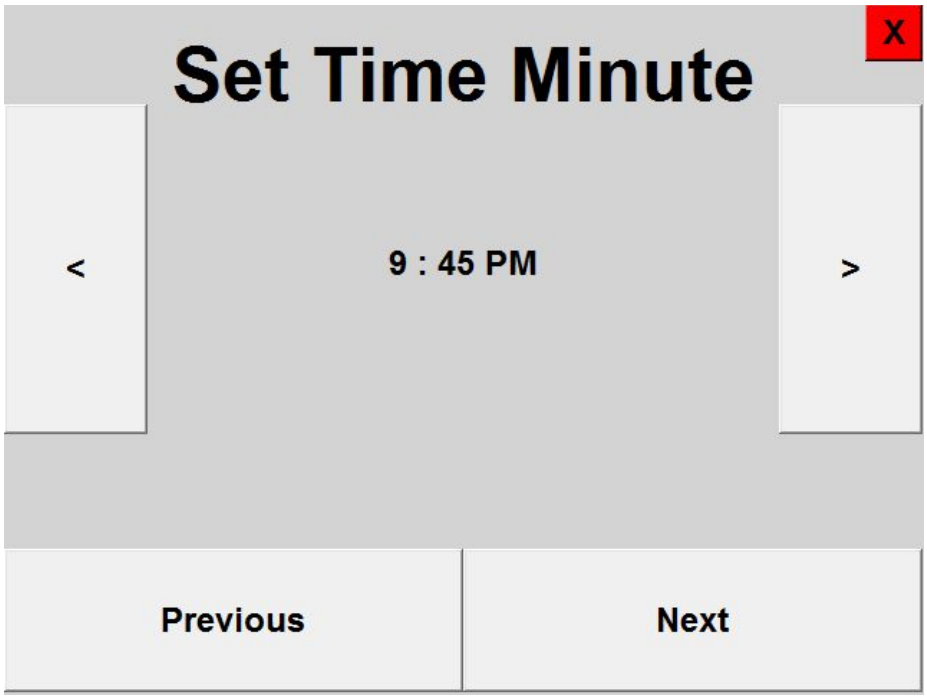
Ryan made the settings pages for the python app and styled them to display on and off states. Ryan and Collin had the touch screen working with all 40 pins plugged in. Collin knew that not all pins were needed, so we started to pull out some wires. We needed open pins to be able to connect the sensor input and the garage door output. Ryan also set up a file on the Pi that stores the previously inputted data. Each time the Pi boots, the program reads the data from the file and uses it for the settings.



Week 4

(1/27 - 2/2)

Collin desoldered the button from the garage door remote and attached wires instead. We found that we need a relay and ordered one. At this time, we did not think that we were going to be connected to the wifi. The Pi had problems keeping the correct time without connecting to wifi. Ryan added a way to change the system time through the settings of the python app. Ryan also tried to make an on screen clock, but ran into problems trying to call a TKInter function from a different thread.

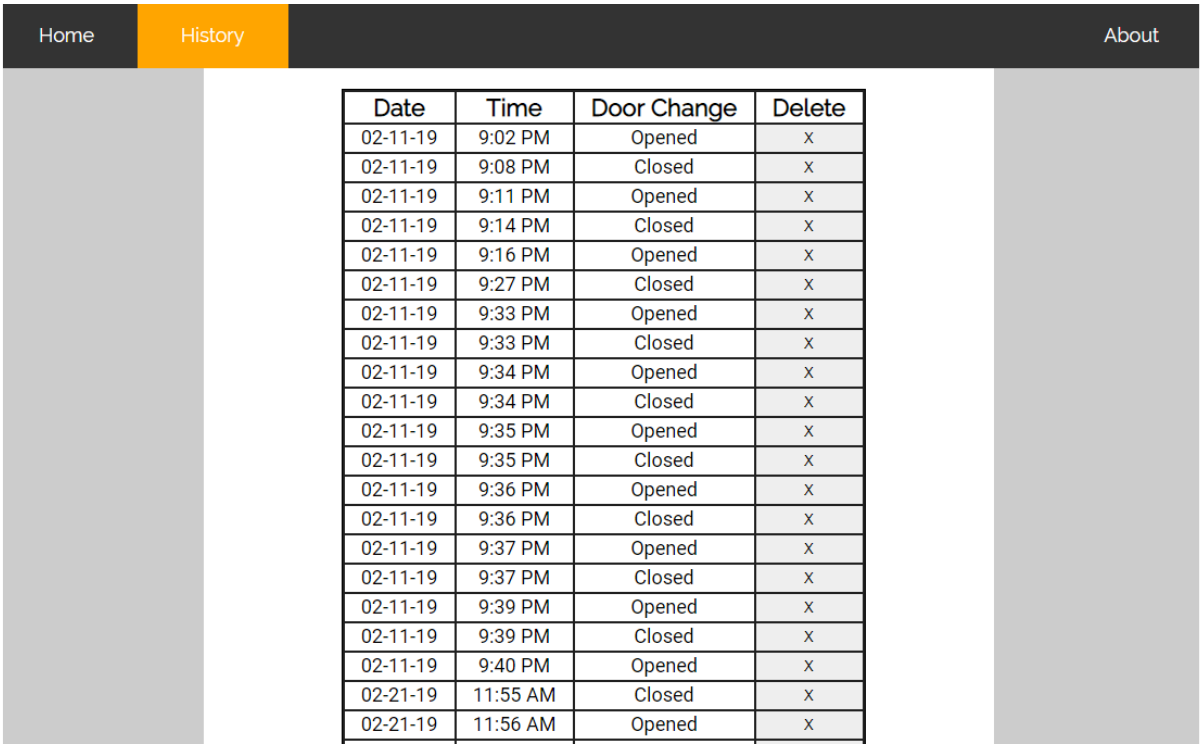


Week 5

(2/3 - 2/9)

Collin received the relay and set it up to toggle 12 volts to the garage door button. Ryan set up a website to display all of the data from the raspberry pi. The Pi sends a get request every minute to his web server, which writes the data to a json file. If the garage door changes states, it saves the data, which is displayed under the history tab. The website displays the current state, time of last update, the settings of the raspberry pi, and the door history.

