ECE 445

Fall 2023

Senior Design Project Proposal

Ground-Breaking Next-Gen Smart Pet Door

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1. Introduction

1.1 Problem

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. 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 Visual Aid

1.4 High-level requirements list

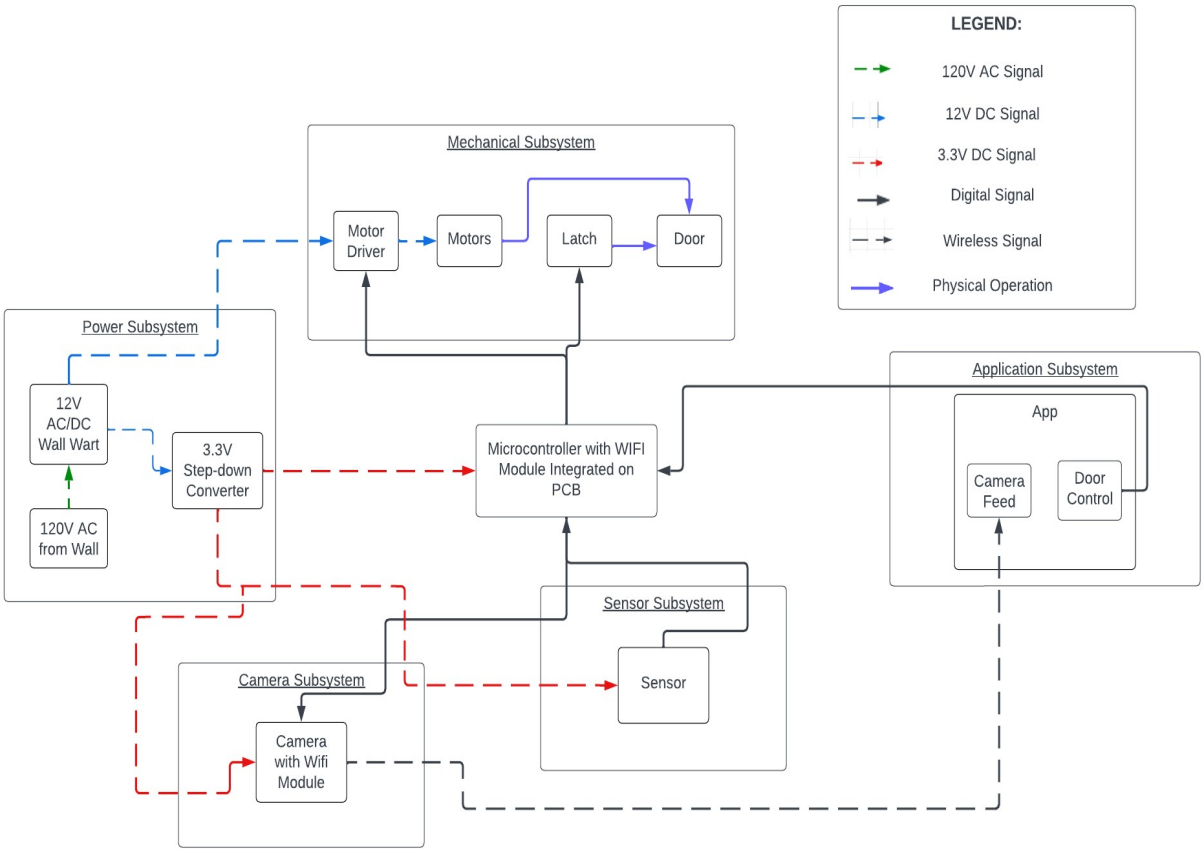
1. Sensors are able to detect motion on both sides of the wall and are able to power on the camera within 5 seconds. Camera will remain on for said duration as long as the pet is detected within the scope of the sensor's field. Camera also must be able to connect to wifi and stream proper video to be 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 Break your design down into blocks and assign these blocks into subsystems. Label voltages and data connections. Your microcontroller can live in multiple subsystems if you wish, as in the example below.



2.2 Subsystem Overview

Camera

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.

Mechanical

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 connected to the motor driver that acts as an H-bridge, 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.

Power Supply

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. The wall wart essentially behaves as a 120V AC to 12V DC converter. 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.

A voltage regulator will be used to step down 12V to 3.3V to connect to our microcontroller, camera, and sensors. This IC will utilize decoupling circuits with capacitors for stable circuit operation and the motor driver will use the 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.

Sensor

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 software to send a signal to turn the camera on.

User App

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.

2.3 Subsystem Requirements

Camera

We will have two requirements for this subsystem: Camera must turn on when sensor detects heat, and camera feed correctly sends video wirelessly. In order to verify the mentioned requirements, it is necessary to trigger the sensor and verify camera response is what we need, and see if video is obtainable on the software side, respectfully.

Mechanical

One requirement is to ensure motors correctly can spin in both directions. To verify this we must see if the door opens and closes properly by sending a signal to and from the motor driver. High signal to A input should rotate clockwise and high signal to B input should rotate counter-clockwise. We also require that the latch functions properly, which will be verified by

pushing on the door to try to force the door open while the latch is engaged. If it remains closed then we confirm functionality. The final requirement is that the motors correctly receive signal from wireless module to spin both directions. This will be confirmed by testing on app with open and closing and seeing if it reflects on the motors action.

Power Supply

A requirement of the power system is to be able to supply 3.3V to the microcontroller, camera, PIR sensor and 12V to the motor driver. 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. 12V will be directly connected to the motor driver in order to supply our motors. We can verify this by utilizing a voltmeter with the triple output DC power supply in the lab to confirm voltage after conversion to make sure it meets the requirements of the microcontroller, camera, and PIR sensor.

Sensor

The sensor subsystem will need to successfully detect a heat source and output a signal to the microcontroller to process and activate the camera. 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 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.

User App

The app has all required buttons, overlays available, and compiles properly with how our logic works. It also needs to correctly receive live feed from the two cameras. Finally it needs to correctly send and receive signals to and from the microcontroller

2.4 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.

3. 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.

4. Reference

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