# Revolutionizing Canine Training: Development and Evaluation of a Humane Vibrational Dog Collar

Diana Ochoa Mendoza
+15098319707
ochoadi@uw.edu

Quentin Fiessinger
+1425-372-6964
qfiess@uw.edu

Lucy Camblin
+1206-483-9614
lcambl@uw.edu

Mason Wheeler
+1360-975-8555
mwheel@uw.edu

## ABSTRACT

This project aims to enhance traditional dog training methods by developing a smart dog collar to measure the force of a dog's pull on its leash. This technology automatically adjusts the collar's vibration intensity in proportion to the measured force, providing immediate feedback to the dog without requiring the owner's constant attention or intervention. The accompanying mobile app pairs with the collar via Bluetooth, serving as a monitoring tool that displays real-time data on the dog's pulling behavior. This enables owners to track their dog's training progress over time and adjust their training methods accordingly.

The smart collar's design addresses the issue that conventional remote-controlled vibration collars rely heavily on the owner's judgment and timing, which can be inconsistent and ineffective. By automating the feedback to the dog, this product aims to facilitate a more consistent and objective training experience. The collar is equipped with a tension and compression load cell that can detect the pull force, and the microcontroller unit (MCU) processes this data to trigger the appropriate vibration response. The accompanying app not only displays the frequency and intensity of the dog's pulling but also stores this data to provide owners with insights into patterns and progress, potentially leading to more effective training outcomes.

In summary, this innovative collar system is designed to improve the dog training process, making it more efficient for the owner and more consistent for the dog, ultimately fostering a better understanding and communication between pet and pet owner.

## Keywords

Smart Dog Collar, Automated Training Device, Behavioral Monitoring, Canine Pulling Feedback, Bluetooth Connectivity, Mobile App Integration, Vibration Intensity Automation, Pet Training Innovation

**Figure 1: End-To-End Prototype**

## 1. INTRODUCTION

In this paper, we introduce an innovative approach to dog training with the development of a smart dog collar, integrating tension and compression load cell technology to measure the force exerted by a dog on its leash. Traditional training methods, including the use of pinch collars and manually operated vibrational collars, have raised concerns both in terms of ethicality and effectiveness. These manual vibrational collars demand constant alertness and input from the dog owner, often leading to inconsistent and delayed feedback due to the varied reaction times and judgments of individuals.

Our project is motivated by the need for a more objective, consistent, and humane training aid. While there is a growing interest in smart devices for pets, many existing products still rely heavily on user intervention, which can be both cumbersome and ineffective. Our device addresses this gap by offering automated feedback through proportional vibration, directly based on the force of the dog's pull, as measured by the collar's embedded components.

By transitioning away from the traditional methods that require significant owner input and potentially cause discomfort or stress to the animal, our device proposes a non-invasive and automated alternative. This aligns with modern animal behavior research, which advocates for positive reinforcement over punitive measures.

The background of our project lies at the intersection of pet care technology and behavioral science. Leveraging advancements in sensor technology and data analysis, our solution adapts to the individual needs of pets and their owners, prioritizing animal welfare. The companion mobile app, which connects to the collar via Bluetooth, serves as both a real-time monitoring tool and a data collection and analysis repository. This enables owners to make informed, data-driven decisions about their training approach without the need for constant manual input.

In the following sections, we will explore the technical specifications of the smart collar, the design and functionality of the mobile app, and the user experience. We will discuss the anticipated impact of our product on the pet care market, including its ethical advantages over traditional training methods. Additionally, we will cover the testing and evaluation process, societal and ethical considerations, and potential future enhancements, underscoring our commitment to ethical responsibility in pet training technology.

## 2. RELATED WORK

The field of pet training technology has seen various innovations aimed at improving the communication between dogs and their owners. Notably, remote-controlled training collars, which can deliver a range of stimuli including sound, vibration, and shock, are prevalent in the market. These devices require manual control by the owner, who must decide when and how intensely to administer these stimuli.

Research in animal behavior and training has also explored the effectiveness of consistent and immediate feedback in reinforcing good behavior. Studies have shown that timing and consistency are critical in helping a dog understand the consequences of its actions. Traditional collars fall short in this regard, as they rely on the owner's perception and reaction time, which can vary significantly.

Commercial products such as the BarxBuddy and the PetSafe Smart Dog Trainer collar offer variations of remote-controlled training with smartphone integration. However, these still require manual input and do not provide objective measures of the dog's behavior over time.

