Pet Pest Protector

Team 8 - Madison Hedlund, Kyle Schildgen, Zuriel Tronco
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TA: Mengze Sha

1 Introduction

1.1 Objective

Approximately 60.2 million homes own a dog and their safety is a concern of owners around the country [1]. Unfortunately, when working with animals you don't know when they will be calm and when they will be triggered to attack going from harmless to harmful. This leads to many attacks between dogs and humans and other animals. Every year about 4.5 million dog bites occur leading humans to approximately 866 emergency department visits and 26 hospital stays per day [2]. Skunks can also appear in your backyard and will be seen as a friendly creature to the dog, but upon approaching the skunk may spray the dog leading them to potential blindness, vomiting and nausea [3]. If a skunk bites your dog they may be infected with diseases including Tularemia, Canine hepatitis, or Listeriosis. Skunks aren't the only animal that can appear in a backyard to harm a dog. Some other animals include coyotes and snakes [4]. When a coyote is provoked its first instinct is to kill the pet and not just injure them so quick intervention is important. Over one-million animals are reported to have been bitten by a snake in one year with dogs enduring the most bites [5]. These bites lead to a twenty percent fatality rate.

Our goal is to provide a safety system for the owner and their pet giving the owner a chance to intervene before a situation gets harmful and gives them an extra sense of security when their dog is in the backyard. The safety system consists of passive infrared sensors and lights on the pets collar. The sensors will detect people and creatures in the yard. When something is detected a light flashes to stun the intruder and an alert is sent to the owner through bluetooth transmission.

1.2 Background

Other companies have tried to come up with systems to alert of intruders in their yard, but none of them took the same approach as what we are doing. Google took one approach with their Nest Cam Outdoor [6]. This system consists of an outdoor camera that sends an alert to your phone when there is motion is your backyard. The downfall of this system is that every time you let your own dog out by themselves or even if you go out with them you will get an alert on your phone. The Pet Pest Protector is unique in that it alerts for other creatures in the yard and can be turned off while the owner is outside with their pet.

Another solution to pet protection took a mechanical approach to solving this issue with the Coyote Vest [7]. The Coyote Vest uses spikes and other pointed, straw-like features to deter coyotes from biting smaller dogs. This vest does not alert the owner of the presence of a threat to their pet. In addition, this vest is primarily geared towards coyote protection, whereas we seek to detect other pests in the user's back yard. This method will also allow for some amount of time to allow for intervention. If someone were to use the Coyote Vest, it may be too late to help you pet.

1.3 High-level requirements List

- The IR sensors must detect a creature in the backyard within 10 feet proximity.
- The Bluetooth transceiver must be able to connect with the UI app on the host's phone.
- The lights on the collar must display when a creature is sensed and must be off when no creature is present.