Since we knew that the Pi was going to be connected to the wifi, Ryan deleted the settings to change the system time.



Date	Time	Door Change	Delete
02-11-19	9:02 PM	Opened	x
02-11-19	9:08 PM	Closed	x
02-11-19	9:11 PM	Opened	x
02-11-19	9:14 PM	Closed	x
02-11-19	9:16 PM	Opened	x
02-11-19	9:27 PM	Closed	x
02-11-19	9:33 PM	Opened	x
02-11-19	9:33 PM	Closed	x
02-11-19	9:34 PM	Opened	x
02-11-19	9:34 PM	Closed	x
02-11-19	9:35 PM	Opened	x
02-11-19	9:35 PM	Closed	x
02-11-19	9:36 PM	Opened	x
02-11-19	9:36 PM	Closed	x
02-11-19	9:37 PM	Opened	x
02-11-19	9:37 PM	Closed	x
02-11-19	9:39 PM	Opened	x
02-11-19	9:39 PM	Closed	x
02-11-19	9:40 PM	Opened	x
02-21-19	11:55 AM	Closed	x
02-21-19	11:56 AM	Opened	x

Week 6

(2/10 - 2/16)

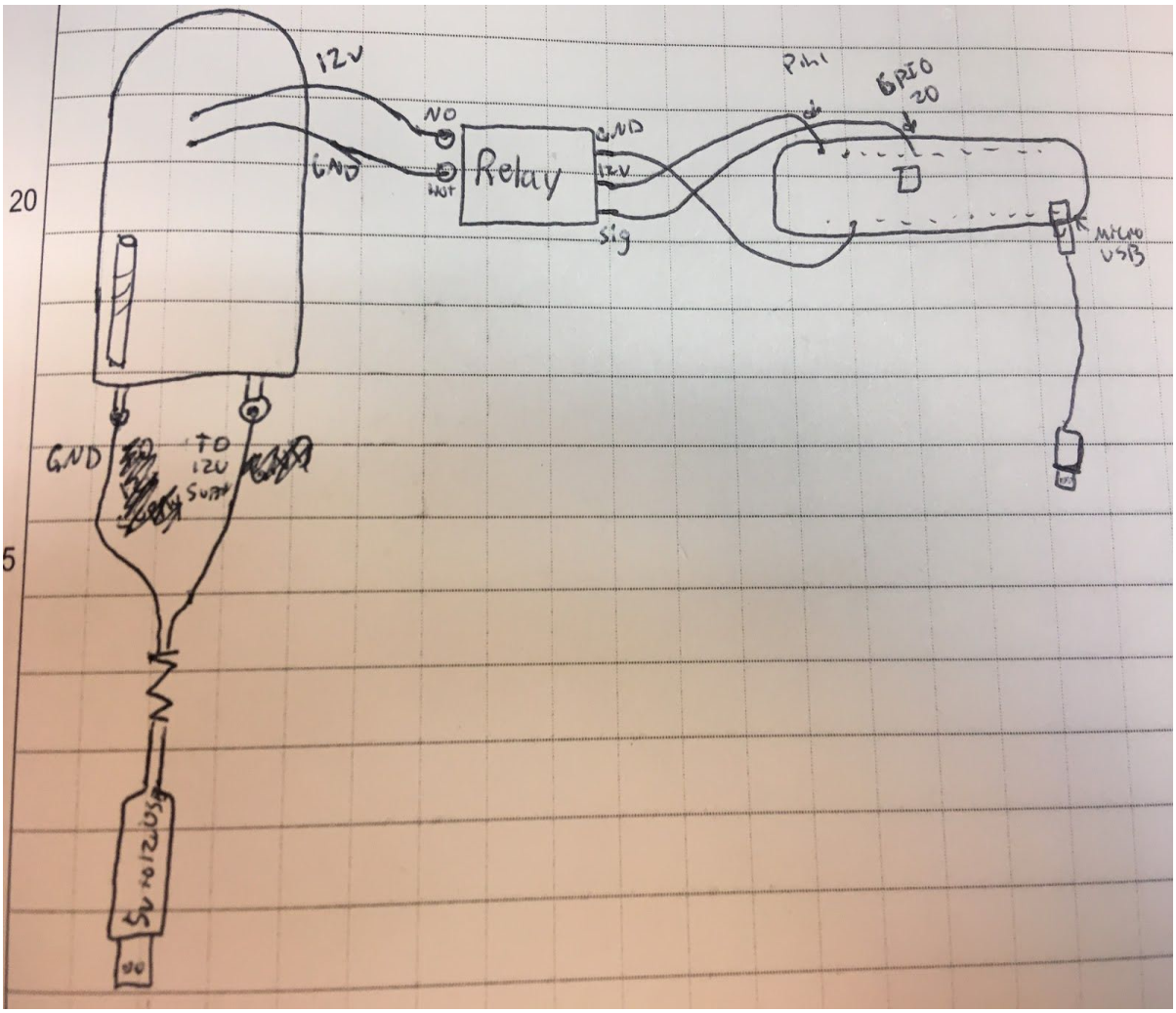
Collin took the product home and tested the bump switch. It successfully sent a digital input to display if the garage is opened or closed. Ryan set up a second json file (history) which only saves data when the garage door changes states. The main json file only keeps the data from the current time and one minute behind. If there is a difference between the states here, the php writes the data to the history json file.

