Automatic Dog Door
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1 Introduction

1.1 Objective

In the U.S., approximately 44% of all households own a dog (apsca.org) - with dogs comes responsibilities, such as having to get up from the couch after a long days of work to let the dog out as it needs. We believe we can provide comfort and ease to the typical american household by having an automatic doggy door that opens when the dog approaches the door so the owner does not have to worry about getting up. Our solution will also allow for dogs to use the door even if the owner is not home while minimizing security risks.

1.2 Background

Most household owners that host a dog and a backyard can get annoyed with having to get up constantly to let their dog out. Another common issue is the dog not going out enough during the day due to the owner being stuck at work. The current solution to both of these problems is the use of a rubber door that the dog can use at free will. Who else can also use the same rubber dog door at free will? Robbers and home invaders!

Our solution of an electronic automatic doggy door can tackle both these problems at once while also providing additional features for user customizability. Upon an owner’s configuration, a dog would be able to use this automatic door while keeping security under control through the use of an RFID chip in the dog’s collar.

1.3 High-Level Requirements

1. Door unlocks only when a dog is approaching and locks within 3 seconds of dog leaving. This is the biggest requirement for security and safety concerns, we need to ensure the dog is not approaching/leaving and not actually stuck in the door when it goes to lock.
2. Door remains locked if dog attempts to use the door outside the bounds of the user’s customization (weather and time)
2 Design

The foundation for our new design will stem from an already existing rubber doggy door that uses magnets to stay shut when no force is applied. We will use a servo motor to move a locking mechanism to block the door from opening when force is applied - the door will only be able to open when the actuator is in an UNLOCKED position. Below is a block diagram of the general overview of our system, the sensors and hardware are detailed after.

Figure 1
Figure 2

Figure 2 illustrates what the door and locking mechanism will look like. The red portions depict the placement of the servo motors and locking mechanism relative to the whole system. The whole door should be roughly 40 x 60 cm.

2.1 Power Supply

Powering the system is handled by a standard AC to DC power supply that will plug into the wall outlet. This will mitigate any risk of electrocution, as we will source a high-quality, well-reviewed adapter. Since the MCU operates from ~2-3.5V, the power supply must be able to constantly supply more than the maximum power, as the MCU also features an internal voltage regulator. It must also be able to provide power to the sensors and WiFi module.

Requirement: The power supply must be rated for 6-12V, and must be able to supply 300mA.

2.2 Sensors

Our system will use a set of several different sensors in tandem to determine whether or not the door should be allowed open.
2.2.1 Rain Sensor

A rain sensor will be utilized to detect basic weather conditions outdoors. If it’s raining, the door will remain locked, not allowing a user to exit through the door. This will not limit a user from re-entering the door from the outdoor area. Our rain sensor will either be our own PCB design, or use a pre-made 5V rain sensor.

Requirement 1: Must be able to differentiate between humidity outside and actual rain/snow conditions.

Requirement 2: Must be able to operate under temperatures ranging from -32 degrees Fahrenheit to 100 degrees Fahrenheit.

2.2.2 Light Sensor

A light sensor will be used to determine if it is day or night, which the user can then specify if they want the door to open during nighttime hours through the user application.

Requirement 1: Must be rated for daily use under 120,000 lux direct sunlight at midday.

Requirement 2: Must be able to operate under temperatures ranging from -32 degrees Fahrenheit to 100 degrees Fahrenheit.

2.2.3 RFID Sensor

An RFID sensor will be used to determine if the user is enroute to the door. If the user is approaching the door, it will unlock for the user. A receiver will be on both sides of the door, with the user wearing a tag to signal the receiver on it’s collar. The collar tag will use a passive design, so in order to get the needed sensing range, we will have to use a high frequency or ultra high frequency system. The design may have to be switched to an active RFID system, depending on the passive design constraints.

Requirement 1: The system should have an effective sensing range of approximately 0.8 - 1.0 meters.

Requirement 2: Must operate at a frequency of 12.56MHz or higher, to ensure readability from a distance.

