ECE 445

Fall 2023

Senior Project Design Document

Ground-Breaking Next-Gen Smart Pet Door

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September 28, 2023
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1. Introduction

<u>1.1 Problem and Solution</u>

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.

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. 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.

1.2 Visual Aid

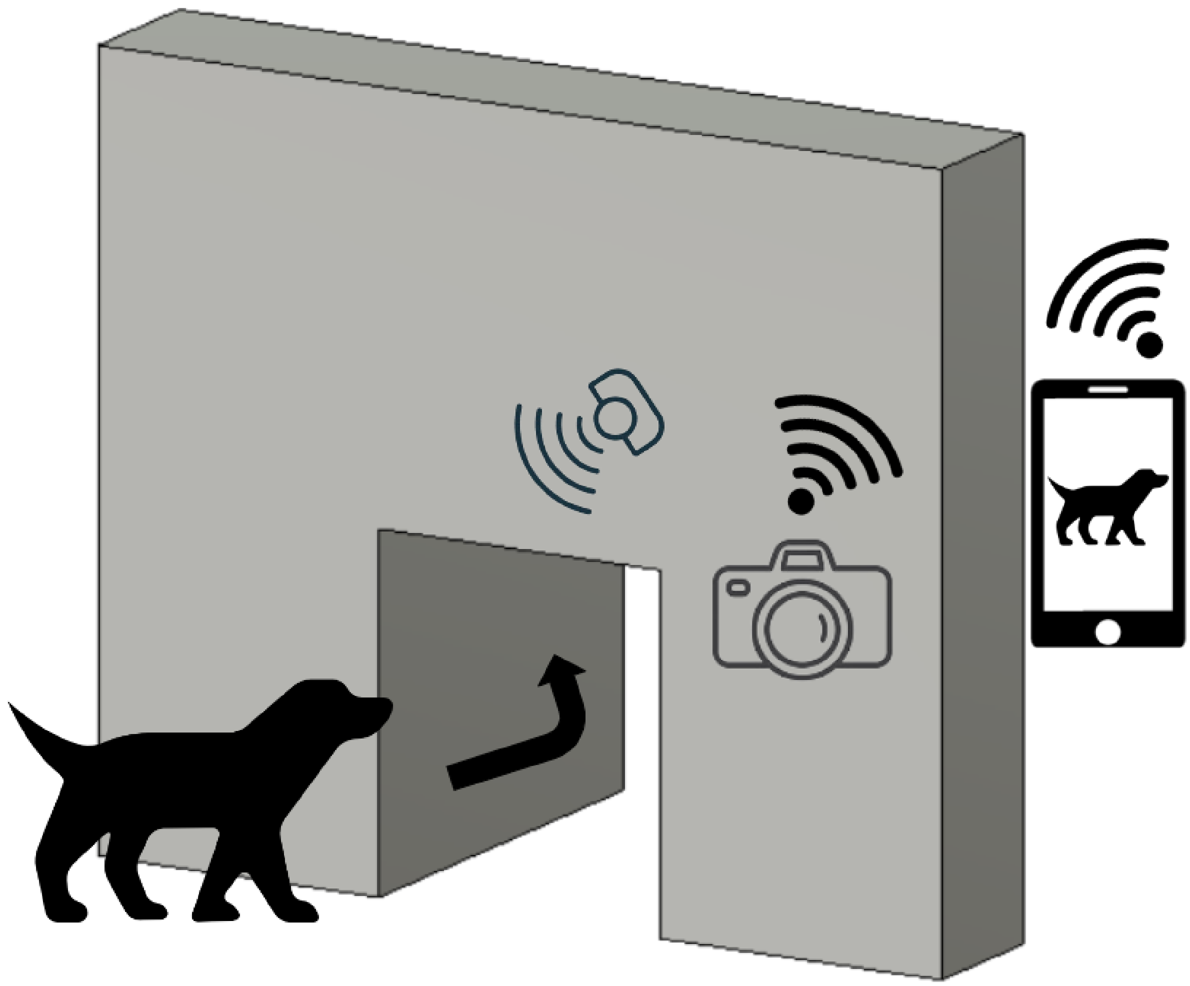

Figure 1: Visual View of Project

1.3 High-level requirements list

1. Sensors are able to detect motion on both sides of the wall and are able to power on the camera within 5 seconds. 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 wifi and stream proper video to be extracted for the app's use.