Collin got an old speaker wire that we are going to use to connect the bump switch to the pi. We did not have enough time to learn how to connect the switch wirelessly.

Week 7

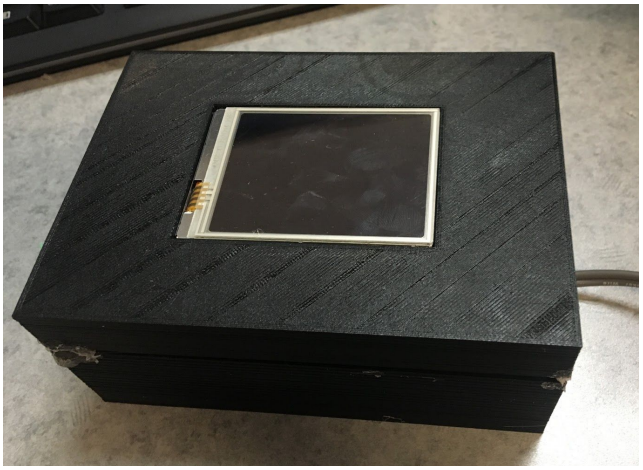
(2/17 - 2/23)

We only had 3 days of school this week. Collin and Ryan worked on finalizing the hardware. Ryan shortened the wires and then Collin secured them using heat shrink. By this point, we were just about finished building.

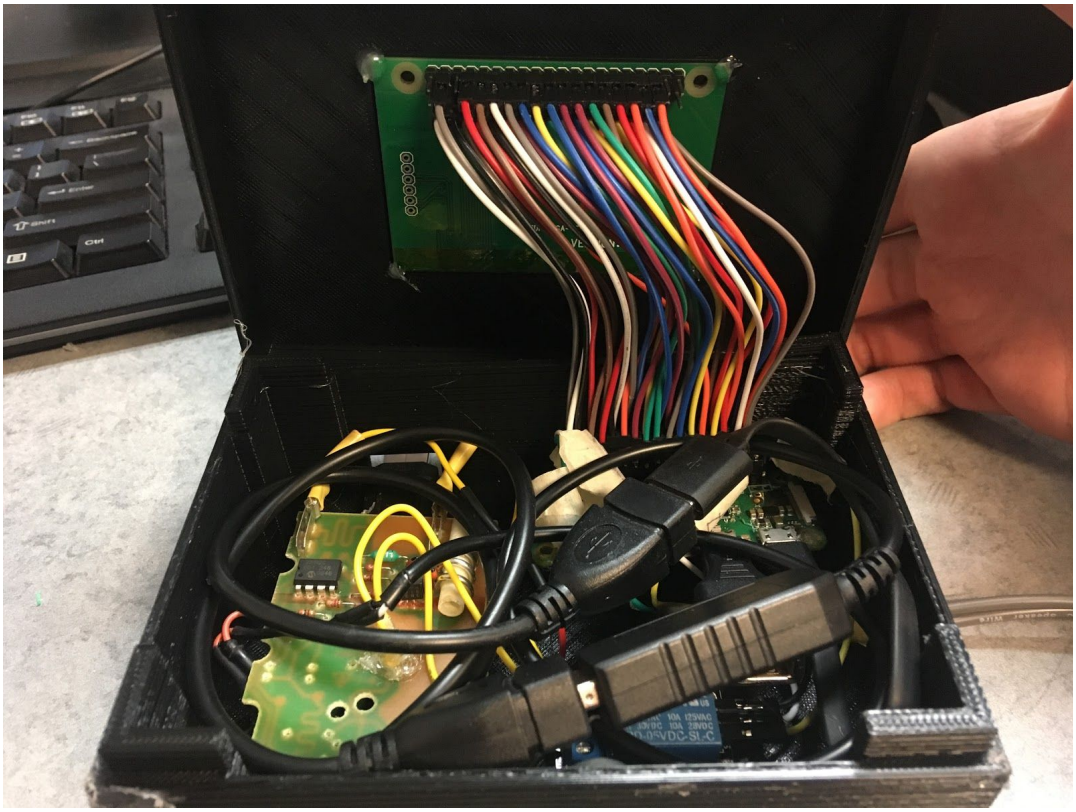


Week 8

(4/7 - 4/13)



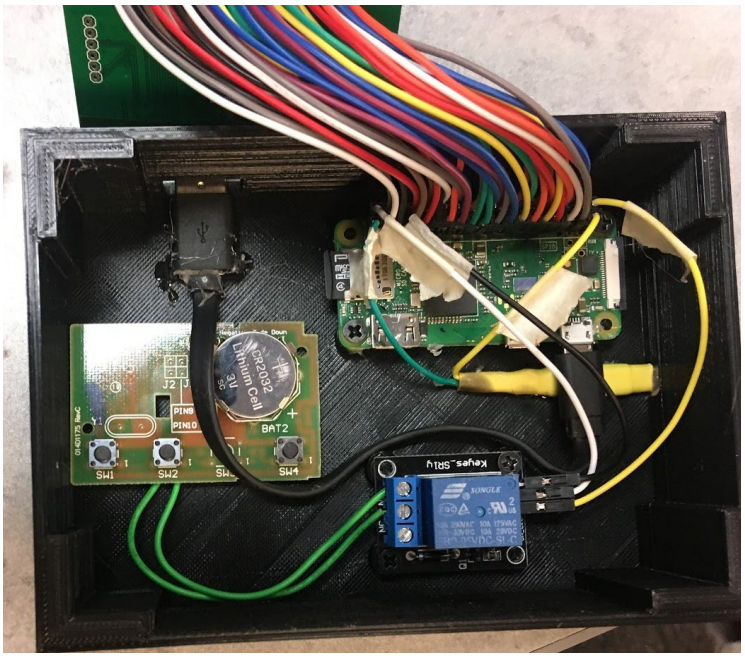
A couple weeks ago, the garage door we were testing on stopped working. We now have a new garage door opener and have to change out the button we soldered into our product. Trevor also printed another box, this one is black and has standoffs inside to secure the pi and the relay in place.