Patents in this space often focus on improving the safety and efficacy of these training devices. For instance, patents for collars with integrated sensors that detect barking and administer corrections accordingly exist, but they do not address the issue of leash pulling with real-time force measurement.

Our work differs from existing technologies in that it automates the feedback to the dog based on objective data rather than relying on the subjective judgment of the owner. By using a tension and compression load cell to measure the force of a dog's pull, our collar can administer a proportionate vibration response automatically. This immediate and consistent feedback aligns with best practices in animal training and is expected to enhance the learning experience for the dog.

The companion app represents a significant advancement over existing solutions by providing a data-driven training tool. It allows owners to track their dog's pulling behavior over time, offering insights that can inform more effective and personalized training programs.

In summary, while our project builds on the principles of behavior reinforcement and technology integration seen in current commercial products and research, it stands out by offering an automated, data-centric approach to dog training that emphasizes consistency, immediacy, and personalization.

## 3. TECHNICAL DETAILS

### 3.1 Overview

The device under discussion is a smart dog collar designed to assist in the training of dogs, particularly in leash behavior. It operates by measuring the force exerted by the dog against the leash and providing corresponding vibration feedback. This feedback is intended to help the dog associate excessive pulling with an immediate response, thereby aiding in behavior correction over time.

The block diagram in Figure 2 below illustrates our smart dog collar's design. It features a rechargeable 3.7V battery connected to a charging module, supplying power to an ESP32 microcontroller. The microcontroller processes inputs and controls outputs, including a tension and compression load cell that detects leash tension and a vibration actuator with a haptic driver (LRA motor) for vibration feedback. When the dog pulls too hard on the leash, the sensor sends a signal to the ESP32, which then triggers the LRA motor to vibrate. This vibration serves as a corrective signal to the dog.

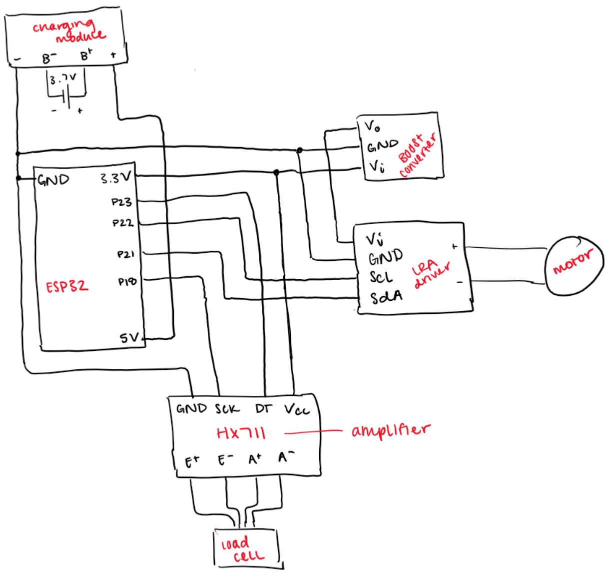


**Figure 2: Block Diagram of Hardware Components**

The smart dog collar is an advanced training device that works in conjunction with a mobile application to improve leash manners in dogs. It's equipped with sensors that monitor the force the dog applies to the leash and uses a vibration mechanism to provide instant feedback to the dog when it pulls too hard.

This immediate feedback is complemented by the mobile app integration, which gives dog owners a comprehensive overview of their pet's behavior. Some of the features designed to improve user experience, such as logging in and adding a dog whose pulling statistics the user would like to track, are shown in Figure 3 below.

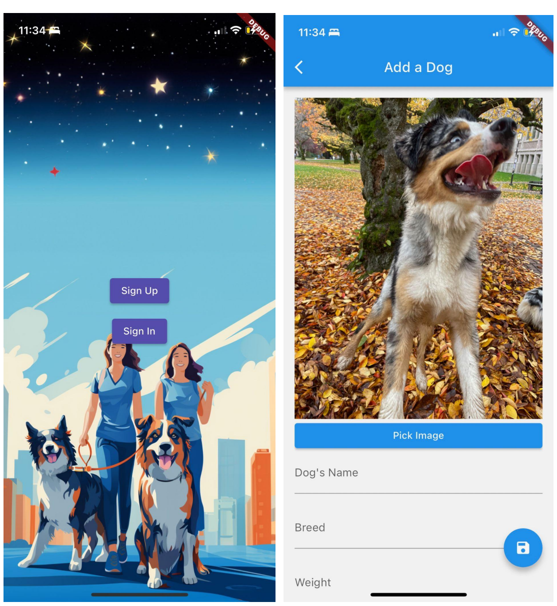


**Figure 3: User Interface Features on Mobile Application**

The app records each instance of leash pulling, providing real-time alerts and compiling historical data as shown in Figure 4 below. This data can then be used to identify patterns in the dog's behavior and to develop tailored training programs.

