ECE 445 Senior Design
Final Report FA 23

GROUND-BREAKING NEXT-GEN SMART PET DOOR

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Professor: Victoria Shao
TA: Abhisheka Mathur Sekar
Jeffrey Deng
Norbert Szczotka
Matthew Wei

Abstract

Our project introduces an integrated system which combines various electrical and mechanical components with practical pet care solutions. The solution includes a modified pet door which is designed to open and close based on information from our subsystems. Key features include PIR sensors with the capability to detect motion on both the front and back of the door, which trigger the camera to activate and display feed. With data being sent to our ESP-32 micro-controller, there is an exchange of information being sent to the user which allows pet owners to make a decision to open or close the door through an application by monitoring the location of the pet through the feed of the camera. The project was nearly successfully completed, and the following report will detail the functionality, subsystem integration, design processes, results, and areas of improvements in the future.

Contents

1. Problem

1.1. Team project overview

Have you ever had to leave work or school to let your dog outside? Have you ever needed to pay dog-sitters and give them access to your home? Introducing the ground-breaking Next-Gen Smart Pet Door, which is designed to convenience both pets and their owners when it comes to technology and pet care. This project specifically aims to create a pet door which opens and closes based on motion-detection through real-time camera monitoring viewed through our own smartphone app. Pet owners have full access in giving their loved ones the ability to roam freely remotely. The app includes full functionality of the door, which gives users the ability to open and close the door based on the display of the camera

1.2. Solution

As described in our problem statement, it will provide customers with a pet door that allows the users to open it remotely. At a high level, our design will revolve around modifying an existing door to fit our dog door 1. This dog door is controlled by the user through a phone app. Subsystems of this design include the app, the door, the sensors, the power system, and the camera. Motion detectors will be used to alert the customer when the pet is near the door and needs to enter. A camera will also be used to prevent unwanted visitors or other animals from entering. The door will close after some time has passed to prevent the door from being always open. This system will be on both sides of the door, so the pet can get in and out and not be trapped outside.

1.3. High-level Requirements

The most recent specifications of our project have been chosen to meet the following requirements:

- Sensors should be able to detect motion on both sides of the wall. Camera will remain on for said duration as long as the pet is detected within the scope of the sensor's field. Camera also must be able to connect to Wi-Fi and stream proper video to be displayed on the application.
- The user app must be able to communicate with the motors sending and receiving signals between the 2 systems within 2 seconds. The user will be able to make the decision to open or close the door via the application by monitoring the camera feed that displays the location of their pet.
- The door should be able to open and close within 5 seconds in order to prevent the pet from waiting too long to enter or other unwanted guests to come into the house after opening. This door design should be sturdy enough to handle any pets that hit or bump the door while waiting for the door to open or while passing through

2. Design

2.1. Block Diagram

The block diagram 2 contains all of our following subsystems: mechanical, power, camera, sensor, and application. All of these are grouped around the micro-controller with the integrated WiFi module on the PCB acting as the central control for the entire project. The ESP32-WROOM is responsible for transmitting signals among subsystems based on logic in the code that we programmed onto the chip. All data connections are represented by the legend on the top right corner. Since our project contains both digital wired and wireless signals, they are distinguished by solid black or dotted black lines. Furthermore, the diagram also has different colored arrows to represent different voltages flowing through the system to power components such as a 12V DC or 5V DC signal. The legend also includes an arrow for a physical operation to indicate the motion of the motors and latch working synchronously to open the door.

2.2. Subsystem Overview

2.2.1. Mechanical

The mechanical subsystem consisted of the door, solenoid latch, and DC motor 4. The door frame also had an additional box attached to it to house and protect our PCB, cameras, and sensors 3. The latch is active low, and only unlocks when we provide 12v to it, ensuring the door remains closed when we do not want anything or anyone to enter. The opening mechanism is a swinging door powered by our DC motor. Forward and backward signals to the H bridge on the PCB control the direction the DC motor spins and whether the door opens or closes.

Design Decisions and Alternatives

Originally, we had planned to use a rolling design similar to a garage door, where it rolls up to open. However, after talks with the machine shop, they recommended we go with a swinging door for ease of build and overall sturdiness of the design.

2.2.2. Camera

The camera will be activated from the micro-controller to send a live feed to a web server that our application will access to display front and back views of the door. Our door consists of two cameras: one will be positioned facing the inside while the other will be positioned facing the outside. We will be using the ESP32 Cam system to transmit feed to the app through a Wi-Fi connection module. The code used mostly revolved around the base code given by an Arduino example project. Modifications were made to change the web-page user interface to get rid of unnecessary or unused features such as color inversion and facial recognition. In addition, we had to change the code to accommodate the type of camera used in order to correctly connect to the IllinoisNet-Guest Wi-Fi network.

Design Decisions and Alternatives

We chose to use the ESP32 Cam due to its ease of use and ability to integrate with the rest of our system easily. It uses 5V power which some of our other systems use so we did not need to use another power converter from 12V to whatever voltage the new camera system might require. Another camera lens we could have used instead of the OV2640 on the ESP32 Cam was the OV7670 however it would offer lower frames per second and lower image resolution. In addition the ESP32 can only be used to send one video feed at a time so we needed to use the two ESP32 Cam boards on top of our main ESP32 micro-controller.