2. 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.

3. 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. The door also has a failsafe in case a pet takes too long to pass through the door and the door tries to close while the pet is inside the frame.

2. Design

2.1 Block Diagram

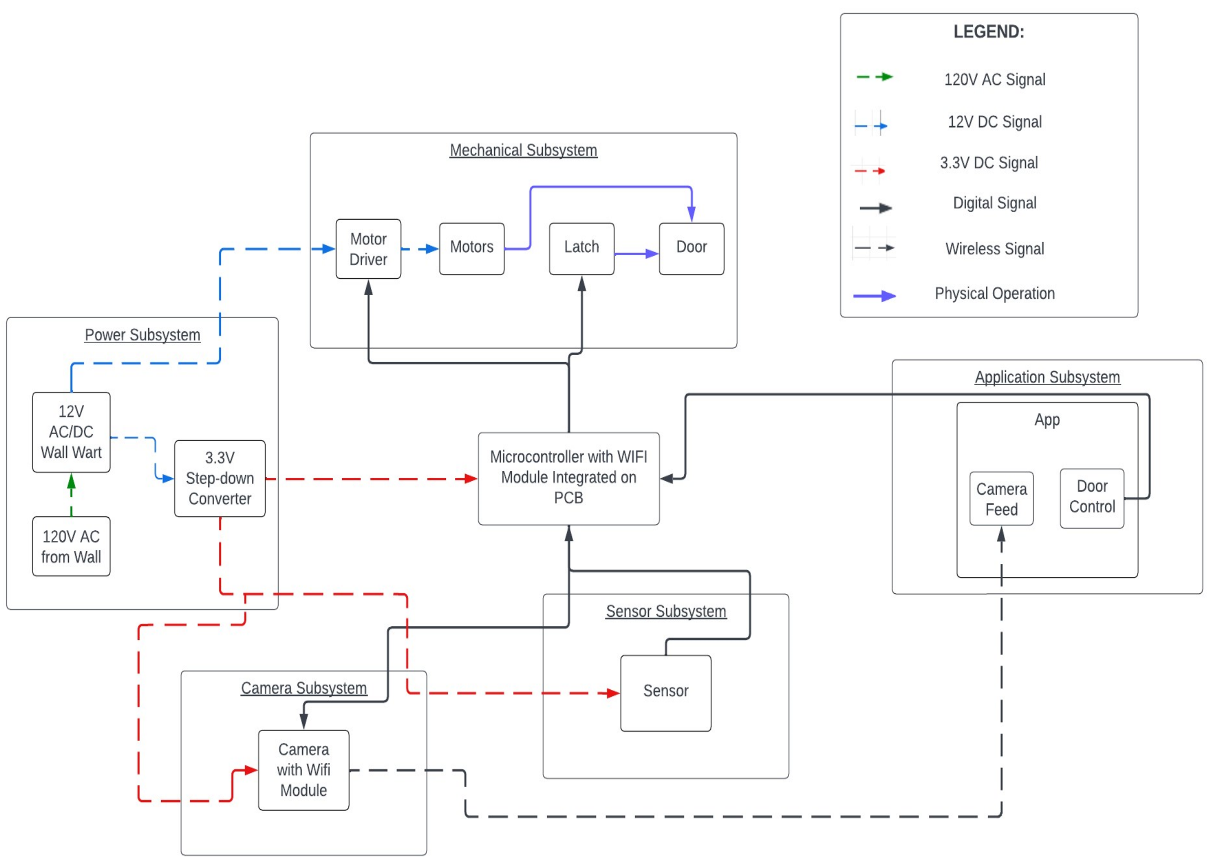

Figure 2: Control Flow of Design

2.2 Physical Design (if applicable)

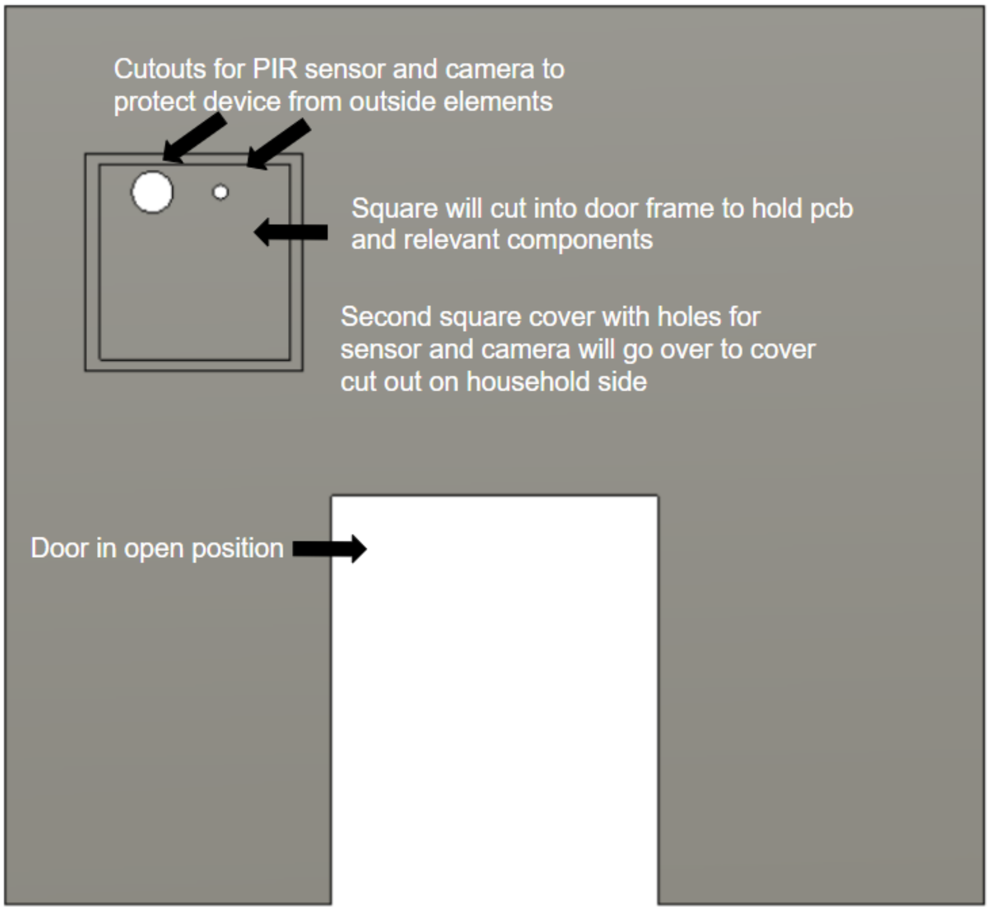

Figure 3: Door Front View

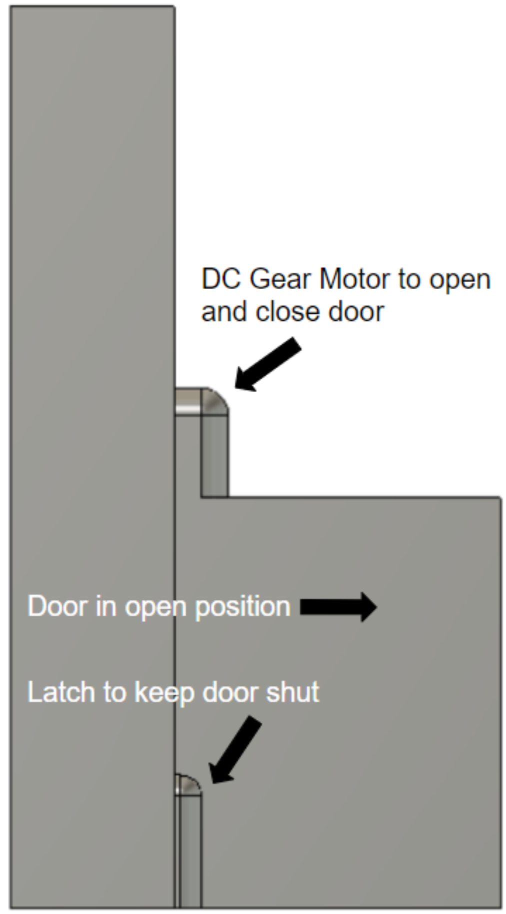

Figure 4: Door Side View

2.3 Camera Subsystem

The camera will be activated from the microcontroller to send a live feed locally to a laptop which will in turn upload to our application. This allows us to workaround the limitations of cheap pcb scale cameras. Our door consists of two cameras: one will be positioned on the inside while the other will be positioned on the outside. We will be using the ESP32 Cam system to transmit feed to the app through a wifi connection module