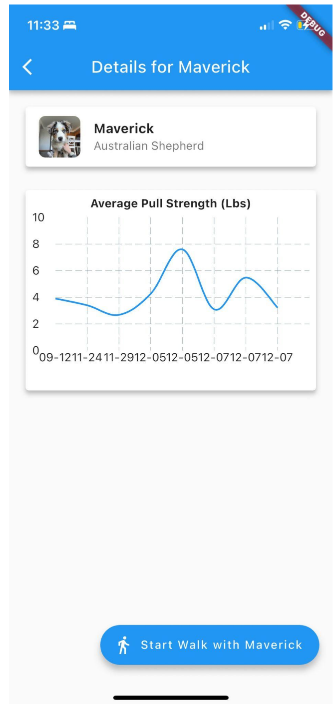


**Figure 4: Historical Data for Dog's Pulling Statistics**

Owners can track their dog's progress over time and adjust training methods as needed. If time allowed, the app would have also offered additional features such as training tips, customizable feedback settings, and social sharing capabilities. With this technology, the collar serves not just as a corrective tool, but also as a comprehensive training assistant.

## 3.2 Theory of Operation

The theory of operation is grounded in behavior reinforcement techniques where immediate feedback is crucial for effective training. When a dog pulls on the leash, the tension and compression load cell measures the force and sends this data to the microcontroller. The microcontroller then activates the vibration motors to provide feedback that is proportional to the force detected. This system aims to condition the dog's behavior by providing consistent and immediate feedback for undesirable actions (i.e., pulling on the leash).

The architecture integrates hardware components for sensing and feedback with software components for control and data analysis. The Bluetooth module allows the microcontroller to communicate with the mobile application via Bluetooth Low Energy, sending over data that is then processed and presented to the user in an understandable format.

A summary of the flow of information and the ways we expect the components to interact is illustrated in Figure 5.

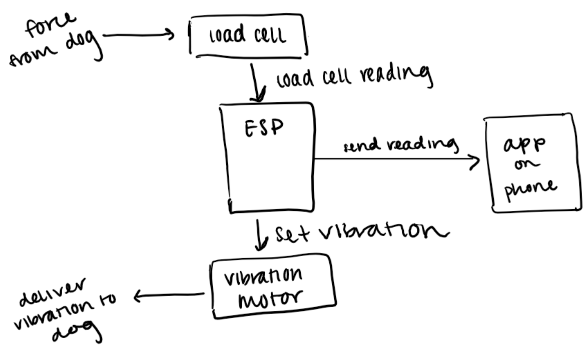


**Figure 5: Device's Flow of Information**

The smart dog collar operates on the principles of operant conditioning, a behavior modification method that reinforces desired behaviors through rewards or consequences. The collar's operation is a type of negative reinforcement, aiming to reduce the unwanted behavior of leash pulling.

### *3.2.1 Behavior Monitoring:*

- A tension and compression load cell is incorporated into the collar, which acts as the primary sensor to detect the force exerted by the dog on the leash. Whenever the dog pulls, this load cell measures the force applied.

### *3.2.2 Immediate Feedback:*

- This force data is instantly relayed to the microcontroller, the central processing unit of the collar, which interprets the force level.

- Based on pre-set thresholds, the microcontroller determines whether the force is excessive and thus whether to activate the feedback mechanism.

### *3.2.3 Feedback Mechanism:*

- If the pulling force exceeds the acceptable range, the microcontroller triggers vibration motors.

- These motors provide immediate, proportional haptic feedback to the dog, with the intensity of the vibration corresponding to the strength of the pull. This feedback is intended to discourage the dog from pulling and to create a psychological association between pulling and the resulting unpleasant sensation.

### *3.2.4 Data Communication and Analysis:*

- The microcontroller in the collar includes Bluetooth capabilities, which enables wireless communication with a mobile application.

- Through this connection, the microcontroller sends detailed data on each pulling event to the app, where it is logged and analyzed.

- The app processes this information, providing owners with both real-time alerts and historical data visualization, offering insights into patterns of the dog's behavior.

### *3.2.5 Training Strategy and Adjustment:*

- By reviewing the data collected, owners can identify if the dog's pulling behavior changes over time and can adjust the training program accordingly.