2.2.3. Power

Our power supply system will include a Chanzon 12V 1A 12W Power Supply Charger AC DC Switching Adapter (Input 100-240V, Output 12 Volt 1 Amp) Wall Wart Transformer specifically for its stability for power and accessibility to be connected to a wall outlet. This 12V output will be directly powered to our H-Bridge motor driver that is then sent to the DC motor in our mechanical subsystem. The electrical-powered latch is also directly supplied by this 12V.

To meet the demands of other subsystems, we will also need to incorporate voltage regulation techniques to control and stabilize the input voltage based on load conditions. Our design will use step-down voltage regulators in the form of integrated circuit chips for our micro-controller to minimize power flowing through to avoid damage. Our initial design consisted of two different IC chips: one that steps down 12V to 3.3V to connect to our micro-controller and another that converts 12V to 5V to connect to our camera and sensors. These ICs will utilize decoupling circuits with capacitors for stable circuit operation based on the recommendations of the manufacturers. The wall wart will connect to these voltage regulators via a 12V DC Power Connector 5.5mm x 2.1mm, CENTROPOWER Power Jack Adapter to make the output of the wall wart, which is a barrel connector into a jumper cable, which is then able to be soldered onto the PCB, which will have the ICs already integrated on it.

Design Decisions and Alternatives

We have made some design decisions and alternatives to modify our power design when issues arose. The decision to use a wall wart transformer instead of a battery was made in order to ensure consistent and stable voltage output for proper functioning of our subsystems as well as eliminating the need for battery management. It was much easier to avoid charging, discharging, and monitoring.

Furthermore, we ran into difficulties when integrating the power system with our other subsystems. When soldering the voltage regulators on our PCB, we damaged the internals of the 5V buck converter making it unusable. We were forced to work around this problem by introducing an external power supply from the lab bench as a 5V input for our cameras and sensors. Our micro-controller also ran into issues since we were not able to properly program it, therefore, we used a development board version and powered it directly via USB. If given more time and proper practice, we would have been able to reorder the voltage regulators and re-solder our PCB to ensure functionality.

2.2.4. Sensor

This subsystem consists of two AM312 Pyroelectric PIR Sensors [1] which are used for detection when a pet is near the door. With a working voltage of DC 2.7-12V, we chose to use 5V to integrate this most efficiently with our power subsystem. The PIR sensor works based on passive body infrared technology with high sensitivity and reliability. With a sensing range consisting of a less than or equal to 100 degree cone angle and 3-5 meter distance, we chose this sensor specifically for its low power consumption and its small size. In the situation of the PIR sensor detecting the pet, it would be powered on, outputting 2.99V, while sending a signal to the micro-controller that it is activated.

Design Decisions and Alternatives

Our initial design had an additional PIR sensor positioned inside the door pointing down the frame to ensure the safety of the animal. This was in place to prevent the door from closing while a pet is still inside. Unfortunately we had to remove this third PIR sensor in order to workaround a power issue which is explained further in section 5.3. An alternative to a PIR sensor would be an ultrasonic distance sensor. Instead of detecting heat, an ultrasonic sensor constantly transmits sound waves and receives the reflected waves if it detects an object in its sensing range. If the received wave is different from the transmitted wave, then it would signal that a pet has been detected.

2.2.5. User Application

The user application is a simple Python application coded with Tkinter that functions as a controller for the motor and a way to simply access the camera feeds. The application contains three buttons, two for the front and back camera and one for opening and closing the door. The application displays the live camera feed by accessing the server that the camera feed is being streamed on. The two buttons for the cameras will open up the server in the browser to their respective camera and show the current live feed. The button to open or close the door will send a HTTP protocol GET request to the micro-controller server and the micro-controller will handle that GET request to open the door.

Design Decisions and Alternatives

Our initial design intention with the application was to have it as a mobile application with the camera feed on constant display without the need to press a button. However, all of the team members use Iphones and none of us had a MacBook to use the right software for mobile application. This resulted in switching the mobile application to a general application that works on Windows. Also, the application was intended to be coded using Qt in C++. However, the code was not able to compile correctly on our laptops due to some errors with the compiler (as well as running out of laptop storage). This resulted us into using Python instead as it was simpler and could still do our basic functions. The camera feed being on display without a button press also had to be adjusted because the way the camera subsystem streamed to its server made it difficult to directly access only the video for the Tkinter application. Multiple methods were tried to no avail. As a result, we changed it to separate buttons to access the camera feeds.

2.2.6. Micro-controller

The micro-controller subsystem contains solely the micro-controller itself. It acts as the brain of the entire system by managing and controlling the signals to and from all the other subsystems. After referencing the online data-sheets [2] we realized that the ESP32 S3 WROOM was the best fit for us. It was chosen for its built-in WiFi modules and compatibility. The micro-controller utilizes three inputs and four outputs. The three inputs come from the sensor subsystem, two of which are for motion detection for the camera. The two sensor inputs are handled by the micro-controller to set their corresponding output high. The high output will turn the camera subsystem on and allow for live streaming to the server. The micro-controller also has its own asynchronous web server looking for requests. It contains code to handle a GET request if one is made. This is how the micro-controller recognizes a button press from the user application and code is present to handle this request to allow the door to open and close. The door should take 1.5-2.5s to open and the door should take 2.5-3.5s to close. The third sensor not talked about above is for when motion is detected while the door is closing to stop it from closing all the way. This is for safety reasons to not have the pet get crushed or caught between the doors.