2 Design

2.1 Block Diagram

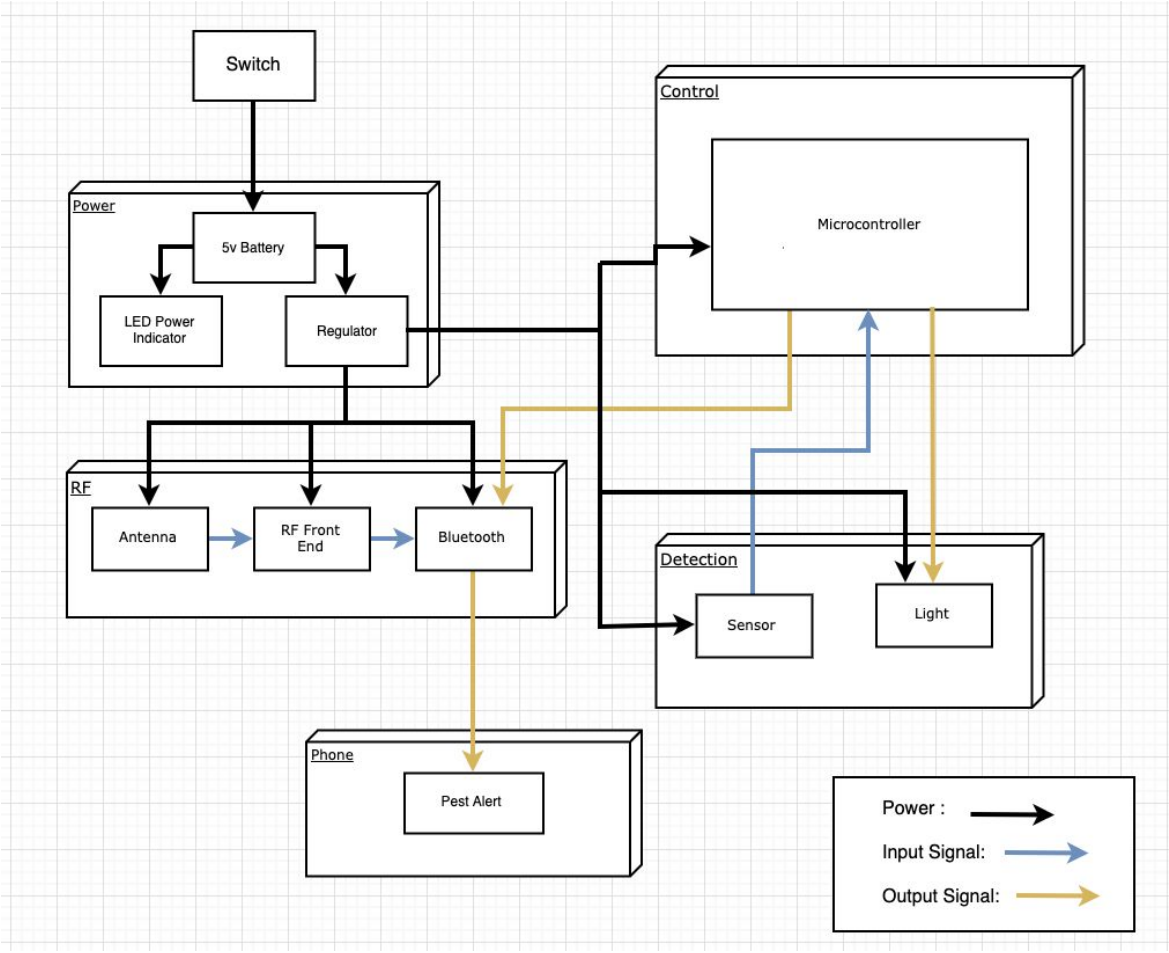

Figure 1: Block Diagram

The complete system is made up of sections for power, control, detection, and RF. The power section is used to power the rest of the system to ensure that the detection and alert of the creature occur successfully. The control section ensures that the proper high signals on the sensor are converted into alerts within the rest of the system. The detection section detects the creature and displays the lights on the collar. The RF block is used to connect the collar and the phone to complete the alert system.

2.2 Physical Design

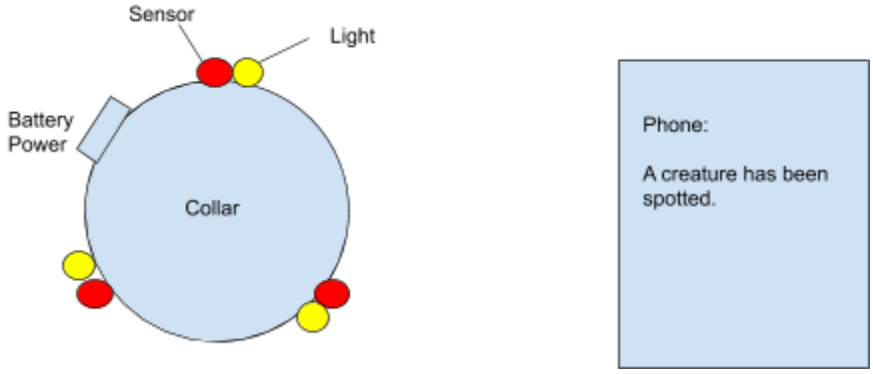

Figure 2. Physical Diagram

The system includes a dog's collar that holds the detection subsystem. The collar holds the infrared sensors that detect creatures and the lights that stun the creature away. These are spaced out around the collar evenly. The collar also holds a battery that powers the sensors and lights. Separately, there is a phone application that generates the alert for the owner.