- The app could also suggest training strategies based on the dog's progress, providing a more customized and effective training regimen.

## 3.3 Implementation Details

### *3.3.1 Hardware*

The components outlined in the block diagram in Figure 2 were all valuable in producing our initial prototype. A comprehensive list of these components is:

- Jacobspart 3.7V type C charging port
- 3.7V lithium ion battery
- Comidox Step Up Power Module Voltage Boost Converter Board to 5V
- ESP32 Microcontroller
- Tinycircuits Vibration Motor with DRV2605 Haptic Driver for ERM and LRA
- Chenbo HX711 Weighing Sensor Dual-Channel A/D Module Pressure Sensor
- Tension and compression load cell

Each of these components were tested and we attempted to implement each of them into our finalized prototype. However, we did not incorporate the charging module, 3.7V battery, or boost converter into the final version of our first prototype. The reasons for excluding these components are outlined in Section 4: Evaluation and Results. The circuit shown in Figure 6 highlights the components that were included in our final implementation. An image of this working circuit is shown in Figure 7.

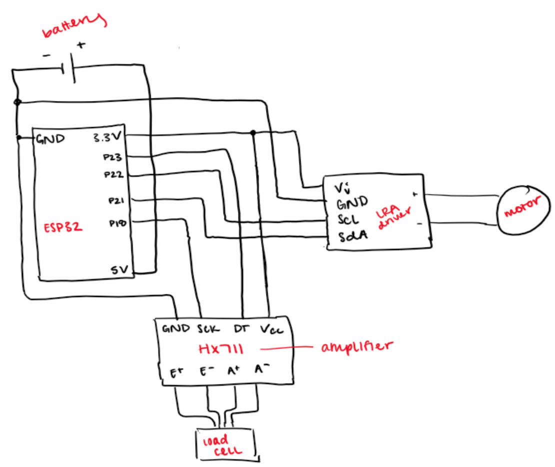


**Figure 6: Block Diagram of Hardware Components Implemented in Finalized Prototype**

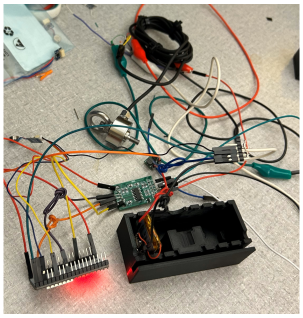

**Figure 7: Disassembled Collar, Battery-Powered Circuit**

An additional implementation for the vibration motors that we considered for our design was to use a custom PCB and power the vibration motors with a PWM signal from an analog output pin on the ESP32. The custom PCB included a 1k ohm resistor, a BC337 transistor, and a 1A 50V rectifier diode. This completed PCB is shown in Figure 8 below.

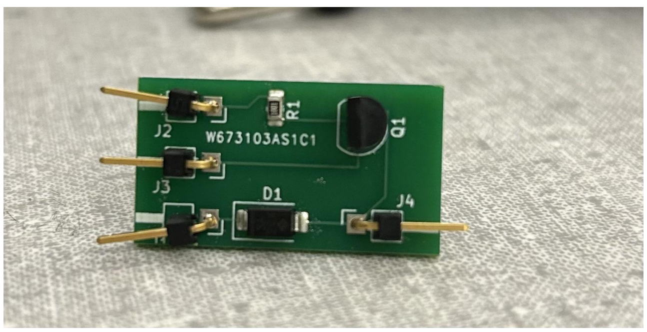


**Figure 8: Custom PCB for Vibration Motors**

Upon further research, we decided against using a PCB in our design simply to save space. We discovered the component mentioned above with vibration motors already attached to a haptic driver board, which eliminated the need for a PCB. It also eliminated the need for a PWM signal being output from the ESP32, which simplified the programming necessary for our prototype.

To house the electrical and hardware components of our device, we designed a 3D-printed encasement with SolidWorks. The design is shown in Figure 9 and it includes features such as designated areas for the load cell, boost converter, ESP32, charging module, and battery.

