Dog Training Collar

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1. Introduction

1.1 Objective

Many dog owners face the problem of their dog breaking, damaging, or otherwise interacting with an object or area they shouldn't. For instance, dogs are often caught chewing electrical wires that may cause fatal injuries as well as accidentally running into and hitting vases that can cause much harm. The trouble becomes greaters for owners of multiple dogs. Such owners often experience the trouble of keeping one dog from eating the other's food, which may lead to either malnutrition or obesity.

When trying to keep their pets away from the area, dog owners often find themselves in a helpless situation of scolding the dogs when they catch them in action, but to come home later to the same problem. Thus, our solution to the problem is to be able to train the dogs even without the presence of the owner to punish the dogs realtime. The training collar will have a bluetooth-enabled system that will spray the dog in the face with citronella spray when the dog approaches the object or region of interest such that the action is instantly punished and thus offers an effective training mechanism.

1.2 Background

Citronella spray collars are not new when it comes to training dogs. As the spray has been tested to be completely harmless to the animal, with multiple products using this spray already in production, they have been a popular alternative to less humane products such as the shock collars. However, such products are more notable in a punishment mechanism for barking (i.e. Petrainer 998DRB Remote Dog Training Collar)**[1]** than as a training tool. Moreover, existing collars are mostly controlled by a remote control (i.e. WWVVPET Citronella Dog Training Collar)**[2]**, making the presence of the owner a must.

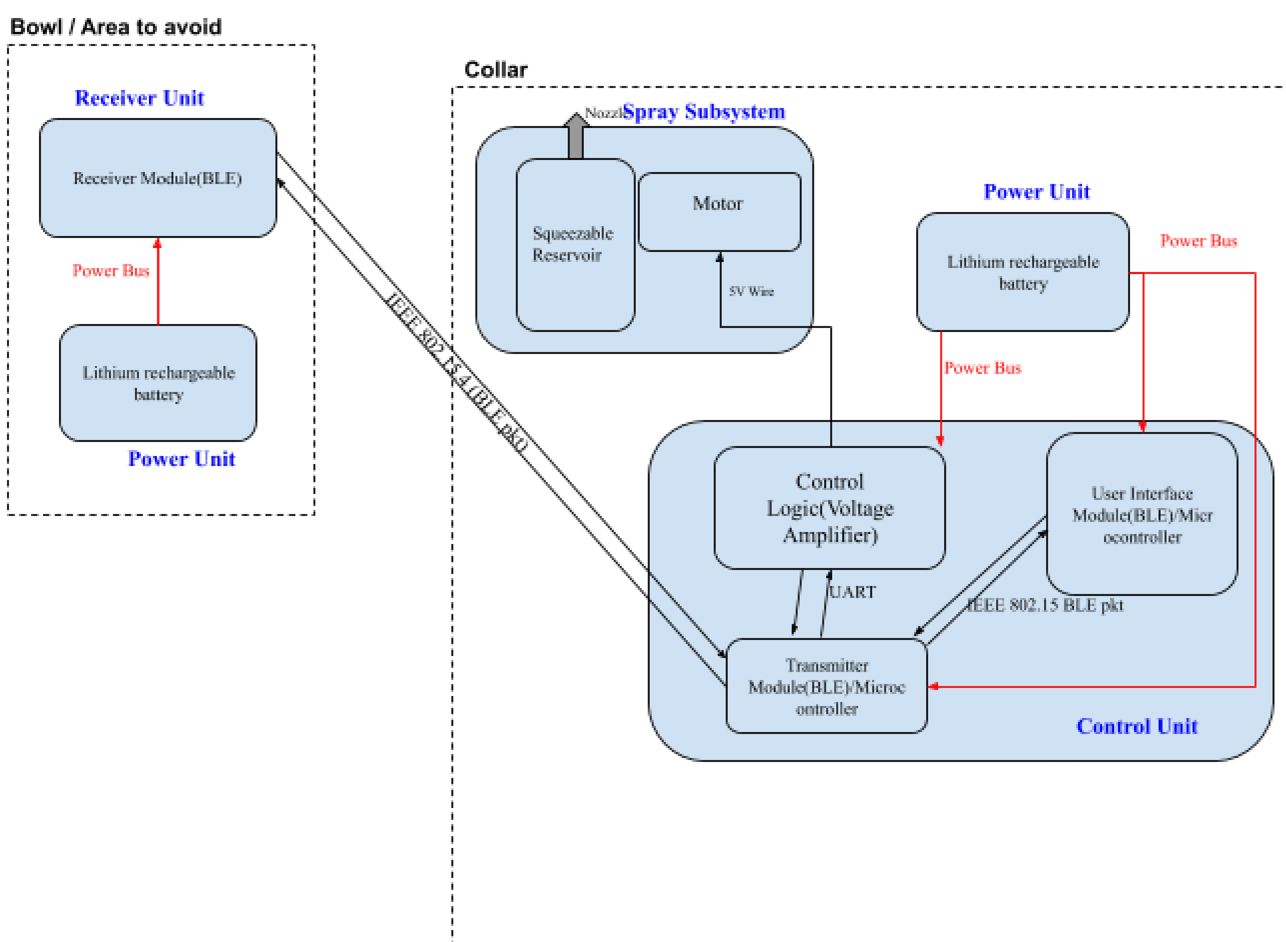
From this, we have determined that there is a need and market for collars that assist owners in training their dogs, while still being humane and not requiring their presence. We aim to target a similar but different problem as aforementioned, while increasing versatility when compared to competing products by using an always-on bluetooth transmitter and receiver that will detect when the dog is in the designated area. We will also provide the users to set the range (10cm, 10m, 100m) of clearance depending on their intention of use, which is provide a more flexible service than the existing options.