Design Decisions and Alternatives

The micro-controller for the most part maintained its original design . The code for the sensors checks if they are high and if they are, they start a counter or timer for how long its respective camera output should be high. Once this timer is done, it sets the output back to low. The micro-controller receives its wireless signals from the user application using HTTP GET requests and has code to check whether a GET request has been made to the asynchronous server or not. This will then set the motor to either open or close the door depending on the current door state. One change we had to adjust here is to have the time to close the door longer than the time to open the door. Although the code has it set to open in 2s, the door ends up opening and closing with inconsistent times. This is due to us not using an oscillator for the timer and can result in different times to open and close the door depending on which millisecond the button is pressed. This leads to having the door not closed all the way, which is bad. Another change we had to make near the end is removing the third sensor that stops the door from closing. This is due to us burning out our power converter for 5V and in order to get the system to still perform its basic functions, we had to remove the third sensor so an external power supply of 5 V could be supplied to the system.

2.2.7. PCB Design

PCB design mostly revolves around integrating the different subsystems as efficiently as possible. To do this we referenced online guides [3] on how to best combine all our components together. Once the general layout was created, we needed to reference the different data sheets to see what additional components were needed in order to make the subsystems work. For the two power converters, we needed decoupling capacitors and a feedback inductor. To create these sub-circuits we referenced the data sheets provided by the manufacturers for the 3.3V [4] and 5V [5] converters. The micro-controller needed programming switches and a UART serial to TTL converter. The DC motor needed an H-bridge [6] for directional control and finally, the cameras needed MOSFETs for power control. The final iteration of the PCB is shown in the appendix 9 8.

Design Decisions and Alternatives

The micro-controller for the most part maintained its original design . The code for the sensors checks if they are high and if they are, they start a counter or timer for how long its respective camera output should be high. Once this timer is done, it sets the output back to low. The micro-controller receives its wireless signals from the user application using HTTP GET requests and has code to check whether a GET request has been made to the asynchronous server or not. This will then set the motor to either open or close the door depending on the current door state. One change we had to adjust here is to have the time to close the door longer than the time to open the door. Although the code has it set to open in 2s, the door ends up opening and closing with inconsistent times. This is due to us not using an oscillator for the timer and can result in different times to open and close the door depending on which millisecond the button is pressed. This leads to having the door not closed all the way, which is bad. Another change we had to make near the end is removing the third sensor that stops the door from closing. This is due to us burning out our power converter for 5V and in order to get the system to still perform its basic functions, we had to remove the third sensor so an external power supply of 5 V could be supplied to the system.

3. Design Verification

This subsection describes the requirement and verification process taken in order to ensure functionality of our project. Breaking down the project in a modular design, we will look at each subsystem systematically. Before we began the soldering process, we conducted unit tests on each subsystem individually on a breadboard. Detailed breakdowns of each requirement and verification table can be found in the appendix.

3.1. Camera

The verification 3 of the camera subsystem was simple, although it did take the longest. First, we tested if the camera worked by itself. This was done just by setting the camera with its code, powering it on directly, and connecting it to WiFi. The MOSFET part of the camera subsystem took the longest. We hooked up the system to how we intended the design to be and triggered a voltage high enough to turn on the MOSFET to see if the camera would turn on properly. This is where we realized the issues related to the camera not turning on fast enough and our initial MOSFET design to not work properly. Adjustments had to be made using online examples of working MOSFET systems and timer delays had to be increased to account for the camera getting turned on and initialized slowly.

3.2. Mechanical

The mechanical portion of the project was tested by verifying the opening and closing time of the door. In our high-level requirements we defined the door to open and close within a 5 second time window. In the testing process, we saw variability in the time it takes for the door to open. When in the opening process, the door was not guaranteed to open at full extension. This was due to logic in our code as well as the timing of the clock in the micro-controller as explained in section 2.3.6. Essentially, this is due to us not using an oscillator for the timer and can result in different times to open the door. However our code ensures that the door will always fully close. As shown in the table 4, the average time for the door to open is approximately 2.08 sec. As we can see, the door is not guaranteed to fully open to the same point each time the owner executes the command to open.

3.3. Power

This was the easiest subsystem 5 to verify. Once we hooked up the respective components to a power source we tested the output with a voltmeter to see if the components were outputting the desired voltage.

3.4. Sensor

In order to verify that our sensor subsystem worked correctly, we tested each sensor on its own to gain a better understanding of its behaviors. Each PIR sensor had three different connections: VCC, Data (GPIO PIN), and GND. At first, we applied a +5V connection. Using a voltmeter, we then tested the Data pin while waving our hand in front of the sensor to activate it. The voltage reads within the range of +2.99-3.1V while motion detected and 0V when no motion is detected. Although the voltage is consistent when high or low, we noticed variability in the time it takes for the sensor to activate. To face this issue, we experimented with the ESP32 development board that signals to an LED to turn on once the sensor detects motion and is high. Using a stopwatch, we conducted trials to determine the time it takes for the sensor to activate and turn on the LED. From the table 6, we can see that the average time for the PIR sensor activation is approximately 3.9 seconds.