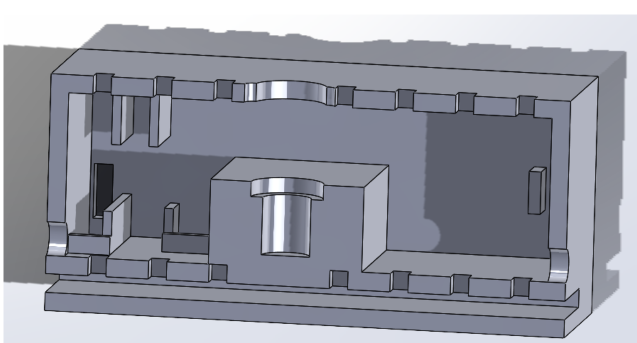

**Figure 9: SolidWorks Model of Hardware Encasement**

### *3.3.2 Software*

We utilized programming tools such as Flutter, Arduino IDE, and several Arduino libraries to complete the software aspect of this device. Flutter was used to develop the frontend and backend of our mobile application, with some of the code rendering the frontend shown in Figure 10 below.

```
return Scaffold(
  appBar: AppBar(
    title: Text(
      widget.viewModel.deviceConnected
          ? "Connected to ${widget.viewModel.dog_name}'s Collar"
          : "Connecting...",
      style: themeData.textTheme.headline6,
    ), // Text
    backgroundColor: themeData.primaryColor,
  ), // AppBar
  body: Padding(
    padding: const EdgeInsets.all(16.0),
    child: ListView(
      children: [
        if (widget.viewModel.deviceConnected && isInitializing)
          Padding(
            padding: const EdgeInsets.symmetric(vertical: 20.0),
            child: Text(
              initializationProgress,
              style: themeData.textTheme.subtitle1,
            ), // Text
          ), // Padding
        Padding(
          padding: const EdgeInsets.symmetric(vertical: 8.0),
          child: ElevatedButton(
            style: ElevatedButton.styleFrom(
              primary: const Color.fromARGB(255, 226, 226, 226),
              onPrimary: Color.fromARGB(255, 18, 53, 177),
            ),
            onPressed: isWalking ? stopWalk : startWalk,
            child: Text(isWalking ? 'Stop Walk' : 'Start Walk'),
          ), // ElevatedButton
        ), // Padding
        ListTile(
          leading: Icon(Icons.speed, color: themeData.highlightColor),
          title: Text("Current Reading: ${safeDisplay(currentReading)} Dog Power"),
        ), // ListTile
        ListTile(
          leading: Icon(Icons.trending_up, color: themeData.highlightColor),
          title: Text("Average Pull During Walk: ${safeDisplay(avgPull)} Dog Power"),
        ), // ListTile
        ListTile(
          leading: Icon(Icons.fitness_center, color: themeData.highlightColor),
          title: Text("Pulls over Threshold: ${safeDisplay(pullCount)}"),
        ), // ListTile
      ],
    ), // ListView
  ), // Padding
); // Scaffold
```

**Figure 10: Flutter Code for App Development**

The ESP32 was programmed in Arduino IDE, and the program flashed to the ESP32 was designed to handle initialization of the amplifier for the load cell, initialization of the LRA motor's haptic driver, as well as initialization of Bluetooth Low Energy to work between the app and the ESP32. This program is intended to execute in a loop after initializations occur, where every 10 ms, a load cell reading is retrieved and evaluated against three predefined thresholds. These thresholds determine the corresponding vibration that should be delivered if any vibration should be delivered at all. This program then ensures that BLE is enabled and the connection is successful before sending the current sensor reading to the app. A summary of this program structure is illustrated in Figure 11 and the code written for this loop is shown in Figure 12.

