“Pawsitive” Pet Feeder

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***Abstract* — In today's busy world, pets have become an integral part of families, owners are becoming increasingly concerned about their pets' health and well-being. This growing health concern has resulted in a surge of products in the market, as a result, the demand for pet feeders has increased.**

The “Pawsitive” Pet Feeder is a new type of pet feeder that uses both optics and electronics to automatically feed the user's pets whenever they are not around. Instead of worrying about getting home in time to fill a bowl, the owners can breathe easy knowing their pets are not being neglected.

***Index Terms* — Optical Sensors, Mobile Application, Motors, Animals, Safety in the Home**

I. Introduction

In households, pet owners are responsible to ensure that their animals are being taken care of every day, these animals need to be fed accordingly to ensure that they get their daily nutrients. The portions given to the pets depend on a lot of factors such as Breed, Age, Gender, Bodyweight & Composition, and many more. These details are easily neglected from unforeseen events such as rushing to work or getting distracted from tasks around the house. When this happens, the owners tend to overfeed the pets, and this leads to obesity that negatively impacts the animal's health.

Another common issue, within a household that contains multiple pets, is ensuring that all the pets are equally fed, or fed according to their size (for example big dog and small puppy). Often, whenever an owner is trying to feed multiple pets, all the pets start rushing toward the bowls and fight to dominate each other's food. This causes an imbalance of portions when trying to ensure they consume enough daily nutrients.

In situations where the pet is sick, the doctor gives medication or prescribes specific food for the pet to consume to ensure they regain health. This can be dangerous if another pet gets a hold of the sick pet’s food. Therefore, the owner needs a way of ensuring which pet is eating from which bowl.

Lastly, canned food is a great alternative to ensure a hydration boost as this food usually is portioned and contains a well-rounded diet that targets all kinds of needs. However, often if the pet is not quick enough to finish the food, the moisture evaporates causing the remaining food to harden. This makes the pet become a picky eater, and they will be less inclined to eat their meal. For that reason, the design of the pet feeder consists of a lid, which will ensure that no bacteria can grow within the food, meaning the food will stay fresh longer.

An automatic pet feeder can help manage the stress owners deal with by dispensing the proper amount of food at the same time each day, ensuring that their pets are taken care of. With this, the owner will only need to focus on refilling the dispenser whenever the food inside is low. And changing the default setting of the pet feeder to ensure it matches the owner's personal dog, these changes are, the amount of food to dispense, time set to dispense food, etc. The design we have planned out consists of the ability to feed multiple pets from one device, this also means that the feeder can feed up to three different pets of the same type (up to 3 cats or 3 dogs). The project will consist of motors, gears, belts, cameras, sensors, and WiFi functionality to ensure that these complex requirements are fulfilled.

1.1 Motivation

In the modern world nowadays, 70% of U.S households (90.5 million homes) own a pet as of 2022. In which 69 million U.S. households have a pet dog, compared to 45.3 million with a cat[1]. With families busy with their own career lifestyle, often these pets get neglected. Such neglect can result in pets illness, starvation and through extreme cases this can lead to the death of the pet. The pet owners then tend to either underfed these pets due to neglect, or overfed them due to trying to make up for the times they have forgotten to feed their pet. Both the cases as mentioned lead to pets misery and poor health. Therefore, this was the main key motivation of the production and design to this Senior Design project. This will not only be something that has already been created in the market, but the additional Optical features adds a unique feature that has not been implemented in the market nowadays. This can also improve the quality of life for these pets and solve the issue pet owners face in their day to day life.

1.2 Goals

The overall goal in this project is to create an automatic system that requires minimum user input in order to ensure that the owner does not need to worry about feeding their pet around their busy schedule. These three pets can be a configuration of 3 dogs or 3 cats There are a few core goals we must hit, which include:

- Having a power supply that allows the system to function properly.
- Use optics and phonics to recognize pets with the correct tag to access each individual feeding bay.
- System will store approximately two days' worth of food, equivalent for three pets.
- The food dispenser dispensing the user's desired amount per feeder.
- Have a self-opening and self-closing lid system when the pet arrives or leaves to the pet feeder device.

Our advanced goals are how Pawsitive Pet Feeder can be unique to the market. They are:

- Create water resistant LED collar tags to avoid damage while not altering the pets' lifestyle
- Create an application for the user to have the ability to control the system remotely for functions.

1.3 Objectives

The project consists of many different components and thus the following objective that are listed below defines the measured actions that will be taken in order to achieve the goals in 1.2. This includes:

- Utlizing a wall outlet adapter.
- Creating a camera system that recognizes RGB colors from LED collar tags in order to open an assigned feeding bay.
- Utilize the use of 3D printers, and maximize components to drive cost of materials down
- Calculate the amount of food to be dispensed within one rotation and calculate to the correct serving.