3.5. User Application

The user application 7 was simple to test. Besides to see if the program compiled, there were only two tests needed to determine full functionality. One was to see if the button presses of the camera buttons opened the camera feed in a web browser and the other was to see if the micro-controller web server properly obtained the GET request. This was done by adding code to print statements in the terminal after GET requests were correctly sent.

3.6. Micro-controller

Although our micro-controller on our final PCB was not able to be programmed, we were able to get the project working on our DEV board. The testing done on the micro-controller was done using power supplies to force input pins high and voltmeters to test output pin values. Since the application was not developed by the time we were testing the micro-controller code with the door, test code was added to simulate the button press of the application with a physical button to test its logic. All of the code was able to work without error, so not much debugging and verification was required for the micro-controller

4. Costs

The total cost for parts including shipping and sales tax is $ 106.20. We will assume it took us 13 hours per week for 10 weeks. We can expect a salary of $50/hr (approximately the average salary of an electrical engineer in the US) x 2.5 (overhead factor) x 130 hours worked = $16,250 per team member. The total labor cost should account for all 3 members, therefore, $16,250 x 3 = $48,750. Now to account for the labor done by the team in the machine shop, we expect $22/hr for a total of 40 hours spent producing the mechanical design, thus, $22 x 40 = $880. This comes out to be a total cost of $49,736.2. A more detailed breakdown of total costs can be found in the appendix 8

5. Conclusion

5.1. Accomplishments

In the end result of our project, we ended up satisfying all of the defined high-level requirements.

Within the sensor subsystem, the PIR sensors were able to successfully detect motion on both sides of the door. This was confirmed by measuring voltage outputs when motion is present. Furthermore, this was integrated successfully with our camera subsystem, as the camera will remain on if the pet is detected by the sensor. We were able to seamlessly connect the camera to the Wi-Fi and stream proper feed to be shown on the user app on both the front and the back cameras.

Furthermore, the user app is able to quickly and efficiently send signals to the motors without delay. The user is able to open and close the door through the application and the system is able to successfully take action with the pre-defined two second time frame. Following this, after the user sends the command, the door is able to open and close within 5 seconds. This ensures that the pet will not have to wait too long to be let in or out. The overall physical design of the door is also sturdy enough that it will not fall or tip during operation.

Our development board micro-controller had all proper controls ensuring full functionality. From receiving and sending signals correctly to subsystems, it was able to correctly open the latch as well as open or close the door wirelessly.

5.2. Uncertainties

Throughout the course of the project, we ran into various issues that were presented. We diligently worked to fix these problems and find solutions.

A major uncertainty was the uploading of our code to the surface mount ESP-32 micro-controller on the PCB. We implemented several methods, such as using ENABLE and RESET buttons soldered onto the board to boot and program code. We attempted using a USB 2.0 to TTL Module Serial Converter Adapter Module USB to TTL Downloader as a UART connection to the RX/TX pins, however, communication failed. We were never able to directly program our Arduino code to the micro-controller. As a workaround, we left the original soldered surface mounted ESP-32 on the PCB and executed an unconventional soldering procedure where we connected jumper cables from the pins of the ESP-32 to the development board ESP-32. In order to ensure proper connections, we ran continuity checks to make sure that the soldering was done correctly. From here we used a USB to power the DEV board and run the code of our system.

Another major uncertainty was a result of damaging the internals of our 5V regulator. As we powered our system and began testing voltages, we shorted the buck converter and it resulted in smoke being emitted from the IC. Afterwards, the regulator no longer functioned properly and only output 12V. In order to work around this problem, we did not connect our third PIR sensor that was intended to be directed inside the door, and rather used this vacant 3-pin connector on the PCB as power for our cameras. We used the power supply in the lab to produce 5V and soldered this to the connector for our PIR sensor then routed it to supply power to the cameras. This method was particularly useful since we did not have to introduce a breadboard and still maintain functionality on the PCB.

5.3. Ethical Considerations

When considering ethics and safety, the safety of the pet is the number one concern as its intended design is to assist animals from entering and leaving an area. The main concerns that arose were animal injuries and interactions with the door, exposure of the electronics to outside factors, and potential leakage in power. The design will be enclosed to prevent the electronics from being exposed to outside factors like water and power will be monitored during the design process to make sure everything is within its required range. The animal's injuries and interactions with the door will also be handled during the design phase. This will be done by choosing a specific door which will be strong enough to avoid damage from the animal and the motor rate will be weak and slow enough to prevent injuries to the animal. Also, there will be an additional sensor by the door to prevent the door from shutting all the way in case the pet is in the door area when the door is closing. This will prevent the pet from being squished within the door. The inclusion of the camera in our design also will prevent wild animals or unwanted guests from entering as it will allow the owner to see what is at the door.

According to the IEEE Code of Ethics I [7], the design needs to have high standards and value human ethics and behavior. As addressed in the paragraph above, the issues regarding safety, health, and welfare have been resolved and considered. Concerning privacy and conflicts of interest, we will honestly disclose any information and usage of data to affected parties. Unprofessional activities will also be avoided to maintain the moral code of the team. Criticism of the design will also be acknowledged and considered as we believe no design is perfect and improvements can always be made. Essentially, the team will always be willing to learn and take in advice.