2.3 Functional Overview and Block Requirements

2.3.1 Power

The power is required to ensure that the detection and alert system work while the dog is out in the backyard. The power will be regulated to ensure that chips get the proper power to operate.

2.3.1.1 Battery

For the battery, we will use a 5V battery as that will be sufficient to provide the other stepped-down voltages that will power the components within the system.

Requirement: The battery must be able to keep the circuit operating properly for at least one hour.

2.3.1.2 Voltage Regulators

Multiple voltage regulators will be used to step down the battery voltage to power the various ICs on our board. The voltage specifications of the regulators will depend on the ICs that we choose for our circuit to operate. Hopefully, we can have a reduced number of regulators that can drive multiple ICs.

Requirement 1: One voltage regulator must provide 3V from the battery source to power the sensor.

Requirement 2: A second voltage regulator must be able to generate 3.3V must be able to stay between 3.0V to 3.6V.

2.3.1.3 LED Power Indicator

The LED Power Indicator will show whether the collar is on or off. The LED will be on when the collar is powered.

Requirement 1: The light must be on at all times that the collar is powered.

Requirement 2: The light must be able to be seen on the collar by the owner one foot away from the dog.

2.4.1 Control

The control section is used to ensure that detections on the sensor are read properly and that communication over bluetooth occurs at the appropriate times.

2.4.1.1 Microcontroller

The microcontroller will be used to interface with the bluetooth chip on the board to send signals to the user's phone at the appropriate time as well as control the timing of the lights on the collar to ensure that they don't flash for false alarms.

Requirement 1: The microcontroller must be able to read signals from the sensor at the appropriate level.

Requirement 2: The microcontroller must be able to trigger the bluetooth connection to send an alert to the user's phone.

Requirement 3: The microcontroller must power the LED when it detects an object from the radar.

2.5.1 RF

The RF block stands for the signals that will be sent over bluetooth to connect the phone application to the collar within the alert system.

2.5.1.1 Antenna

The antenna must be able to operate at the same frequency as the bluetooth transceiver (~2.4GHz). Antennas can be tricky, so it is important to find one for low insertion loss to ensure that the sensitivity of the bluetooth transceiver is not affected.

Requirement: The antenna will operate between 2.4 and 2.5 GHz.

Requirement: The Antenna will be linearly polarized PCB mount antenna.

Requirement: The antenna's return loss must be greater than -15.0dB and Peak Gain must be greater than 2.0dBi.

2.5.1.2 BlueTooth Transceiver

The bluetooth transceiver will operate at 2.4GHz and be using bluetooth v4.0-v4.2. The transceiver will be a critical component for communication between the collar device and the user's phone.

Requirement 1: Bluetooth must trigger signal to the phone application when the microcontroller is triggered by the sensor

Requirement 2:Bluetooth receiver must operate within a 10 meters distance from the dog owner's application device to the collar of the dog.

2.5.1.3 RF Front End

The RF front end is responsible for taking in the antenna's signal and matching it to the proper bluetooth signal. The front end will contain a Low Noise Amplifier (LNA) and a matching network to reduce the loss from the antenna.

Requirement: The matching network will be designed with a center frequency of 2.4GHz and a bandwidth of 100MHz to give us some amount of headroom.

2.6.1 Detection

The detection block is crucial for finding the creatures since it includes the sensor that locates the creature and the light that flashes off the collar when the creature is detected.

2.6.1.1 Passive Infrared Sensor

This is the core component of our design. The PIR Sensor is crucial for detecting living pests within the proximity of the device. The sensor detects the heat from the creature which will trigger that there is a foreign object in the backyard.

Requirement: The sensor must generate a high signal saying it recognized a creature when the creature is within ten feet of the dog.