Week 9

(4/14 - 4/20)

One week before the presentation, we finalized the physical components of our product. Trevor printed a new box with better standoffs for the screws and more sturdy connectors to keep the lid in place. We managed to remove more wires and make the inside cleaner.



Bill of Materials

Item	Quantity	Description	Source	Cost
Raspberry Pi Zero W	1	Micro computer	Adafruit	$14
Jumper Wires	40	Female to Female - Sold in packs of 80 (40 long, 40 short)	Amazon	$5.99
Jumper Wires	8	Male to Female - Sold in packs of 80 (40 long, 40 short)	Amazon	$5.99
HDMI to HDMI Mini Adapter	1	Temporary for coding Pi	Amazon	$2.99
USB to Micro USB Adapter	2	Temporary for coding Pi	Amazon	$3.99
Heat Shrink	8	Heat shrink tubes to protect solder joints - Sold in pack of 580	Amazon	$5.99
Relay	1	5-12v control input signal, controls up to 250v AC power	Amazon	$5.50
USB Cable Splitter	1	Used to power both raspberry pi and garage remote with same cord	Amazon	$5.99
Garage Door Controller	1	Old unused garage door remote	Collin's House	___
Touch Screen	1	GPIO driven touchscreen, specific to Raspberry Pi Zero	Amazon	$22.99
Screws	4	Used to mount Pi and relay to housing	Collin's House	___
Power Brick	1	LiIon battery bank with 5v 2A USB output	Collin's House	___

Tools and Equipment

Tool	Exists in Class	Source (if not in class)	Notes
3D printer	Y	Also at Trevor's house	Used to create housing of the electronics and the bump switch activator
PLA Filament	Y	Also at Trevor's house	Black
Solder	Y		Used to connect wires together securely
Screw Driver	Y	Collin also keeps this on him	Used to secure components down inside housing

Conclusion

After lots of minor tweaks and changes, we ended with a clean, reliable product. To further simplify the end result, we could have printed our own microboard. This would allow for less power consumption, smaller housing, and a lower cost. At first, we did not anticipate the difficulty of creating a mobile app that could wirelessly talk to the Raspberry Pi. Instead, we used a touch screen with a custom interface. We did not plan to use WiFi at first, but a few weeks in to building, we realized that we want to display data to the user. This simplified some of the interface code but made the initial set up slightly more difficult. The most challenging part of the build process was unexpectedly having to switch out our garage door controller during our last week of building.

Element H

To ensure that our product is reliable and solves the problem of garage doors being left open, we will put our product through three main tests. The first of which will check if the garage door closes after the set interval. To determine if the test is a success, the door must close within 30 seconds of the expected time. If it takes the door more than 30 seconds then the test will be considered a fail. The second test will check if the garage door closes at the specified time. To test this, we will change the set time to close a few minutes after the start of each trial. If the garage closes within the specified time, down to the minute, then the test is successful. The third test will be to determine if the bump switch properly reads the state of the garage door. It is very important that the switch reads the state of the door properly to guarantee that the code closes the garage instead of opening it.

Test Criteria

Criteria / Benchmark	Description	Quantitative or Qualitative
Garage closes within 30 seconds or less.	Garage closes within 30 seconds of the specified time	Quantitative
Connects to the wifi	Device properly connects to the wifi to send data and set system time	Qualitative
Sends data to website	The Pi sends data to the web server which displays it on the webpage	Qualitative

Test Plan 1

TEST: Close After Specified Amount of Time

Collin's Garage Test: # Date:

Purpose:

To make sure that the garage successfully closes when it is supposed to.

Initial Conditions:

Garage state:

Time garage was opened:

Time expected to close:

Materials:

- Garage
- Team designed product
- Bump switch actuator

Success Criteria:

For the test to be considered successful, the garage must be closed at the specified time (within 1 minute).

Safety:

Make sure that:

- No one is under garage door
- The box does not overheat
- There are no exposed wires / any electrical danger
- Pi detects that garage is closed (doesn't randomly activate door)

Procedures:

- ❑ Plug in cord to outlet
- ❑ Connect Pi to wifi (if not already connected)
- ❑ Run latest version of software
- ❑ Attach sensor at bottom of garage door
- ❑ Set times for garage to close through touchscreen interface
- ❑ Wait for Pi to actuate garage
- ❑ Record when garage closes
- ❑ Check website and see if data was recorded properly

Results:

Timeout duration	T_D	
Time taken to close	T_T	
Time difference	T_E	$T_E = \lvert T_D - T_T \rvert$

If $T_E < 30$ seconds then the test was successful

SUCCESS or FAIL

Signatures:

Ryan Unroe _____ Date_____

Trevor Schmit _____ Date_____

Collin Whitfield _____ Date_____

Teacher Approval _____ Date_____

Test Plan 2

TEST: Close at Specified Time

Trevor's Garage Test: # Date:

Purpose:

To make sure that the garage successfully closes when it is supposed to.

Initial Conditions:

Garage state:

Time garage was opened:

Time expected to close:

Materials:

- Garage
- Team designed product
- Bump switch actuator

Success Criteria:

For the test to be considered successful, the garage must be closed at the specified time (within 1 minute).