1.3 High-level requirements list

1. Receiver bluetooth module at the bowl or area to avoid and transmitter bluetooth module on the collar should interact successfully.
2. Spray should successfully diffuse citronella liquid upon receiving an activation signal from the control unit.
3. Control unit successfully handles the range input from the user such that the transmitter and receiver modules operate at the corresponding orders of magnitude, i.e. meters, decimeters, centimeters.

2. Design

2.1 Block Diagram



The left-hand-side of the design would be the receiver and its power subsystem, which would be set up at the area to avoid, i.e. the other dog’s bowl. The always-on receiver bluetooth module will be powered by a rechargeable lithium ion battery and receive BLE packets from the transmitter module in the collar’s control unit. Once it receives packets from the transmitter, it will send an acknowledgement package back to the transmitter to notify the control unit of the dog’s presence.

The left-hand-side of the design would be implemented on the dog’s collar. The control unit will consist of a user interface bluetooth module/microcontroller for input data to program the transmitter module’s power settings, transmitting bluetooth module to interact with the receiver module, and a control logic that will process the incoming and outgoing data and enable the spray unit. Each component of the control unit will also be powered by the rechargeable lithium ion battery. The spray subsystem will mainly consist of a motor to be activated by the control unit, as well as a squeezable reservoir with an output nozzle.

2.2 Physical Design

Dog With Spray Collar **[6][7]**

The green point on the structure would be the bluetooth signal transmitter, while the pink point would be where the citronella liquid will be sprayed upwards. The control, spray, and power units will be placed inside a box-like structure so that it can be attached to the dog’s collar. The receiving device will be a much simpler structure with an always-on receiver and power unit so that it can be placed in any desired space.

2.3 Functional (Block) Overview and Requirements

2.3.1 Control Unit

This unit contains or is responsible for interfacing with the three bluetooth modules in our device. The control unit PCB itself contains the transmitter and user-interface modules use bluetooth protocol to communicate with each other and the receiver module.

User-interface unit:

The user-interface module will be an nRF52832 module or similar. This is a bluetooth enabled SoC containing an ARM core and on-chip memory. This module must be capable of receiving bluetooth packages containing data from the user's mobile app. These will contain user settings for configuring the transmitter's maximum output power and therefore maximum range. The user-interface module will then write to the transmitter and adjust the output power or transmit power Tx accordingly.

Requirement:

- Must receive bluetooth packages from the user's mobile device.
- Must extract relevant information concerning distance settings from these packages.
- Must communicate distance settings to dedicated control unit.

Transmitter unit:

The transmitter module will also be a SoC with the ability to adjust its Tx transmit power. This is standard on all modern bluetooth chips so we do not anticipate this as a problem. The transmitter will constantly be sending and acquiring packages to/from the receiver unit, only stopping when interrupted by the user-interface module to adjust its range. When the transmitter successfully communicates with the receiver package, we know that the dog has entered the restricted region and the transmitter must assert a high voltage via its serial connection to the control logic.

Requirement:

- Must constantly output bluetooth packages to be processed by the receiver.
- Must be powered by a low voltage below 3.3V (lithium-ion battery).

Control logic:

The control logic is essentially a simple amplifier. When a low voltage is asserted by the transmitter module, the input to the motor will be low. When a high (3.3V) is asserted, the control logic amplifies this to the 5V required by the motor.

Requirement:

- Must assert high voltage to activate spray subsystem
- Must be powered by a low voltage below 3.3V (lithium-ion battery).