According to the IEEE Code of Ethics II and III, all persons in the team and outside the team will be treated equally and without discrimination. No harassment shall be allowed and this will be upheld by the team members being accountable with each other. To avoid injuries, all members of the team have taken the Lab Safety Training and know how to be responsible in the lab. Additionally, two people will be in the room at the same time to watch each other incase of an emergency. Finally, we will ensure each of the team members will keep each other in check with the ethics. We shall strive to ensure the code is upheld and report to higher-ups when not in compliance.

5.4. Future Work

While this project has achieved our desired results and has satisfied all of our initial high-level requirements, there are various areas of improvement and further development. If given more time and resources, we can further innovate the design of the pet door.

The first area would be to send a notification to the user by implementing a real-time notification system that will send an alert to the user with immediate updates on the status and location of the pet. Integrating a push notification would keep users more engaged and provide peace of mind. This was particularly difficult since the code of our micro-controller was entirely focused on outputting signals to our subsystems rather than receiving signals. This would have required different logic and we unfortunately did not have enough time to explore this.

Another improvement we could make would be within our camera subsystem. To make it more efficient and functional, it would be ideal to have a camera with a faster turn-on speed as well as a better resolution. If the camera would turn on faster, it would result in better responsiveness and clarity of the system. Additionally, a higher resolution camera would improve the quality of the video feed, leading to improved security and an enhanced experience for the user of the app.

Finally, we would like to devote further time to fixing issues mentioned above in the section 5.2 Uncertainties. Any problems that required workarounds could have been fixed with proper consideration and more careful planning. Conducting through testing and refining the system will ensure a proper and reliable user experience in the system.

References

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A. Appendix A

Table 1: PIR Activation Times

Test Number	Time for PIR Sensor Activation (s)
1	3.2
2	5.6
3	2.4
4	3.5
5	4.8

Table 2: Door Opening Times

Test Number	Time for Door to Open (s)
1	2.1
2	2.3
3	1.3
4	1.9
5	2.0
6	1.8
7	2.5
8	2.2
9	2.1
10	2.6

Table 3: Camera Verification Table

Requirements	**Verification**	**Verification status (Y or N)**
Camera is on when sensor detects heat	Trigger sensor and verify camera is on to send video feed	Y
Camera feed correctly sends video wirelessly	See if video is obtainable on the software side	Y

Table 4: Mechanical Verification Table

Requirements	**Verification**	**Verification status (Y or N)**
Motors correctly can spin both directions	See if the door opens and closes properly by sending a signal to the quad encoder. High signal to A input should rotate clockwise, and high signal to B input should rotate counter-clockwise.	Y
Latch functions properly	Push on the door to try to force the door open while the latch is engaged. If it remains closed, then we confirm functionality.	Y
Motors correctly receive a signal from the Wireless module to spin both directions	Test on the app with opening and closing and seeing if it reflects on the motor's action	Y

Table 5: Power Verification Table

Requirement	**Verification**	**Verification status (Y or N)**
The power system must be able to supply 3.3V to the micro-controller and 5V to the camera/PIR sensor and 12V to the motor.	Utilize a voltmeter with the triple output DC power supply to confirm voltage after conversion to make sure it meets the requirements of the micro-controller, camera, and PIR sensor.	Y

Table 6: Sensor Verification Table

Requirement	**Verification**	**Verification status (Y or N)**
The sensor subsystem will need to successfully detect a heat source and output a signal to the micro-controller to process.	To test this system, group members will walk back and forth in front of the sensor to attempt to trigger the detection system; if functioning properly, we will be able to record a signal from the voltmeter.	Y

Table 7: Application Verification Table

Requirements	**Verification**	**Verification status (Y or N)**
App has all required buttons and overlays available	Make sure there is a way to look at the video feed from the camera and make sure the open and close button is available. Done through visual verification and testing if open and close button work properly on the software side as well as looking to see if video feed can be properly viewed	Y
App compiles properly and logic works	Make sure the app is complete with working logic. Can be done with test cases and seeing if specific input and outputs match with each other	Y
App correctly receives a signal from the camera	Check for correct live video feed from the camera. This can be tested by seeing if the video can be shown on the app	Y
App correctly receives a signal from the micro-controller	Check for a signal received originating from the sensor to trigger the camera on. This can be tested on the software side by adding test cases to see if anything is picked up	Y
App correctly sends a signal to the micro-controller	Check if a signal from the hardware side is received. This can be tested with an oscilloscope to see if the signal is sent properly	Y