Safety:

Make sure that:

- No one is under garage door
- The box does not overheat
- There are no exposed wires / any electrical danger
- Pi detects that garage is closed (doesn't randomly activate door)

Procedures:

- ❑ Plug in cord to outlet
- ❑ Connect Pi to wifi (if not already connected)
- ❑ Run latest version of software
- ❑ Attach sensor at bottom of garage door
- ❑ Set times for garage to close through touchscreen interface
- ❑ Wait for Pi to actuate garage
- ❑ Record when garage closes
- ❑ Check website and see if data was recorded properly

Results:

Set time to close	T_S	
Time garage closed	T_C	
Time difference	T_E	$T_E = \lvert T_S - T_C \rvert$

If $T_C = T_S$ then the test was successful

SUCCESS or FAIL

Signatures:

Ryan Unroe _____ Date_____

Trevor Schmit _____ Date_____

Collin Whitfield _____ Date_____

Teacher Approval _____ Date_____

Test Plan 3

TEST: Bump Switch Activated

Trevor's Garage Test: # Date:

Purpose:

To make sure that the sensor successfully detects if the garage is open or closed.

Initial Conditions:

Garage state:

Materials:

- Garage
- Team designed product
- Bump switch actuator

Success Criteria:

For the test to be considered successful, the garage must be closed at the specified time (within 1 minute).

Safety:

Make sure that:

- No one is under garage door
- The box does not overheat
- There are no exposed wires / any electrical danger

Procedures:

- ❑ Plug in cord to outlet
- ❑ Connect Pi to wifi (if not already connected)

- ❑ Run latest version of software
- ❑ Attach sensor at bottom of garage door
- ❑ Click button to close garage
- ❑ Record if bump switch is pressed

Results:

State of Garage Door	G	If G = 'open' then $S_A = 0$ If G = 'closed' then $S_A = 1$
Expected Bump Switch State	S_A	
Recorded Bump Switch State	S_R	

If $S_A = S_R$ then the test was successful

SUCCESS or FAIL

Signatures:

Ryan Unroe _____ Date_____

Trevor Schmit _____ Date_____

Collin Whitfield _____ Date_____

Teacher Approval _____ Date_____

Conclusion

The most challenging aspect of testing our product will be the time it takes to record each trial. The minimum time the garage will automatically close is 5 minutes after it has been opened. Each one of our trials is time consuming, making it difficult to record mass amounts of tests. The set time tests will also take around 5 minutes per test. Each one of our tests will be recorded with a stopwatch to verify the actual time it took to close the garage. We will also include all tests recorded, success or fail. These steps will ensure that each test is unbiased.

Element I

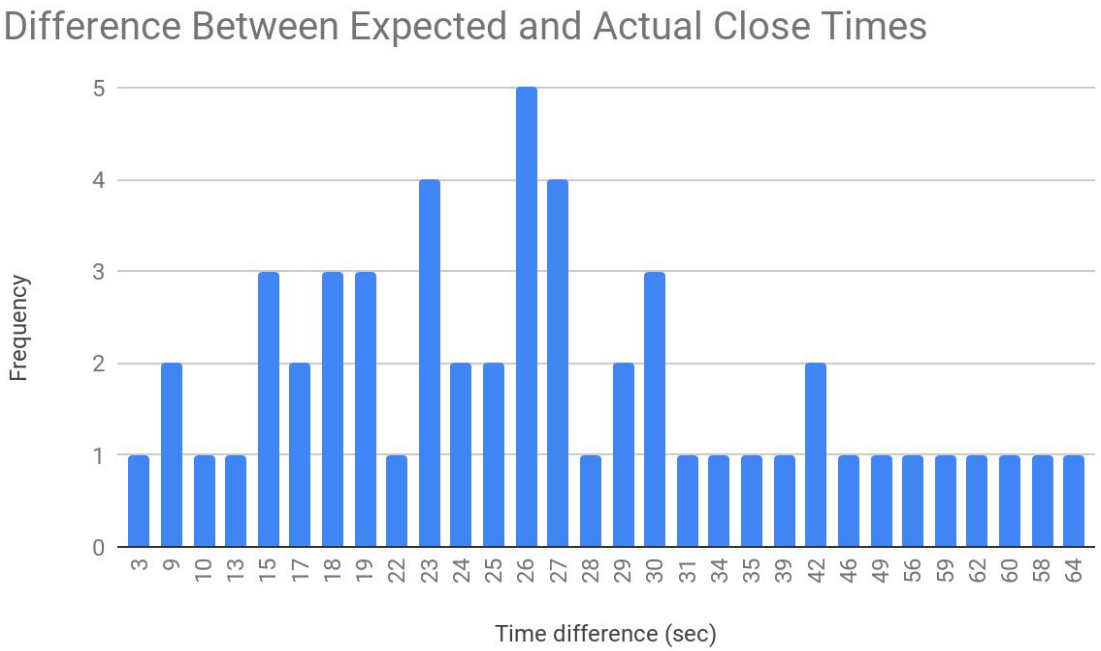
From the data collected, we have verified that our product always closes the garage door. Although it always closes, it does not always close at the specified time. Our test data shows that the garage closes within 30 seconds of the expected time 69% of the time. From the 55 data entries of test 1, there were only 3 entries that took more than one minute to close the garage door.

