Senior Design Project Proposal

Design Project: Smart Doggy Door

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Problem Statement

Need (BC, JH)

According to the National Insurance Institute, in a national survey in America, 64.3 million people own a dog ("Facts Statistics"). As known by dog owners and confirmed by Dr. Kristy Conn, dogs need to be let out three to five times a day ("How Often"). With many of these situations falling during times when the owner is not at home, there needs to be a way to let a dog outside remotely. While this can be done currently with a dog door, this can leave the house vulnerable to unwanted entries. As a result of these circumstances a more secure and connected way to let a dog outside is needed.

Objective (BC, JH)

The objective of this product is to create a device that allows a dog to enter and exit the home without the owner needing to be home. The device prevents the dog door from opening unless the user's dog is wanting to be let out. Information on the activities of the dog will be sent to the owner so that they can track the dog's activities.

Marketing Requirements/Top 5 User Needs (JM, NH, JH, BC)

1. Ability to let dog/pet out when user is away from home
2. Door securely locked when dog not outside
3. User receives notification when dog wants outside
4. Track statistics about dog's outside activities
5. Device on dog and door both require little maintenance

Block Diagram Level 0 with Functional Requirement Table (JM, NH, JH, BC)

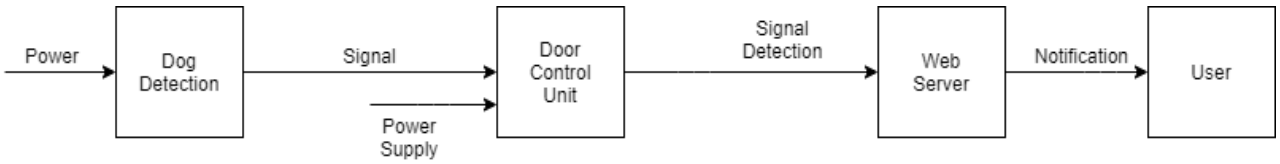

Figure 1: Level 0 diagram of Smart Doggy Door system

(JM, NH)

Module	Dog Detection
Inputs	-Battery power
Outputs	-EM signal
Functionality	Worn on the pet and outputs a signal to be acquired by the door control unit. This is an active RFID tag.

Table 1: Dog Detection module functional requirements.

(JM, NH)

Module	Door Control Unit
Inputs	-EM signal -Wall power
Outputs	-Voltage signal
Functionality	RFID tag reader and motor controller that senses presence of tag in proximity of RFID tag reader and then opens or closes door. Also sends a signal to the web server to notify the user of the door state.

Table 2: Door Control Unit module functional requirements.

(JM, NH)

Module	Web Server
Inputs	-Voltage signal
Outputs	-SMS or Email
Functionality	Handles wireless interaction with the user/owner of the pet.

Table 3: Web Server module functional requirements.

(JM, NH)

Module	User
Inputs	-SMS or Email
Outputs	
Functionality	User receives the state of the door over either SMS or Email.

Table 4: User module functional requirements.

Mechanical Sketch Of System (JM)