Table 8: Parts and Labor Cost

Quantity	**Part**	**Part Number**	**Manufacturer**	**Total Cost ($)**
1	DC gear motor	N/A	BBQ Driver	14.88
1	Solenoid lock	A19042500ux0016	uxcell	15.49
3	PIR sensor	AM312	HiLetgo	8.69
1	Microcontroller	ESP-WROOM-32	Aokin	8.99
2	Camera	ESP32-CAM	HiLetgo	18.49
1	3.3 V Converter	AP63203WU-7	Diodes Incorporated	0.87
1	USB 2.0 to TTL Module Serial Converter Adapter Module USB to TTL Downloader	CP2102	HiLetgo	7.39
1	H-Bridge Motor Driver for DC Motors	110300681	ECE Supply Store	1.85
1	Wall Power Supply	N/A	Chanzon	9.99
1	Female Header	N/A	Centropower	7.99
3	MOSFET N-CH	DMG3402LQ-7	Diodes Incorporated	1.32
1	4.7μH Inductor	LQM21DN4R7N00D	Murata Electronics	0.25
N/A	Miscellaneous Circuit Elements	Resistors, Capacitor, Inductors	N/A	10
N/A	Parts total	N/A	N/A	106.20
3	Labor (group)	N/A	N/A	48,750
1	Labor (machine shop)	N/A	N/A	880
N/A	Labor Total	N/A	N/A	49,630
N/A	**Grand Total**	N/A	N/A	**49,736.2**