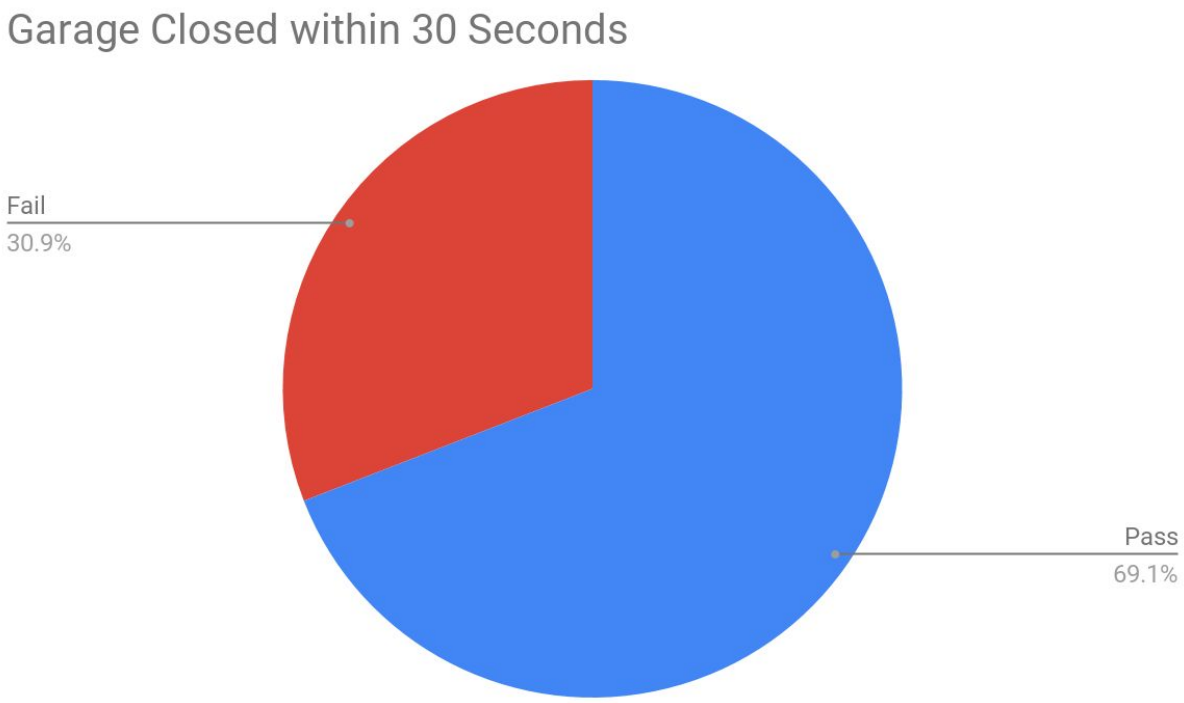
Test 1

Close After Specified Amount of Time

We first started testing with version 9 of our software. We discovered minor errors and adjusted the software respectively. After 6 tests of version 9, we created a version 10 and started recording in that version. The garage door always closed, but not always at the right time.

To determine if the test was a success, we checked if the garage closed within 30 seconds of the expected time. If it took longer to close, we deemed the test a fail. A little less than a third of our tests failed the 30 second tolerance. This is caused by the way the program records the time. We gave up some accuracy to ensure that the garage would always close. The garage most commonly closed within 26 seconds of the expected time.





Test 1 - Garage Closes After x min				
	Test A			
	Software Version: blink9.py			
Test #	Set Timeout (min)	Time Taken to Close (min)	Time Difference (sec)	Pass / Fail
1	5	3:58	62	Fail
2	5	5:09	9	Pass
3	5	0:30	270	Fail
4	5	6:00	60	Fail
5	5	5:58	58	Fail
6	5	6:04	64	Fail
	Test B			
	Software Version: blink10.py			
Test #	Set Timeout (min)	Time Taken to Close (min)	Time Difference (sec)	Pass / Fail
1	5	5:23	23	Pass

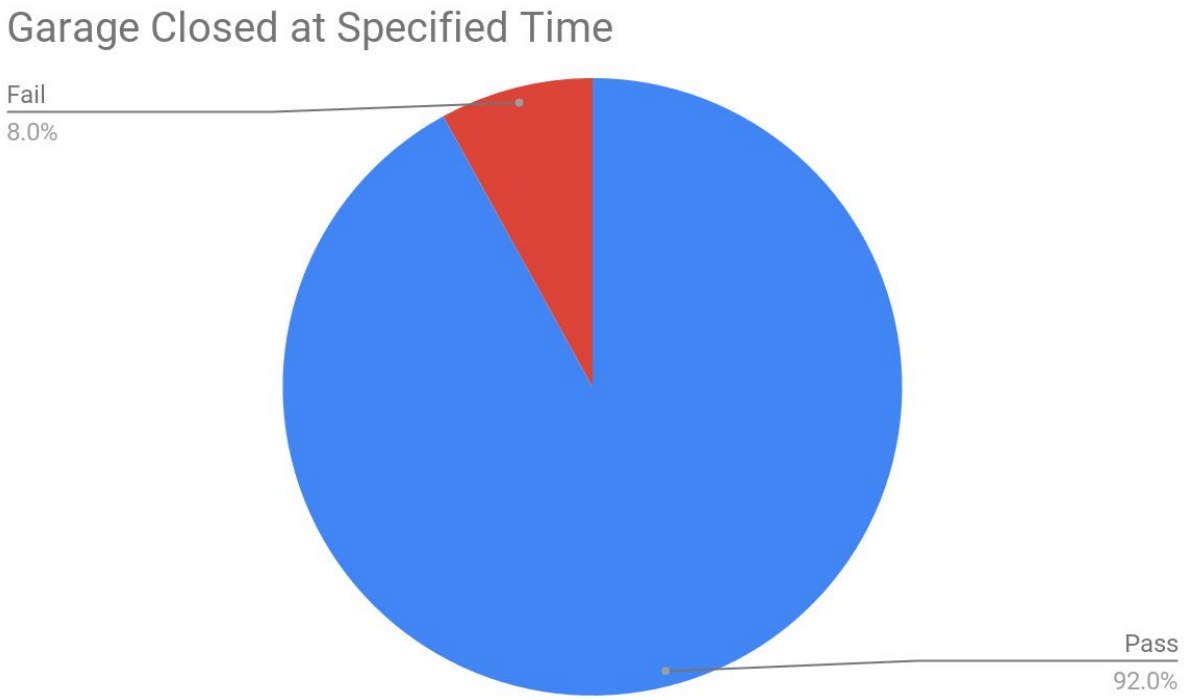
2	5	4:34	26	Pass
3	5	5:10	10	Pass
4	5	4:31	29	Pass
5	5	4:45	15	Pass
6	5	5:27	27	Pass
7	5	5:30	30	Fail
8	5	4:51	9	Pass
9	5	5:28	28	Pass
10	5	5:31	31	Fail
11	5	5:15	15	Pass
12	5	5:18	18	Pass
13	5	5:26	26	Pass
14	5	5:39	39	Fail
15	5	5:19	19	Pass
16	10	10:27	27	Pass
17	10	10:18	18	Pass
18	10	10:25	25	Pass
19	10	10:26	26	Pass
20	10	10:30	30	Fail
21	10	10:23	23	Pass
22	10	10:17	17	Pass
23	5	5:26	26	Pass
24	5	5:24	24	Pass
25	5	5:19	19	Pass
26	5	5:27	27	Pass
27	5	5:18	18	Pass
28	5	5:25	25	Pass
29	5	5:26	26	Pass
30	5	5:29	29	Pass
31	5	5:23	23	Pass
32	5	5:17	17	Pass
33	5	4:45	15	Pass
34	5	5:24	24	Pass