Requirements	Verification
Camera turn on when sensor detects heat	Trigger sensor and verify camera response is what we need
Camera feed correctly sends video wirelessly	See if video is obtainable on software side

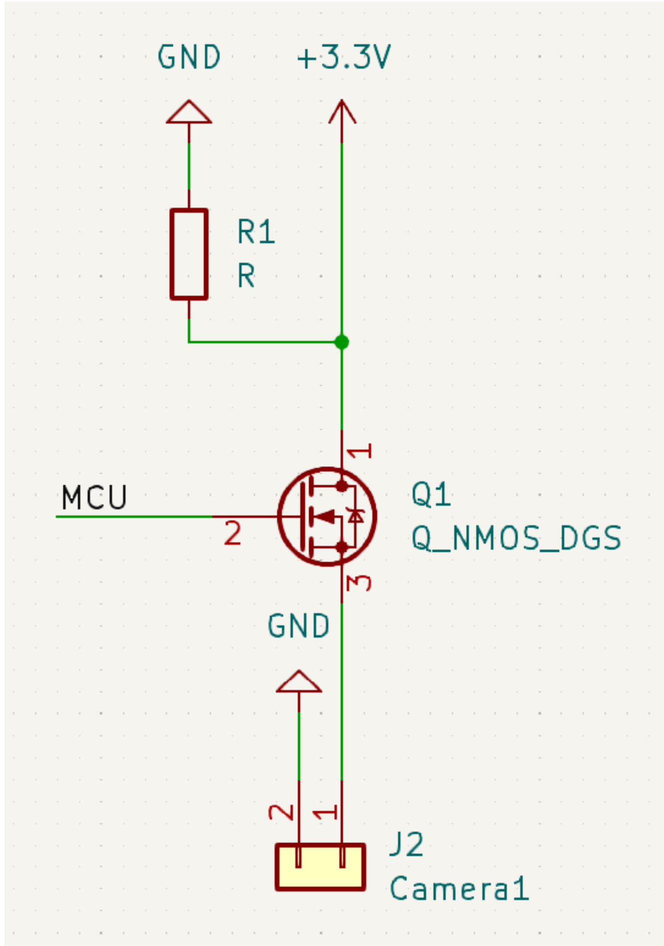

Figure 5: Camera Basic Design

2.4 Mechanical Subsystem

This subsystem will be the mechanical side of our project. It will involve a DC gear motor connected to a swinging door system that we will design. It will be a small version of the actual product and will be bolted onto a piece of plywood to demonstrate its functionality. It will have an opening and closing function. We plan to use a DC motor with a quad encoder which allows the motor to operate forward and reversed in order to open and close the door. In addition to the motor, we will have a solenoid latch to prevent unwanted door openings from either side of the door.

Requirements	Verification
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.
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.
Motors correctly receive signal from Wireless module to spin both directions	Test on app with open and closing and seeing if it reflects on the motors action

2.5 Power Supply Subsystem

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. 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 microcontroller to minimize power flowing through to avoid damage.

Two different IC chips will be used: one that steps down 12V to 3.3V to connect to our microcontroller 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 and The motor will use the unregulated voltage of 12V directly from the wall wart. 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.