2.3.2. Receiver module

The receiver will be paired at all times to the transmitter and configured to output at max power, but respond with acknowledgment packages only when a package from the master transmitter is successfully received. With this simple functionality in mind, we would like to use a bluetooth module that is not a SoC with an ARM core and memory, though this may not be possible.

For reference, the three defined bluetooth classes are listed below with accompanying power specs. **[3]**

Class Number	Max Output Power (dBm)	Max Output Power (mW)	Max Range
Class 1	20 dBm	100 mW	100 m
Class 2	4 dBm	2.5 mW	10 m
Class 3	0 dBm	1 mW	10 cm

Requirement:

- Must constantly check for packages from the transmitter.
- Must signal the control unit to notify the spray subsystem once it receives the initial package.
- Must be powered by a low voltage below 3.3V (lithium-ion battery)

2.3.3 Spray Subsystem

For the spray unit, we will use a flexible material as a reservoir so that a motor can push the structure to spray the liquid out. The reservoir will need a thin nozzle that will output a small amount of liquid. The mechanical unit must respond to a high voltage asserted on the activation line, specifically on the rising edge of the signal.

Push Motor:

To implement such a spray unit, we will use a motor similar to ROB-11015 to implement the push movement.

Requirement: 5V voltage supply. Power to push liquid out upon voltage supply.

Spin Motor:
Another way we can implement this is to use the spinning movement of a motor(i.e. DCM015) to squeeze the reservoir, like a toothpaste tube.

Requirement: 1.5 or 3V supply. Power to roll the tube to push liquid out upon voltage supply.

2.3.4 *Power Subsystem(2)*

Lithium-ion battery (x2) and accompanying power bus to drive the circuitry in both the control unit, transmitter/receiver, and spray subsystem.

Requirement: Must be able to provide 1.7~3.6V range of power supply to the control unit, transmitter, and receiver units, as well as the spray subsystem.

2.4 Risk Analysis

The spray subsystem poses the greatest risk, as its ability to respond to a control signal and accurately squeeze the reservoir to spray the liquid without constant refilling will be a great challenge. Most ideally, we hope to use a squeezable bottle large enough to hold a considerable amount of citronella liquid to last about 3 days of use but not too big to cause discomfort on a dog's neck. The bottle will be attached to a nozzle so that with a pressure caused by the motor's movement liquid will be diffused from the outlet. One design concern would be that the nozzle should only allow liquid flow upon the control signal and contain liquid elsewise. With such a design, if the motor doesn't provide enough pressure to push the liquid high enough, it may not diffuse the fluid even if it holds more than enough.

After consulting with the machine shop staff, we have also looked into other possible options our intended design is impossible to implement accurately. We may also implement the spray subsystem with a box to hold the collar's structure with a pump and separate reservoir. It is possible that a small enough pump cannot be acquired such that the control unit and spray subsystem can be housed in a single box on the collar. In this case we would have two separate boxes housing the control unit and spray subsystem separately, with a wire interconnecting the two. This may also allow us to distribute weight around the collar more evenly. The nozzle may also be separate with tubing connecting it to the pump and reservoir. These are design decisions that are actively being considered as we search for the smallest, cheapest, and easiest delivery mechanisms that fit our needs.

3. Ethics and Safety

The most important relevant IEEE Code of Ethics**[4]** in the context of our project is the first, which states that our device must prioritize the safety and health of the consumer and the environment. Citronella oil is a well-studied and widely used product. According to the FDA, the product has been classified as GRAS (generally recognized as safe), and sees use as insect repellent and in dog training products such as other citronella dog spray collars.**[5]** The spray's scent is offensive to dogs and other animals, but not dangerous.

Furthermore we hold that our product is ethical in that it does not cause lasting psychological or emotional damage to the animal. Exposure is brief and is only surprising or at worst unpleasant to the dog. Our product compares favorably to shock collars for instance, which are legal but results in brief but sharp pain. Possible safety concerns mostly arise from the housing unit for our device. If this unit is not secure and subsystems are dislodged such as the power unit, reservoir, or other small parts, there is a risk of choking hazard for small children or the dog. Emphasizing build quality in our design will be crucial to avoid these issues.

In the development of the product, we will make sure to follow the seventh IEEE Code of Ethics**[4]** and openly accept honest criticism of other group members and course staff to help better the design of the product and not take credit of those whose work was involved in the progress. We will also respect all involved so that everyone is respected and not discriminated based on factors implied in the 8th IEEE Code of Ethics**[4]**. The project will involve no injuries caused due to malicious behavior according to the 9th Code**[4]** and keep a professionally supportive environment for all colleagues involved by the last Code of Ethics**[4]**.

References

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