35	5	5:56	56	Fail
36	5	5:42	42	Fail
37	5	5:42	42	Fail
38	5	5:49	49	Fail
39	10	10:23	23	Pass
40	10	10:34	34	Fail
41	10	10:46	46	Fail
42	10	10:59	59	Fail
43	10	10:03	3	Pass
44	10	10:27	27	Pass
45	10	10:13	13	Pass
46	10	10:22	22	Pass
47	10	10:19	19	Pass
48	10	10:30	30	Pass
49	10	10:35	35	Fail

Test 2

Close at Specified Time

During this testing, we only encountered two trials of the 25 recorded that failed. Both trials closed exactly one minute after the expected time. Each test passed if the garage closed on the same minute as the specified time. To prevent the garage from overheating, we tested across multiple days mainly on 10 minute intervals. The garage closed on every trial, but did not consistently close on the specified times showing that the product is reliable but not as accurate as we hoped for. If we had more time, we could have improved the code to allow for more accurate time records. This would also risk using more processing power, which we did not have with our Raspberry Pi Zero.

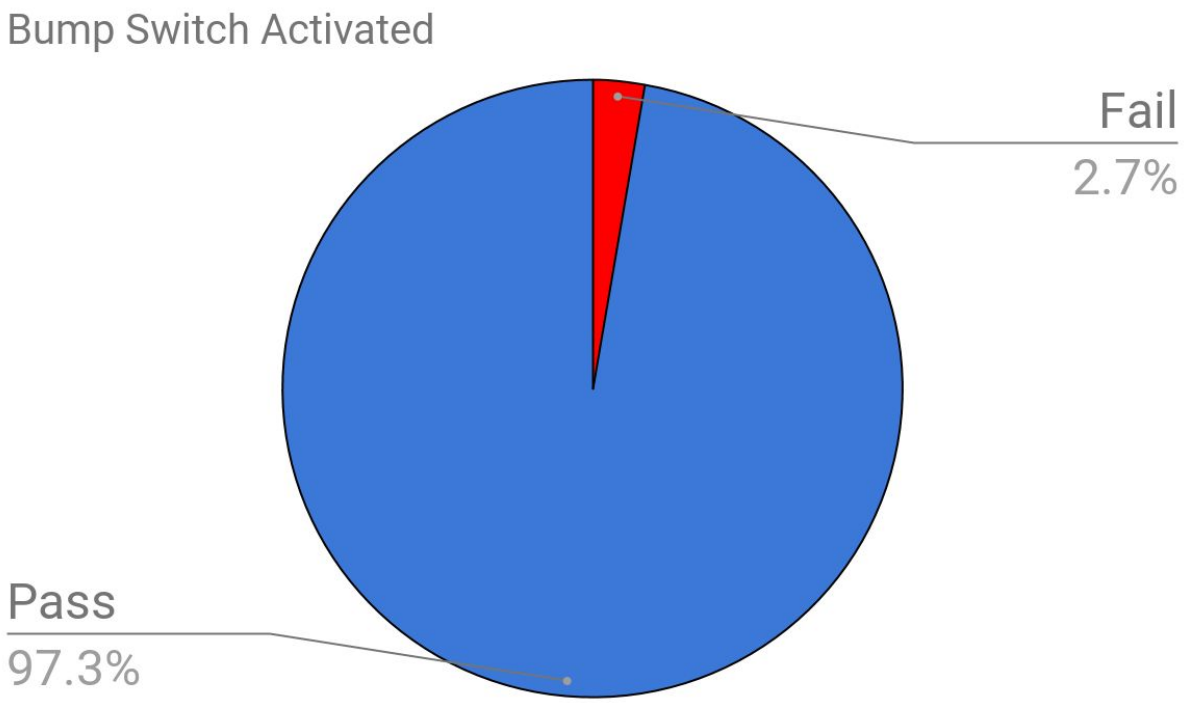


Test 2 - Garage Closes at Set Time			
	Software Version: blink10.py		
Test #	Set Time	Time Closed	Pass / Fail
1	2:30	2:30	Pass
2	2:50	2:50	Pass
3	2:55	2:55	Pass
4	3:00	3:00	Pass
5	3:05	3:05	Pass
6	3:15	3:15	Pass
7	3:25	3:25	Pass
8	3:35	3:35	Pass
9	3:45	3:45	Pass
10	3:55	3:55	Pass
11	2:20	2:20	Pass
12	2:30	2:30	Pass
13	2:40	2:40	Pass
14	2:50	2:51	Fail
15	3:00	3:00	Pass
16	3:10	3:10	Pass
17	3:20	3:20	Pass
18	3:30	3:30	Pass
19	3:40	3:40	Pass
20	3:50	3:50	Pass
21	4:00	4:00	Pass
22	4:10	4:11	Fail
23	4:15	4:15	Pass
24	4:20	4:20	Pass
25	4:30	4:30	Pass

Test 3

Bump Switch Activated

A little less than 3% of the 150 tests we recorded resulted in failure. All of the fails happened around the same time due to a minor error. After adjusting the switch, it read the state of the garage door properly for the rest of testing. If the bump switch is secured, it will accurately read the state of the garage door, but any error can lead to multiple misreads. Our product heavily depends on the bump switch relaying correct data. This can be made more reliable based on how the switch is mounted. The tricky part is that mounting would be different for every garage.