Requirement	Verification
The power system must be able to supply 3.3V to the microcontroller and 5V to the camera/PIR sensor and 12V to the motor.	Must use a 12V 1A 12W Power Supply Charger AC DC Switching Adapter (Input 100-240V, Output 12 Volt 1 Amp) Wall Wart Transformer to convert the voltage from the wall outlet into 3.3V and 5V. 12V will be directly connected in order to supply our motors. Utilize a voltmeter with the triple output DC power supply to confirm voltage after conversion to make sure it meets the requirements of the microcontroller, camera, and PIR sensor.

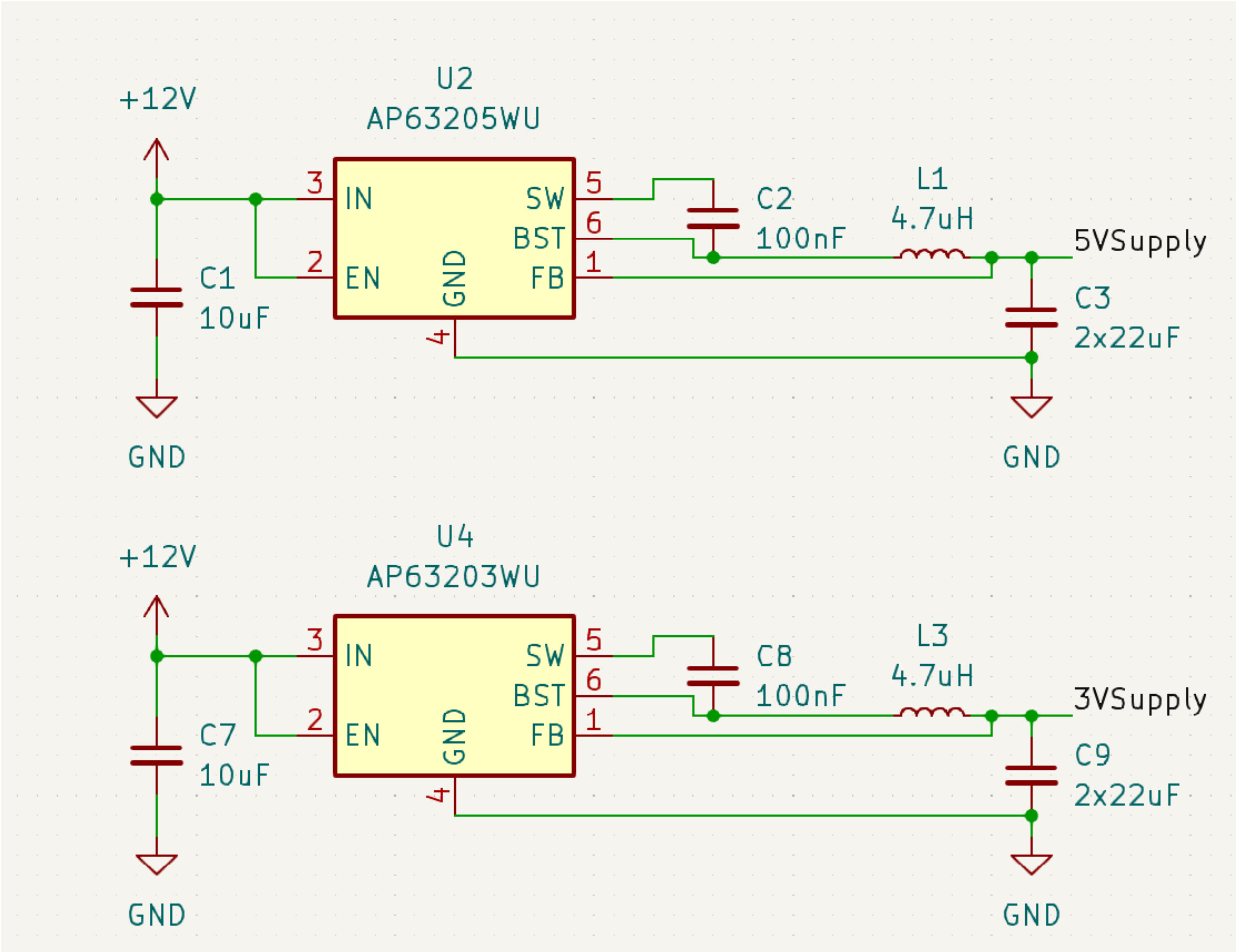

Figure 6: Power Supply Basic Design

2.6 Sensor Subsystem

This subsystem is the part of our design that senses movement and feeds live video. The system will use 2 HiLetgo AM312 Mini Pyroelectric PIR Detectors. Once the sensors get triggered, a notification will be sent to the app and the cameras will start sending live feed as well. When it is detected that the sensor is high, a signal will be sent to the microcontroller, where it will be processed by logic to send a signal to turn the camera on. We will need sensors for motion detection, cameras for live feed, and a wireless transmitter to send video to the app for the owner to see.

Requirement	Verification
The sensor subsystem will need to successfully detect a heat source and output a signal to the microcontroller to process and	To test this system, group members will walk back and forth in front of the sensor to attempt to trigger the detection system; if

activate the camera.	functioning properly, we will be able to record a signal from the oscilloscope. Additional testing includes the delay time of the sensor. Confirming it is indeed 2 seconds will help prevent false triggers such as the dog just passing by instead of waiting at the door.

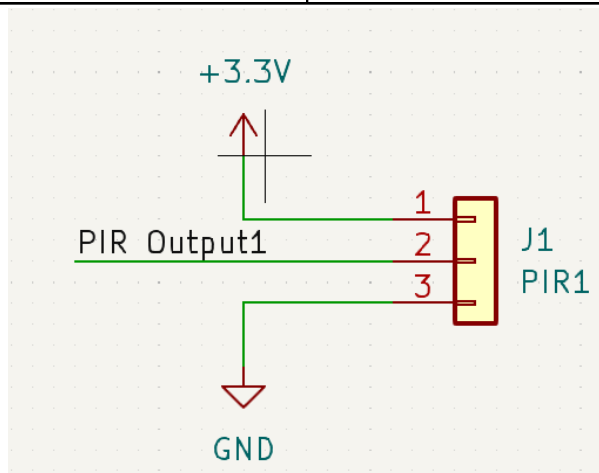

Figure 7: Sensor Basic Design

2.7 User App System

This subsystem contains the controls for the door. It will receive the video feed from the cameras as well as send out controls to the door to open and close when necessary. This part of the project will be entirely software based and will go off of the wireless transmitter on the other subsystems to send and receive the required signals. The app will need a connection to the wifi module in order to communicate with the camera subsystem on the same local network. From there, the wifi module will transmit data so the camera feed and door control will be available.