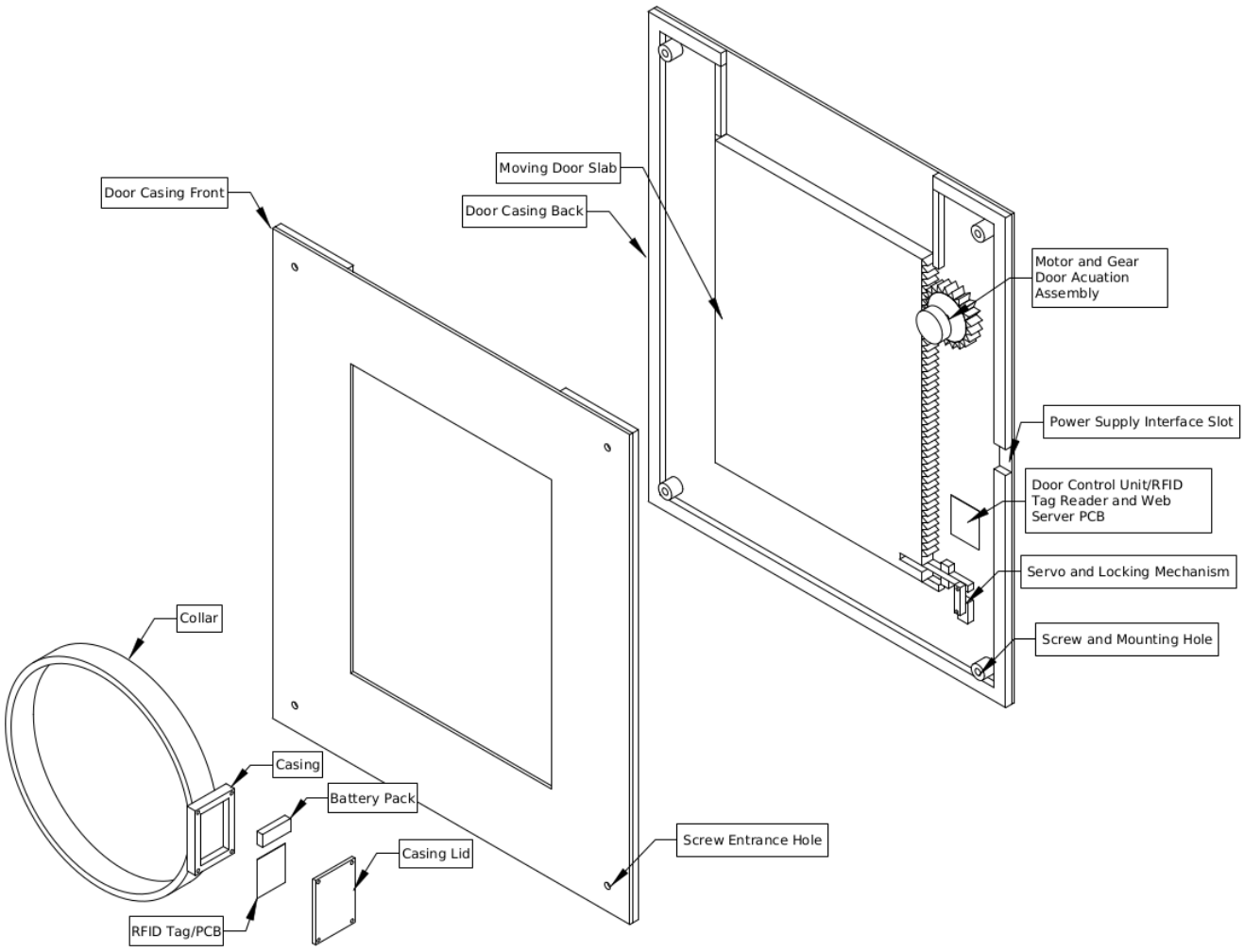

Figure 2: Mechanical mockup sketch of complete Smart Doggy Door system.

Background

(BC) The idea of a more automated smart pet or doggy door has been researched and patents for those specific designs exist. A patent that follows a similar concept to ours is the Automatic Pet Door Controlled by Smartphone invented by Richard Brown. In their design, they have multiple programming operating modes that control the ways a pet can use the door to go outside. The design also includes different features such as whistles and signal lights. Operating modes are controlled by the user using an associated app. An operating mode that is similar to the idea being implemented is where a device connected to the pet, most likely a collar, will enable the door to be open and closed according to where the dog is. For the design, it is not necessary to create an app since it won't be implementing as many operating modes; however, logging into a web server can allow for adjusting settings or for doing setup operations.

(JM) The theory behind the smart pet or doggy door is that it is a door mounted to a regular door, of course modified for a hole that a pet can travel through, and can sense a pet with an active RFID chip/circuit attached to its collar. Upon the pet being within range of the pet door, a signal will be picked up by the door, also referred to as the base station, from the active tag. After validation of the signal—acquisition of signal—the door will open and close automatically, or send a notification via SMS or Email to the owner allowing them to decide if the door should open or close. A valid signal acquisition will be decided in a two step process. First, the signal emitted from the pet collar needs to be picked up and then the second step exists to avoid false positives. To verify that the pet should be let out, the pet will need to stay within range of the system for a certain amount of time; this avoids changing the door state or sending a notification if the pet gets too close for a small amount of time when wondering, concluding the

second step. An additional feature is data collection of the pet's activities, such as the number of times going through the door or amount of time spent outside. Communication between the base station to collar and the owner will be across two mediums or techniques, RFID and WiFi.

(JM) Wireless communication or verification between the collar and base station will be through Radio Frequency Identification—RFID—technology. The goal in using RFID is for proximity detection where the pet's tagged collar will be sensed. RFID systems consist of devices called tags, readers, and hosts (Bolic, Rostamian, & Djuric 2014). For the smart doggy door, a tag will only communicate with a reader device in an active, high-power mode. Bolic, Rostamian, and Djuric's paper mentions that tags could communicate in a low-power mode with other surrounding tags, but this product—Smart Doggy Door—does not need this interaction. Obviously, any wireless communication, as discussed, will be through electromagnetic signals and therefore radio transponders on both the tag and reader devices are needed for transmitting and receiving the signals.