Test 3 - Bump Switch Activated									
Test #	Garage State	Expected Switch State	Recorded Switch State	Pass / Fail	Test #	Garage State	Expected Switch State	Recorded Switch State	Pass / Fail
1	open	0	0	Pass	76	closed	1	1	Pass
2	closed	1	0	Fail	77	open	0	0	Pass
3	closed	1	0	Fail	78	closed	1	1	Pass
4	closed	1	0	Fail	79	open	0	0	Pass
5	open	0	0	Pass	80	closed	1	1	Pass
6	closed	1	1	Pass	81	open	0	0	Pass
7	open	0	0	Pass	82	closed	1	1	Pass
8	closed	1	1	Pass	83	open	0	0	Pass
9	open	0	0	Pass	84	closed	1	1	Pass
10	closed	1	1	Pass	85	open	0	0	Pass
11	open	0	0	Pass	86	closed	1	1	Pass
12	closed	1	1	Pass	87	open	0	0	Pass
13	open	0	0	Pass	88	closed	1	1	Pass
14	closed	1	1	Pass	89	open	0	0	Pass
15	open	0	0	Pass	90	closed	1	1	Pass
16	closed	1	1	Pass	91	open	0	0	Pass
17	open	0	0	Pass	92	closed	1	1	Pass
18	closed	1	1	Pass	93	open	0	0	Pass
19	open	0	0	Pass	94	closed	1	1	Pass
20	closed	1	1	Pass	95	open	0	0	Pass
21	open	0	0	Pass	96	closed	1	1	Pass
22	closed	1	1	Pass	97	open	0	0	Pass
23	open	0	0	Pass	98	closed	1	1	Pass
24	closed	1	1	Pass	99	open	0	0	Pass
25	open	0	0	Pass	100	closed	1	1	Pass
26	closed	1	1	Pass	101	open	0	0	Pass
27	open	0	0	Pass	102	closed	1	1	Pass
28	closed	1	1	Pass	103	open	0	0	Pass
29	open	0	0	Pass	104	closed	1	1	Pass

30	closed	1	1	Pass	105	open	0	0	Pass
31	open	0	0	Pass	106	closed	1	1	Pass
32	closed	1	1	Pass	107	open	0	0	Pass
33	open	0	0	Pass	108	closed	1	1	Pass
34	closed	1	1	Pass	109	open	0	0	Pass
35	open	0	0	Pass	110	closed	1	1	Pass
36	closed	1	1	Pass	111	open	0	0	Pass
37	open	0	0	Pass	112	closed	1	1	Pass
38	closed	1	1	Pass	113	open	0	0	Pass
39	open	0	0	Pass	114	closed	1	1	Pass
40	closed	1	1	Pass	115	open	0	0	Pass
41	open	0	0	Pass	116	closed	1	1	Pass
42	closed	1	1	Pass	117	open	0	0	Pass
43	open	0	0	Pass	118	closed	1	1	Pass
44	closed	1	1	Pass	119	open	0	0	Pass
45	open	0	0	Pass	120	closed	1	1	Pass
46	closed	1	1	Pass	121	open	0	0	Pass
47	open	0	0	Pass	122	closed	1	1	Pass
48	closed	1	1	Pass	123	open	0	0	Pass
49	open	0	0	Pass	124	closed	1	1	Pass
50	closed	1	1	Pass	125	open	0	0	Pass
51	open	0	0	Pass	126	closed	1	1	Pass
52	closed	1	1	Pass	127	open	0	0	Pass
53	open	0	0	Pass	128	closed	1	1	Pass
54	closed	1	1	Pass	129	open	0	0	Pass
55	open	0	0	Pass	130	closed	1	1	Pass
56	closed	1	1	Pass	131	open	0	0	Pass
57	open	0	0	Pass	132	closed	1	1	Pass
58	closed	1	1	Pass	133	open	0	0	Pass
59	open	0	0	Pass	134	closed	1	1	Pass
60	closed	1	1	Pass	135	open	0	0	Pass
61	open	0	0	Pass	136	closed	1	1	Pass
62	closed	1	1	Pass	137	open	0	0	Pass

63	open	0	0	Pass	138	closed	1	1	Pass
64	closed	1	1	Pass	139	open	0	0	Pass
65	open	0	0	Pass	140	closed	1	1	Pass
66	closed	1	1	Pass	141	open	0	0	Pass
67	open	0	0	Pass	142	closed	1	1	Pass
68	closed	1	1	Pass	143	open	0	0	Pass
69	open	0	0	Pass	144	closed	1	1	Pass
70	closed	1	1	Pass	145	open	0	0	Pass
71	open	0	0	Pass	146	closed	1	1	Pass
72	closed	1	1	Pass	147	open	0	0	Pass
73	open	0	0	Pass	148	closed	1	1	Pass
74	closed	1	1	Pass	149	open	0	0	Pass
75	open	0	0	Pass	150	closed	1	1	Pass

Conclusion

To guarantee that our product works in the way it is designed to, we must test multiple times through an iterative process. The more testing done, the more accurate our statistics are. The test results are used to ensure that the product works with minimal error. If we had more time, we could increase accuracy of the garage door close time by changing the code. This would be a big change, and we did not have enough time to implement it.