Requirements	Verification
App has all required buttons and overlays available	Make sure there is a spot for video feed from camera and make sure open and close button is available Done through visual verification and testing if open and close button work properly on software side
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.
App correctly receives signal from camera	Check for correct live video feed from the camera. This can be tested by seeing if video can be shown on the app.
App correctly receives signal from microcontroller	Check for a signal received originating from the sensor to trigger camera on. This can be tested on the software side by adding test cases to see if anything is picked up.
App correctly sends signal to microcontroller	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

2.8 Tolerance Analysis

In our design, we utilize PIR sensors to detect the animal and activate the camera system to transmit live feed to the phone application. However, there is an intrinsic flaw in the PIR sensor design. While its range of seven meters is sufficient for our uses, the field of sensing is only 100 degrees. This means that when the animal is close and off to either side of the sensor it might not be able to detect them. This can be solved with overlapping sensor fields that cover each other's blindspots. We need to make sure that the angle we point them at sufficiently covers this.

Another issue we could run into is insufficient current delivery. We are using a wall wart that supplies 1A to the system. The ESP32 microcontroller has a minimum load requirement of 0.5A, the PIR sensors each use 0.1mA, the two cameras use 40mA each. This totals to less than 1A so we should be fine to use this wall wart.

Another key factor is the power and heat generated from our voltage regulation techniques. The wall wart AC/DC converter outputs 12.05-12.18V at low load, and 11.81-11.97V at full load. The current will be 1A. Thus, Ptmax = 12.18V * 1A = 12.18W, and Ptmin = 11.81 * 1A = 11.81W. Next, according to Figure 8, the 3.3V voltage regulator operates at a 90% efficiency at Vin = 12V and Vout = 3.3V. So, Pvrmax = Pin * (1 - eff) = (12V * 1A) * (1-0.9) = 1.2W.