B. Appendix B

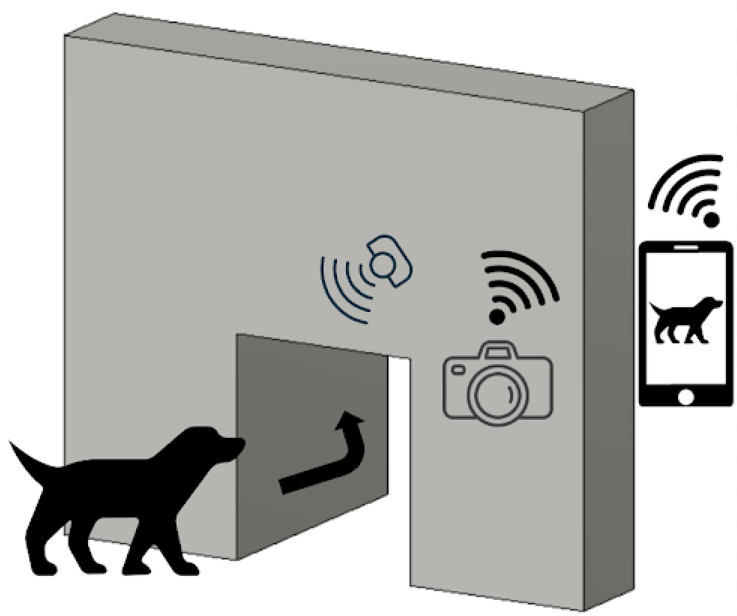

Figure 1: Visual Aid

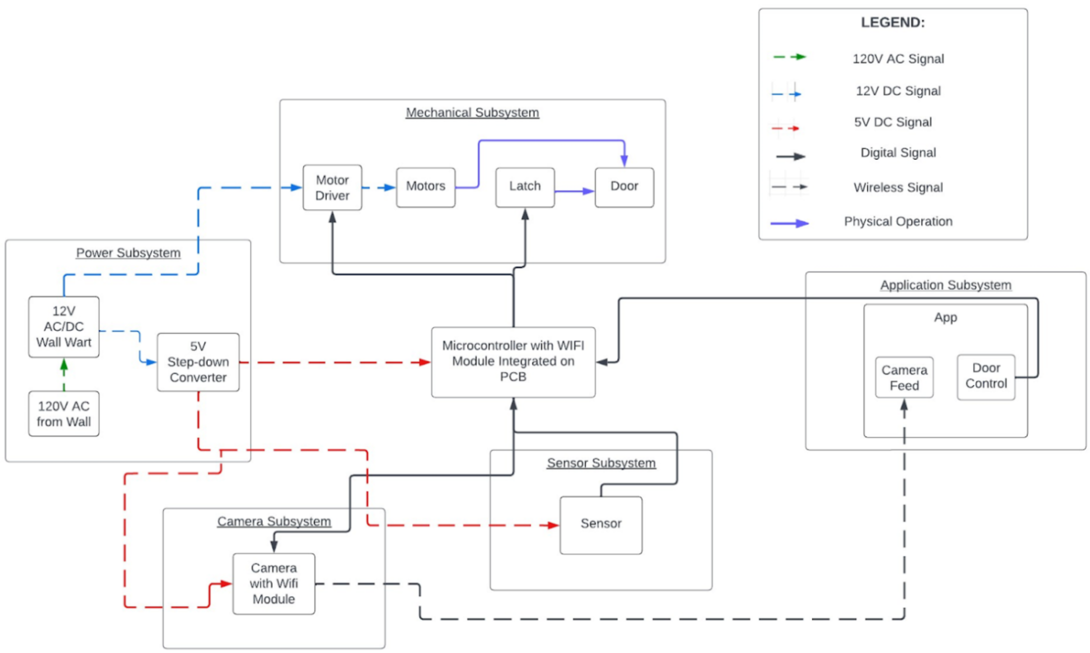

Figure 2: Block Diagram

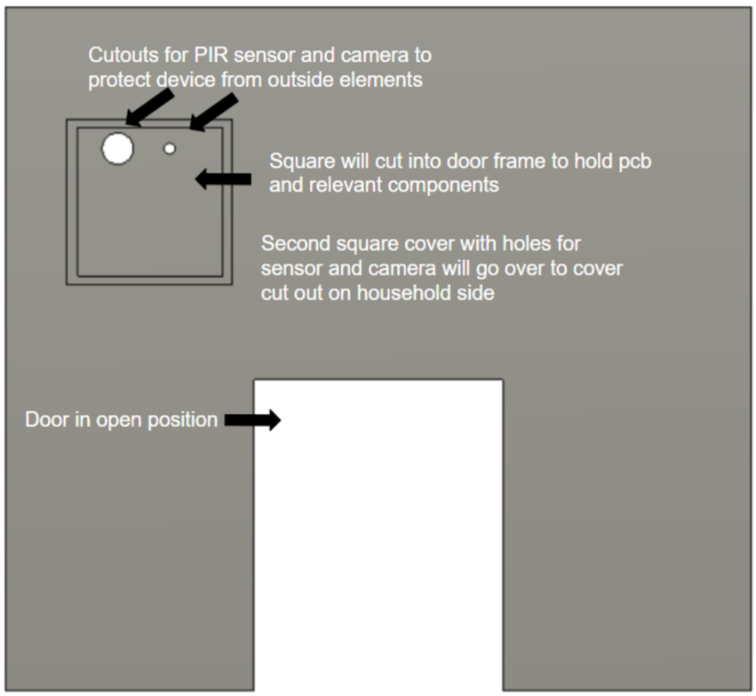

Figure 3: Physical Door Design: Front

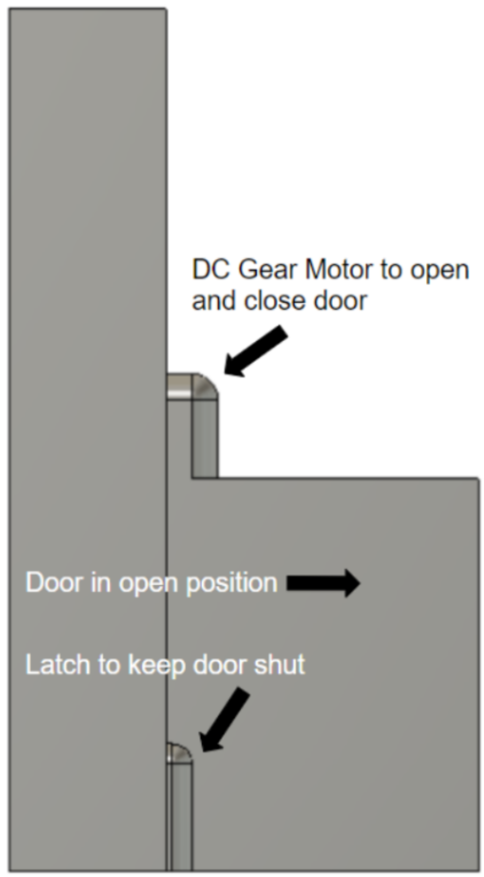

Figure 4: Physical Door Design: Side

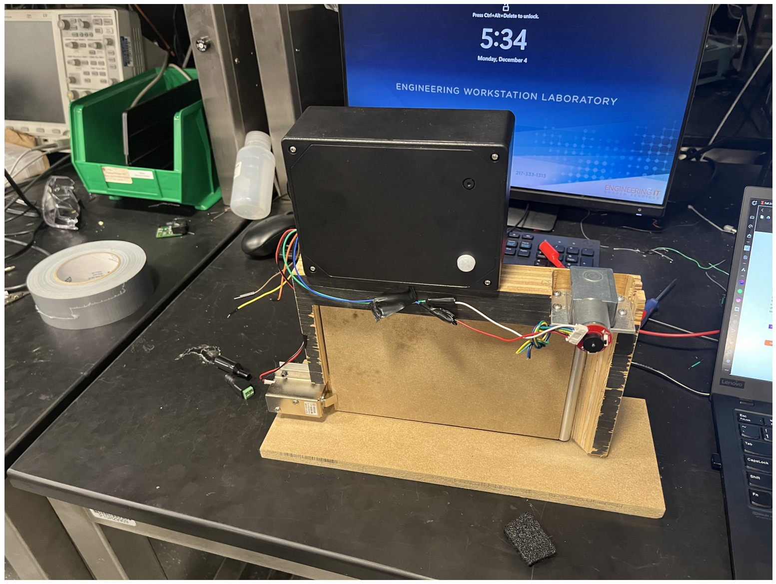