2.2.4 IR Sensor

A key concern is accidentally triggering the door to unlock when the user is walking past the door rather than straight-on towards the door. IR sensors will be used in tandem with RFID to ensure the user is heading straight towards the door. This will ensure that accidental unlocks do not occur with the system.

Requirement 1: Multiple sensors must be used to indicate which direction relative to the door an object is.

Requirement 2: Must have an effective sensing distance of 0.5-1.0 meters.
2.3 **Servo Motor**

This will be a bidirectional 12V DC servo motor. It will drive a deadbolt-style lock to prevent the door from opening when not in use. Since the motor only needs to drive the lock back and forth, a 180 degree servo motor is perfect for our design. Once triggered by our system, the door will unlock, allowing the user to push open the door. A linear actuator would fit this system better, but due to wanting the system low in cost, it will be better to use a simple 12V DC motor in our case.

*Requirement 1: Needs enough torque to drive a deadbolt style lock*
*Requirement 2: Freedom of rotation within ~5% of 180 degrees*

2.4 **Control System**

2.4.1 **Microcontroller**

We'll be using a PIC32 microcontroller that can handle enough analog to digital input pins to read the sensor data, and also have a PWM output pin to connect to the motor driver, which is what we will use to control the motor, and ultimately the lock. The microcontroller must also feature a UART interface, that will allow us to connect to the WiFi module and read system settings from our server.

*Requirement 1: Supports PWM with pulses that range from 1-2ms in length.*
*Requirement 2: Has a JTAG UART interface for communication with the WiFi controller.*
*Requirement 3: Has at least 4 analog input pins to pull data from the sensor.*
*Requirement 4: Has at least 2 digital output pins to drive the LEDs.*
*Requirement 5: Supports Analog to Digital conversion.*

2.4.2 **Motor Driver**

The MCU can’t drive a motor directly, as a DC motor requires more voltage and current than a Microcontroller can typically handle. We will be using the L293D motor driver, which can supply up to 600mA, and can handle a voltage range of 4.5V to 36V. This will insure that we can drive a motor that is strong enough to push our deadbolt style lock across the door.

*Requirement 1: Can output a voltage of at least 5V.*
2.5 WiFi Module

Our design will feature the ESP8266 WiFi Module. We have chosen the chip because of its low cost, while offering an integrated TCP/IP protocol stack, which will allow our control system to connect to a home’s WiFi network. This is what will allow our control system to connect to the server that will be telling the board about the user’s current settings.

*Requirement 1:* Can utilize UART communication.
*Requirement 2:* Supports 2.4 GHz IEEE 802.11b/g/n to communicate with modern WiFi routers, with a read speed greater than 10kbps.

2.6 LEDs

Our circuit will use 2 LEDs for simple system status information. They will be connected to output pins on PIC32, and will be used to display if a RFID tag was read, and if the system is currently connected to a wireless network.

*Requirement 1:* Emits light visibly when sent a 10mA current in a well-lit room.

2.7 Server

The server holding the user’s lock hours, rain preferences, etc. will be hosted on a laptop. It is an essential aspect of our project, but since it is entirely software based, it is outside the scope of the design.

2.8 Risk Analysis

The RFID implementation is a significant risk to the completion of this project. An accurate, consistent, and reliable sensing range is key to the entire system’s implementation. Additionally, the RFID is the basis of the system’s secure design, and just IR sensors will not be enough to ensure security of the door. To ensure the range requirements are met, the design may be switched to an active RFID system rather than the current passive design, to ensure the completion of the entire project scope.
3 Safety and Ethics

There are several potential safety hazards with our project.

The principal safety hazard is potential injury to the user of the door. There is no risk of the user being crushed since the system never manipulates the door or allows the door to get in a position to crush/hit the user. Since our system is only altering the locks, the door is completely safe for the user.

Since part of the electrical system is outdoors, moisture could cause damage to the system (apart from the specific rain sensor). An enclosure will be created for all relevant electrical components that must be kept out of moisture. This enclosure will adhere to IP64 guidelines for this system.