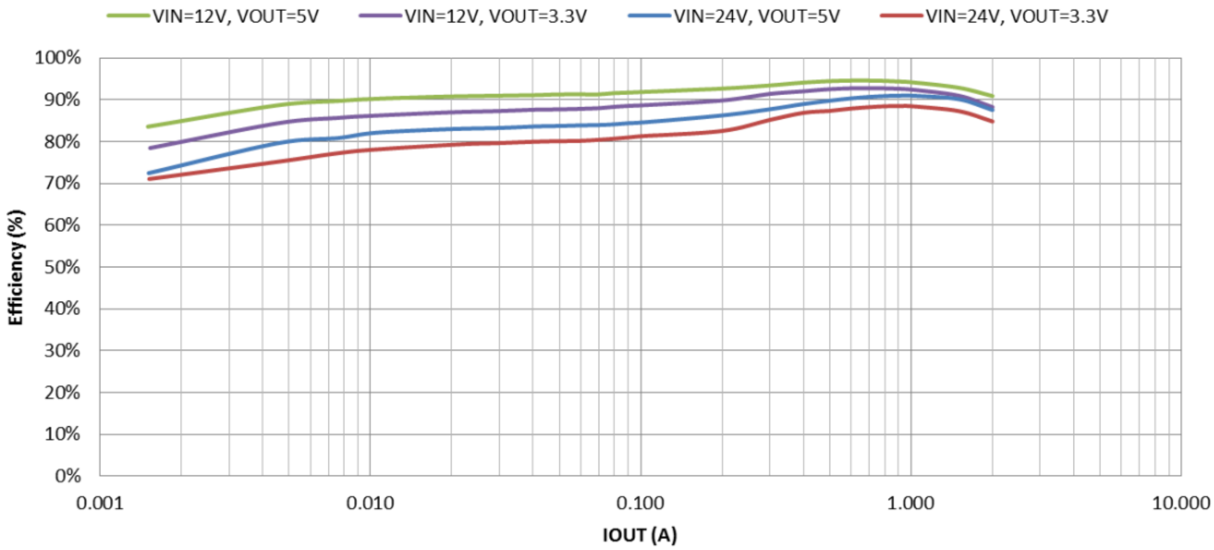

Figure 8: Efficiencies of 3.3V Voltage Converter

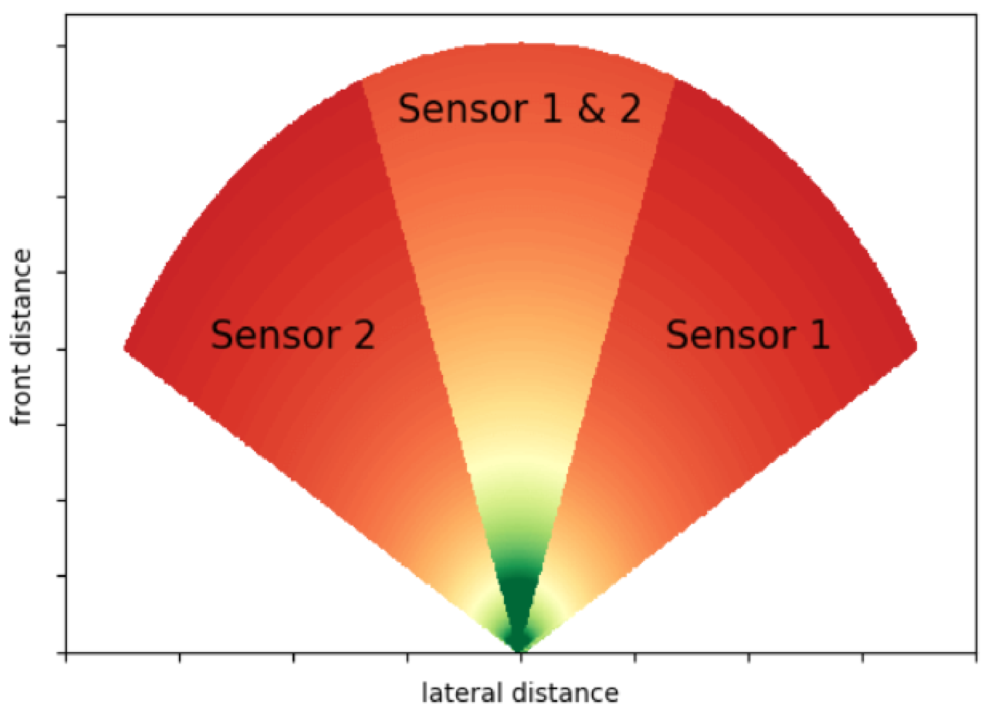

Figure 8: Example of Overlapping Sensor Fields

3. Cost and Schedule

3.1 Cost Analysis

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

		Inductors			
Parts total				**106.20**	
3	Labor (group)	N/A	N/A	48,750	N/A
1	Labor (machine shop)	N/A	N/A	880	N/A
Labor Total				**49,630**	
Grand Total				**49,736.2**	

The total cost for parts as seen above including shipping and sales tax is $96.26. 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) ×2.5 (overhead factor) × 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.

3.2 Schedule

Week	Task	Team Member
9/18	Begin design document Complete parts list	All
	Begin structuring app	Matthew
	Look into PCB and microcontroller requirements	Norbert
	Finish 3D model for machine shop and review with Greg	Jeffrey
9/25	Finish design document Finalize PCB design	All
	Work on app development	Matthew
	Supervise hardware and software design to ensure correctness Order all necessary parts and components	Norbert
	Check with machine shop on mechanical design and make any adjustments necessary Assist in PCB design	Jeffrey
10/2	Design review with instructor and TA PCB review	All
	App must be nearing completion. Testing not required at this point since we will need to wait for PCB to come in	Matthew
	Ensure PCB design meets all requirements based on our subsystems	Norbert
	Finalize mechanical design with machine shop to begin build	Jeffrey
10/9	Program the microcontroller Order PCB	All
	Ensure software is programmed to take care of every scenario possible based on user demands	Matthew
	Responsible for making sure PCB is able to communicate with software on the app as well as the mechanical design	Norbert
	Work on integrating PCB with the mechanical subsystem from the finalized product from machine shop	Jeffrey