(JM) Patents pertaining to the use of wireless communication to identify devices to each other exist, but this is the function of the mentioned RFID system. In fact, the previously mentioned Bolic, Rostamian, and Djuric paper briefly discusses a patent. In the patent, the devices with radio transponders are mobile ones like phones but the purpose is to track interactions, meaning cases where two devices are close to each other. The two devices will identify each other and track information about the identity of the device and the location (Liao). In the case of the Smart Doggy Door, the tag and reader are akin to the two devices in the patent; however, only the reader will identify the tag and its ID, the tag will not identify the reader. RFID technology is implemented using

radio transponders emitted and receiving electromagnetics signals, however the signal processing will take place on a microprocessor on the tag reading portion of the doggy door/base station.

(JH) According to Floerkemeier and Sarma a RFID reader will be composed of a radio module, a general purpose computing module, a network interface, and general input/output pins. It is also mentioned that this computing module can be an embedded microprocessor with significant power which will be needed to control other aspects of the doggy dog. This reader will be classified as a DPSS reader as described by Floerkemeier and Sarma as it will need to be able to eliminate redundant reads so that the door is not opened multiple times for a single event (Floerkemeier and Sarma). Once the RFID tag has been detected the microprocessor will first confirm that the detected RFID tag is one that the door is allowed to open for. The next step is that it will upload information saying that an event has taken place to a web server where notifications can be sent out to the owner or data on the dog can be processed. Lastly, the second step will be to send information out to tell the door to open.

(JH) Once the microprocessor has received the RFID signal and processed it to determine that the dog in front of the sensor is one that should be let in it will send a signal out that will control the speed of a motor. An example of a motor that can be controlled in this way is a stepper motor. A stepper motor's speed as well as its direction can be accomplished with a single microprocessor. By sending pulse sequences based on what the motor should do. With control commands that will be issued based on if the dog is present the signal will be sent to the motor the motors will run and a timer will start and the motors will run for a certain time before a stop command is issued to the

motors (Kang & Qu). With an implementation as described above the commands will also be able to tell the motors which speed to run at, but not for how long at the same time so timing of motor runs will be done on the microprocessor during this time it will stop looking for the presence of an RFID tag and start a timer to control how long motors will run for. A similar operation can be done to control other types of motors, such as a servo, in a similar way. Which type of motor to use in this application is also a concern as different types of motor have different strengths and drawbacks. In fact, to implement a locking mechanism, a mechanical mechanism will have to be actuated in some way but that can be done via a small servo or perhaps using a pneumatic component.

(NH) For opening and closing the door, a motor will be activated by the microprocessor when the pet approaches the door. To provide security for the door, the motor must be able to resist entry. There are many different types of motors that can be used for this project, based on the desired specifications and design for the door. The two motors that are good candidates for the doggy door are the servo motor and the stepper motor. A servo motor is a motor that allows for precise rotation or position, and the motor also has a feedback loop to adjust the output. According to "Mode-free adaptive control method application for Auto-Door servo system", there are trade offs between the AC and DC versions of the servo motor. The AC version of the motor is a good system for converting the rotational torque to linear movement, the AC motor can be used as a brake unit when there is no input (securing the safety of the doggy door). The article goes on to mention that the DC motor is a simpler machine and has faster response, but is more

prone to error. Servo motors implement gear boxes into the system which can make the system more mechanical.

(NH) A stepping motor is another option for operating the doggy door. Stepping motors are good for positional movement application, such as moving the door to the open position and holding it there. The article “Instantaneous torque analysis of hybrid stepping motor” mentions that the stepping motor designs are more difficult to design and are usually used for low speed applications, the stepping motor also has a higher efficiency and high torque. Stepper motors do not have a feedback loop, and are good at generating and holding torque. The goal for the motor design is to be able to implement a design that is functionable, is able to secure the door, and is a practical. The two types of motors both have trade-offs and provide different areas of quality. As the motor operates the door opens or closes depending on what the microprocessor tells the motor to do.

(BC) During the process of the doggy door opening and closing, the owner of the doggy door will get a notification saying the former or the latter. The process by which this is done is that the device that opens the door needs to be able to connect to the internet whether that be hardwired or a wireless transceiver. According to Cuno Pfister’s book, there are many ways to connect to the internet and have the microcontroller send data to a destination. Once the data is sent it can be controlled by a web server which will then determine what notifications to send. Also stated in Getting Started with the Internet of Things, the author talks about using the ASP.net framework to set up the web server to receive and send out commands. This is the common way of setting up a web server that can interact with other inputs and devices

Design Team Information

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