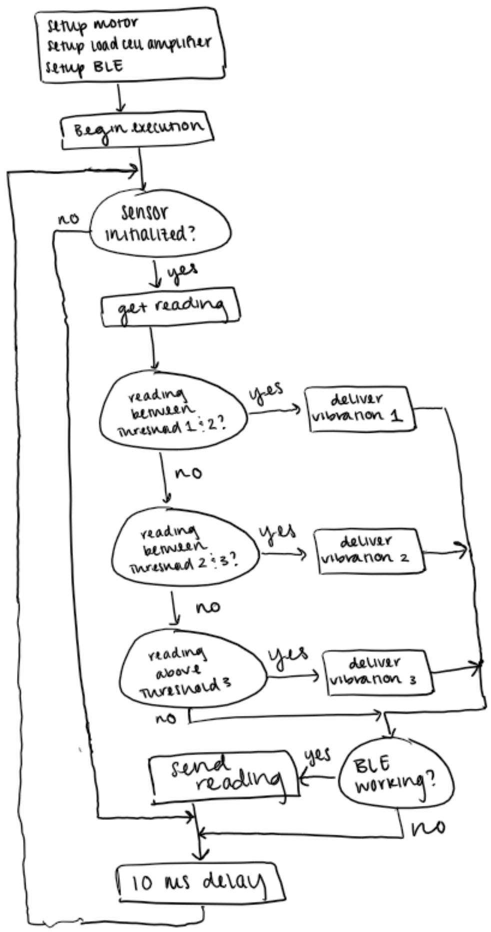


**Figure 11: Block Diagram for ESP32 Code**

```
if (!ready) {
  initializeSensor();
} else {
  long filteredReading = scale.read() - avgReading - avgDiff;
  Serial.println(filteredReading);
  // Play the effect
  if (filteredReading >= lowThresh && filteredReading < medThresh) {
    drv.setWaveform(0, 123);
    drv.setWaveform(1, 0);
    drv.go();
    digitalWrite(ledpin, HIGH);
  } else if (filteredReading >= medThresh && filteredReading < highThresh) {
    drv.setWaveform(0, 119);
    drv.setWaveform(1, 0 );
    drv.go();
    digitalWrite(ledpin, HIGH);
  } else if (filteredReading >= highThresh) {
    drv.setWaveform(0, 47);
    drv.setWaveform(1, 0);
    drv.go();
    digitalWrite(ledpin, HIGH);
  } else {
    digitalWrite(ledpin, LOW);
  }

  if (deviceConnected) {
    pCharacteristic->setValue((uint8_t*)&filteredReading, sizeof
    (filteredReading));
    pCharacteristic->notify();
  }
}
delay(10);
```

**Figure 12: ESP32 Code for Project Execution**

# 4. EVALUATION AND RESULTS

The prototype has the expected functionality and meets the goals that we outlined in the PRD, which were to deliver a product that vibrated based off of the force delivered to it. To evaluate whether or not our prototype functioned as intended, we established the following performance metrics:

- The device delivers the correct vibration for the correct event.
- The force of each pull is transmitted via BLE from the ESP32 to the app.
- The vibration delivered relates to the force readout.

To test our prototype, we first ensured proper force readouts using a variety of methods. We printed readings on the serial terminal of Arduino IDE when the ESP32 was powered by a laptop, and we compared these values to what was displayed on the app. These results were consistent. To test vibrations, we ensured that the vibration motors had the capability to deliver at least three vibration patterns with differentiable vibration intensities. We could effectively differentiate between the three vibration patterns that we chose and we could effectively trigger these vibrations separately at various thresholds. We incorporated this with the force readouts and used various force readings as the thresholds that would trigger these vibrations. Finally, we tested that different pull strengths produced different vibrations. We were able to detect the three thresholds that we established for the vibration motors, and we did indeed identify the following: when the collar experiences a greater pull, the vibration delivered becomes more intense and more irritating. These results were consistent when our circuit was disassembled and when all the components were combined into our final prototype.

Upon testing our prototype, we encountered some issues and areas for improvement in future iterations of this device. We had three main issues that need to be addressed in future prototypes. We first ran into issues configuring our charging port and powering the ESP32 with a 3.7V battery. We observed that while we were able to attain functionality of the thresholds of vibration based on pull measurement from the sensor, we were unable to get the Bluetooth to the app to work at the same time. The second issue revolved around the charging port and battery itself where when the charging port was plugged in, it would overheat rapidly. The charging port is supposed to come with a limiter circuit to ensure optimal charging. With that in mind we did not have enough time to dig deeper into the limitations of the battery or the charging port. Finally, we believe we fried our first ESP when we ran two vibration motors of the same pin. This resulted in us limiting our design to just one motor which severely dampens the impact of the vibration. Another observation we made when testing our device was that powering the vibration motors with 5V vs. 3.3V did not result in noticeably different vibrations. Therefore, we excluded the boost converter from our final prototype to save time and space in our encasement for the electronics. Future progress would include figuring out how to run multiple vibration motors and determining an appropriate voltage for powering the vibration motors in order to make the resulting vibrations and thresholds more noticeable and significant.

## 5. DISCUSSION

The embedded system in the smart dog collar is working effectively. Its central component, the microcontroller, accurately processes data from the leash tension sensor and controls the vibration feedback mechanism efficiently. This quick response is crucial for training the dog effectively. Additionally, the system's Bluetooth connectivity allows for smooth communication with the mobile app, enabling real-time monitoring and data analysis for dog owners. Overall, the system demonstrates reliable performance and meets our design goals from our initial PRD well.