10/16	Begin testing PCB with a breadboard/prototype design	All

	Identify weak/strength points in current PCB design	Matthew
	Document progress and begin data collection	Norbert
	Visualize how the PCB can be integrated better with mechanical design	Jeffrey
10/23	Begin integrating PCB with mechanical design as well as all subsystems	All
	Ensure app can communicate with WIFI module on PCB	Matthew
	Search for optimizing design, look for weak points and assist with integration and verification of subsystem connections	Norbert
	Begin mounting subsystems on mechanical design	Jeffrey
10/30	Carry out testing of product	All
	Ensure electrical connections are proper	Matthew
	Assist in both mechanical/electrical verification	Norbert
	Ensure mechanical design is proper	Jeffrey
11/6	Continue testing and making adjustments of product	All
	Data collection	Matthew
	Document all technical information related to performance of design	Norbert
	Verify that performance of product matches data	Jeffrey
11/13	Mock demo	All
	Prepare for mock demo	Matthew
	Prepare for mock demo, ensure requirements are met	Norbert
	Prepare for mock demo, transport final product	Jeffrey
11/20	Fall break	All
	Catch up on work	Matthew
	Catch up on work	Norbert
	Catch up on work	Jeffrey

11/27	Prepare final demo for instructor and TA	All
	Carryout final demo	Matthew
	Carryout final demo	Norbert
	Carryout final demo	Jeffrey
12/4	Prepare for final presentation for instructor and TA Return lab equipment	All
	Present final presentation Turn in Lab Notebook with Github	Matthew
	Present final presentation	Norbert
	Present final presentation	Jeffrey

4. Discussion of Ethics and Safety

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, 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 complied.

5. Citations

"IEEE Code of Ethics." IEEE, https://www.ieee.org/about/corporate/governance/p7-8.html.