2.6.1.2 Light

The light goes on when a creature is detected by the passive infrared sensor and is off when there is no creature there. The light must not flash too fast in a repetitive manner to ensure that we do not cause any physical harm to the people around.

Requirement: The light must be visible from 10 meters.

2.7.1 Switch

The switch is used to turn the batteries on and off which power the collar. This ensures that the batteries are not being wasted when the collar is not in use.

Requirement 1: The switch must be easily moveable.

Requirement 2: The switch must be able to stay in its state during light movements.

2.8.1 Phone

A phone will be used to receive the Bluetooth signal and will generate an alert saying that a pest has been detected. We will not be building a phone for the project. We will be creating the alert.

2.5 Risk Analysis

The bluetooth connection will be the greatest risk to the completion of the project. The connection is what links the phone and the collar that is shown in Figure 2. Without the connection we eliminate the notification system to the owner which cuts out half of the alert system. The risky parts of the connection include ensuring that we can connect to the user's phone and that we can send data from the collar over that same connection. These connections

will be challenging to use because no one in our group has built a system with a bluetooth connection so we need to learn how the elements will communicate with each other.

For the antenna, we need an antenna that will have low directivity to allow for the signal to radiate in all directions from the collar. This will allow for the user's phone to pick up the signal in any direction with respect to the position of the collar. As a consequence of having a low directivity antenna, it will also have a lower antenna gain. This means that our transceiver must have a higher sensitivity to ensure that it can pick up the bluetooth signal coming from the antenna on the collar.

3 Ethics and Safety

Depending on the size of the device that is wearable on the collar, it could pose a choking hazard to peoples pets. Even if a pet is not able to sufficiently swallow the device, it is still very well possible that if it were to come detached, then if a curious pet decides to tear it open there are numerous small and hazardous electrical components that could pose a threat. In order to mitigate this, several measures could be put into place. The most obvious is to ensure that the device is snuggly secure to the collar or harness such that even during frantic movement it will remain in place. This also could place responsibility on the owner to ensure that they have a proper fitting and adjusted collar. In addition, it could also be constructed to ensure significant damage must be down in order to crack it open to expose the circuitry. As a last measure of safety, it is possible that we could coat the device with an odorless coating that would be distasteful to the pet to make it not want to put it in their mouth again, discouraging it from eating or chewing on the device.

The housing for the device must be constructed in order to handle outdoor conditions to ensure that the pet is kept safe in all environmental conditions. The most common conditions would be to safeguard the electrical components from rain and mud. It would probably be in our best interest to ensure that the device could also handle some amount of underwater exposure as someone may have a pool in their backyard. A pet could be tempted to jump in while wearing the device thus exposing it to serious water damage.

IEEE's Code of Ethics, #9 states that we need "to avoid injuring others" which is a concern in our project since we will have a flashing lights on the collared device. We will prevent these flashing lights from randomly flashing in quick instances as it could pose a risk to someone that is sensitive to flashing lights (i.e. a person that has been diagnosed with epilepsy) [8]. To mitigate this, we plan on using a microcontroller to keep track of the timing of the lights to ensure that the flashing lights will behave in a more controlled manner. By ensuring that the light does not flash randomly we are ensuring that we keep the safety and the health of the user at our

utmost priority which follows IEEE Code of Ethics #1 by not endangering the creatures that are in the yard.

Another cause for concern regarding the lights on the collar is the actual brightness of the lights. When choosing a light to use for the device, we must be mindful that it is not so overly bright that it could risk potentially temporarily blinding someone. This could have numerous adverse effects, and it is known that bright light exposure to the eyes can cause some amount of permanent damage if exposed over a long period of time. A typical 100W bulb is around 1600 lumens, and if it is uncovered (without a lampshade), it can be rather bright up close. We will opt for an LED type of light as it will draw less power, but still be relatively bright. We will pick a light that will not exceed a typical luminosity value say in comparison to our 100W bulb example.

As noted in IEEE's Code of Ethics, #10, we as a team will make sure to hold each other accountable as well as encouraging each other to do our very best. If someone needs assistance, it is the responsibility of all team members to put forth his or her best effort towards aiding the one in need.

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