Looking ahead, the primary focus would be on enhancing the precision of the collar's vibration feedback. By fine-tuning this aspect, the collar could potentially improve the dog's learning curve, thereby expediting the training process. Complementing this hardware refinement, significant strides can be made in optimizing the accompanying app to enrich the training experience. Personalized training programs and more sophisticated analytics could offer owners a deeper insight into their dog's behavior, allowing for more targeted training strategies.

Beyond these immediate improvements, considering alternative applications for the underlying technology could open up new markets. For instance, similar principles of behavior reinforcement could be applied to develop devices for human use, such as in physical therapy to correct posture through vibration feedback. Furthermore, the device's communication technology could be adapted for discreet command signaling in working dogs serving in security or assistance roles.

Reflecting on the journey so far reveals the critical role of user-centric design and the value of early and diverse testing scenarios. Understanding how different breeds and temperaments respond to the collar's feedback has likely provided numerous insights, highlighting the importance of adaptability in the product's design.

For future iterations, focusing on the user interface and experience of the app will be paramount. A more streamlined and intuitive interface can significantly reduce the learning curve for new users. Additionally, incorporating customizable vibration patterns could cater to the individual sensitivities of different dogs, potentially enhancing the effectiveness of the training.

Furthermore, looking into the sustainability of the product design by considering the environmental impact and incorporating sustainable materials could be a decisive factor for eco-conscious consumers. Enhancing energy efficiency to extend the battery life would add convenience for the users, minimizing the need for frequent recharges.

Finally, establishing a robust customer service framework and an active community feedback loop can ensure that the product continues to evolve in alignment with user experiences and expectations. This commitment to continuous improvement and user engagement will be key to maintaining the relevance and effectiveness of the smart dog collar in the years to come.

## 6. CONCLUSION

In conclusion, the development of a smart dog collar with integrated tension and compression load cell technology represents a significant step forward in pet training and owner interaction. Our system not only automates the feedback necessary for effective leash training but also provides invaluable data for owners to track and analyze their dog's behavior. This project stands out by offering a practical solution that enhances the well-being of pets and the convenience of their owners.

The device demonstrates the potential for technology to positively influence pet care and training. With the data provided by the collar, owners can make informed decisions to improve the training process, which could lead to a reduction in the stress associated with leash training for both dogs and their owners. Future developments could include advanced features such as GPS tracking, more nuanced vibration patterns, and integration with other smart devices in the home.

Our work contributes to the growing field of smart pet products and offers insights into how technology can be leveraged to improve the human-animal bond. The implications of this technology stretch beyond mere convenience, potentially transforming how we train and interact with our pets.

## 7. RESEARCH SECTION

Our vibrational dog collar project aims to improve dog training methods by focusing on humane practices. The collar's design is informed by current research in dog training, particularly studies highlighting the negative effects of aversive methods and the benefits of reward-based approaches. This project represents not just an engineering challenge but also an opportunity to enhance the relationship between dogs and their owners through technology.

The study by Vieira de Castro et al. (2020) provides insights into the detrimental effects of harsh training methods on dogs. This research serves as a critical reference point for our project. In designing the vibrational dog collar, our primary objective is to offer a training tool that overcomes the pitfalls associated with traditional harsh methods, particularly shock collars. Shock collars, known for delivering electric shocks to correct undesirable behavior, have been criticized for their potential to cause harm and distress to dogs. Such methods not only trigger immediate discomfort but can also lead to long-term psychological issues, including increased anxiety and fearfulness. These negative effects can undermine the dog’s overall welfare and strain the dog-owner relationship. In contrast, our vibrational collar employs a fundamentally different approach. It utilizes gentle vibrations as a means of communication and guidance, rather than punishment. When the dog exhibits unwanted behavior, such as pulling on the leash, the collar responds with a mild vibratory sensation. This sensation is designed to be noticeable but not distressing, serving as a cue for the dog to adjust its behavior. The operational principle of our collar hinges on a tension sensor that detects when the dog pulls on the leash. Upon detection, the collar emits vibrational feedback, which is immediate and directly linked to the dog’s action. This feedback loop is consistent and predictable, allowing the dog to learn the association between pulling and the resulting vibration. Over time, this understanding can lead to a reduction in pulling behavior, achieved without the use of fear or pain. Our approach aligns with more humane and compassionate training practices. By steering clear of fear-inducing techniques, we aim to foster a training environment where the dog can learn effectively while maintaining a positive state of mind. This method not only supports the dog's well-being but also promotes a more trusting and cooperative relationship between the dog and its owner.