Figure 5: Front View of Door

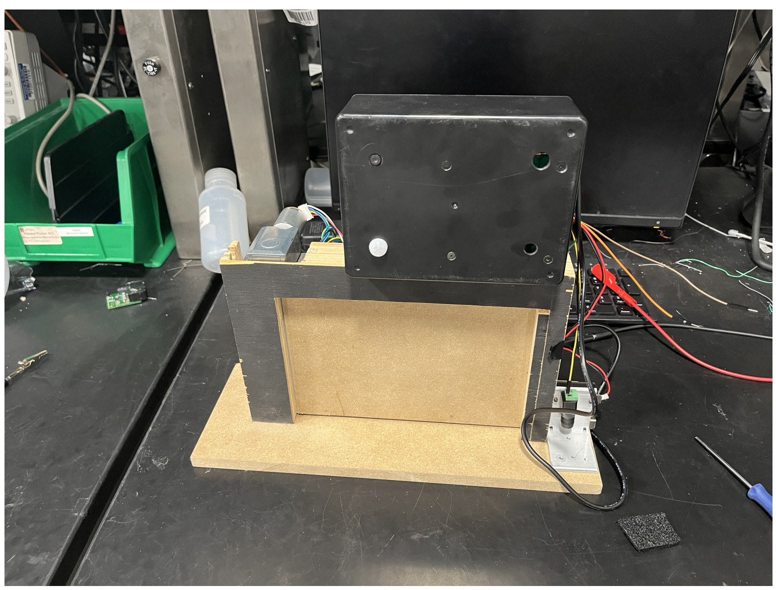

Figure 6: Back View of Door

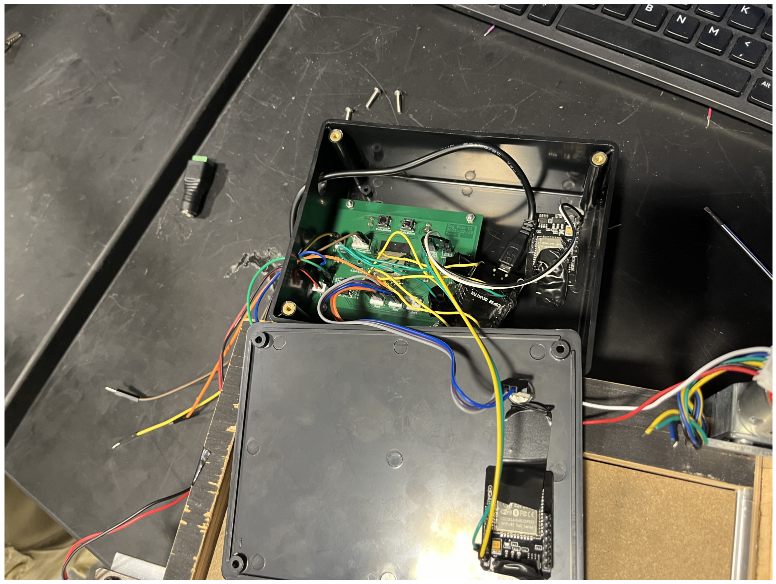

Figure 7: Door Internals

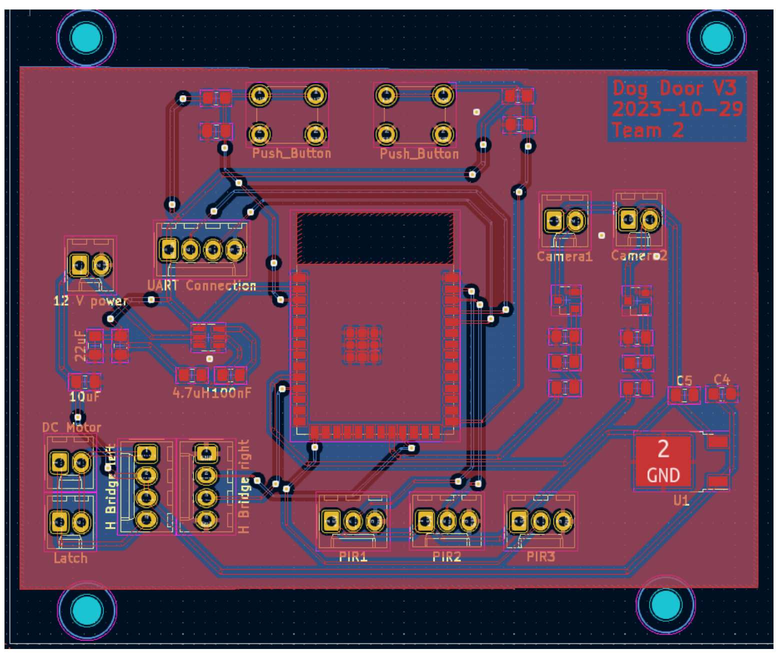

Figure 8: Final PCB Design

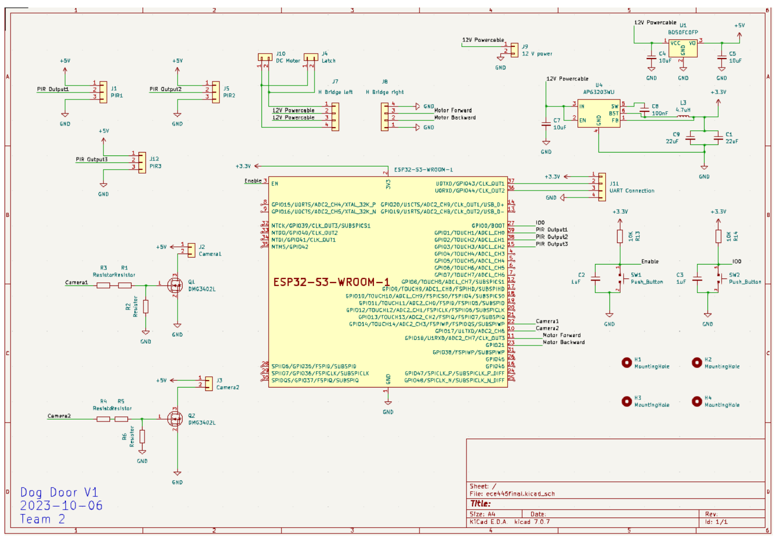

Figure 9: Final PCB Schematic