The study by Yin et al. (2008) highlights the effectiveness of reward-based training in modifying dog behaviors such as excessive barking, jumping, and crowding at the door when visitors arrive. This approach aligns closely with the principles behind the design of our vibrational dog collar, which integrates seamlessly into reward-based training regimes. In Yin et al.'s study, dogs were trained using a remote-controlled food reward dispenser to reinforce desired behaviors. This method of positive reinforcement proved successful in teaching dogs to adopt a calm and controlled demeanor, particularly when faced with the common trigger of visitors at the door. By rewarding the dogs for remaining in a down-stay position with treats, the study demonstrated that consistent, positive reinforcement is key in modifying canine behavior effectively. Our vibrational dog collar operates on a similar principle, through a combination of negative punishment and positive reinforcement. When a dog pulls on the leash, the collar emits a gentle vibration. This vibration is not harmful or painful but serves as an attention cue to the dog. As soon as the dog stops pulling and the leash slackens, the vibration stops. This cessation of vibration acts as negative punishment – the removal of an "undesirable" stimulus when the dog exhibits the correct behavior (not pulling). To complement this, owners can immediately follow up with positive reinforcement, such as giving treats, verbal praise, or affection when the dog walks calmly without pulling. This dual approach mirrors the training method in Yin et al.'s study, where dogs were rewarded immediately after displaying the desired behavior. For instance, if an owner is training their dog to walk calmly by their side, they can use the collar's vibration as a cue for the dog to slow down. Once the dog adjusts its pace and the leash relaxes, the vibration stops, and the owner can immediately reward the dog with a treat or praise. This immediate feedback loop helps the dog to quickly associate the cessation of the vibration with positive outcomes, reinforcing the desired behavior of walking calmly. The integration of such technology in dog training aids not only in reinforcing good leash manners but also significantly enhances the dog-human bond. The use of gentle, non-aversive methods like the vibrational collar, combined with positive reinforcement, ensures that the training experience is stress-free and enjoyable for both the dog and the owner. This approach fosters a positive learning environment, crucial for effective behavior modification and the overall well-being of the dog.

The research by Dale et al. (2017) highlights the potential benefits of aversive training techniques in certain contexts, such as reducing unwanted behaviors in dogs. However, a key concern in implementing such methods is ensuring they are conducted in a way that prioritizes the animal's wellbeing. This is where our vibrational dog collar project plays a crucial role, as it seeks to balance effective training with humane treatment. Our vibrational dog collar is designed to provide a gentle, consistent response to undesirable behaviors like leash pulling. Unlike traditional methods that may use pinch collars or other harsh techniques, our collar employs subtle vibrations. This method is less intrusive and stressful for the dog, aligning with the principles of positive reinforcement training. For instance, when a dog begins to pull on the leash, the collar emits a mild vibration. This sensation is enough to get the dog's attention without causing discomfort or fear, similar to a tap on the shoulder rather than a punitive shock. One significant advantage of our collar is its consistency. Dogs thrive on consistent feedback during training, which can sometimes be challenging for owners to provide, especially those new to dog training or with busy schedules. The vibrational collar automates this feedback process. Whether the owner is distracted or not entirely consistent with commands, the collar ensures that the dog receives the same response to a specific behavior. This consistency aids in quicker learning and a clearer understanding for the dog of what is expected. Moreover, the collar's design can be particularly useful in situations similar to those described in Dale et al.'s study, where techniques were used to avoid dangerous or undesirable behaviors. For example, if a dog tends to chase after cars, the vibrational feedback can be used to interrupt and redirect this behavior safely and humanely. It serves as a cue for the dog to pause and refocus its attention, potentially averting harmful situations

Looking ahead, we plan on integrating advanced technological features into the collar to enhance its functionality. The incorporation of data analytics and AI could allow the collar to adapt its response based on the dog's behavior over time, offering a more personalized training experience. Moreover, we plan to expand the capabilities of our accompanying app. This app, already a cornerstone of the project, will be enhanced to offer more in-depth insights into the dog's behavior, track training progress, and possibly suggest training modifications. This addition aims to provide owners with a comprehensive tool that supports and guides the training process.

In conclusion, our vibrational dog collar project goes beyond being a purely engineering challenge. It represents our determination to transform dog training by combining effectiveness and compassion. As we progress, we remain dedicated to incorporating ongoing research findings into our design, guaranteeing that our collar remains a leader in humane and efficient dog training technology.

## 8. ACKNOWLEDGEMENTS

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## 9. REFERENCES

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