Our advanced objectives are to:

- Use IPX-4 LEDs
- Use sensors within the system as received data
- Create an android mobile application for the user to use to set certain times when the pets' food should be dispensed and to dispense the desired amount of food.

1.4 System Flowchart

To be understood as a complete system, a flowchart is helpful to understand the processes

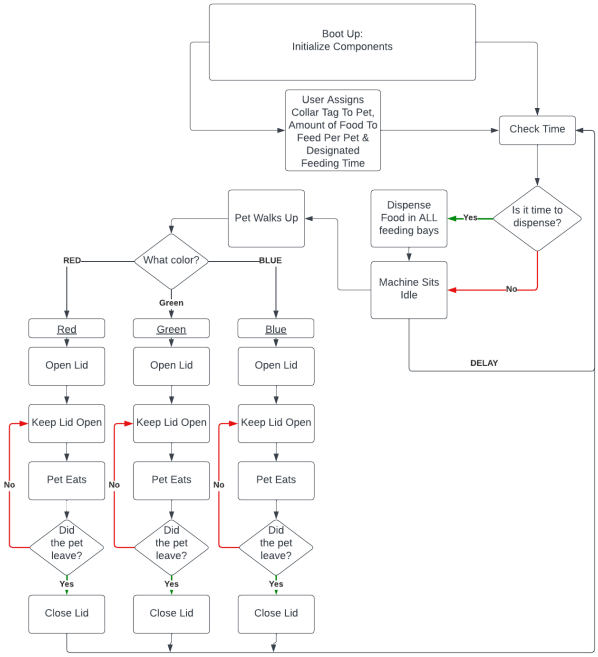

Figure 1: Pawsitive Pet Feeder Operational Flowchart

In order for the system to function, all users must register first. This is so that the user can input data that is needed for the pet feeder to operate in a normal capacity. For example, assigning each pet to a feeding area, and placing how many cups are needed when the system is activated. Once a pet walks up, the assigned feeding bay will open and will remain open until the pet leaves.

II. Subsystems

2.1 Color Detection

The feeder will detect the color from the LEDs in the collar tag with the camera which is connected to the Raspberry Pi 4.

2.1.1 Raspberry Pi 4

The Raspberry Pi 4 is an inexpensive Raspberry Pi microprocessor. The Raspberry Pi 4 is capable of doing all of the fundamental tasks of a computer, such as navigating the internet, playing high-definition video, making spreadsheets, typing documents, and playing games, among other things.

For our project, the Raspberry Pi 4 will act as the main base of operations for the product, allowing the system to process information and relay signals. From

camera, to activating the food dispenser in the correct bay, and opening and closing the lid. Information from the Raspberry Pi 4 also needs to relay to the mobile application to alert users on the food storage running low or a malfunction.

2.2 Collar Tag

The collar tag will have the ability to be integrated into any normal collar so that pets of all sizes can use it. Each pet will have a different color LED (Red, Green or Blue). In front of the LED, we will use a Fresnel lens to diffuse light in order to enable a larger detectable distance for the camera system to detect. Below is a diagram schematic of the collar tags and a picture of the tag without its housing.

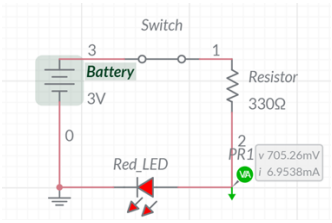

Figure 2: Red LED Multisim

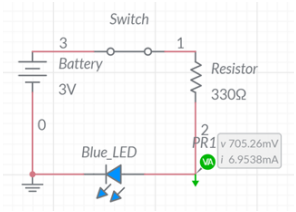

Figure 3: Blue LED Multisim

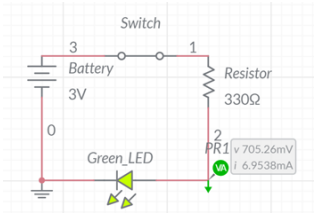

Figure 4: Green LED Multisim

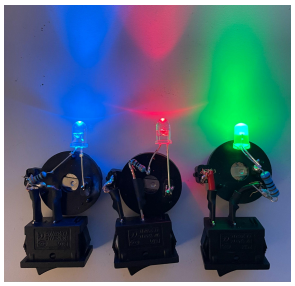

Figure 5: Red, Green and Blue LEDs

2.2.1 LED

Light emitting diodes, also known as LEDs, are semiconductor devices that emit light when current flows through them. They are cheap, light and low power devices. They are great for our design because we are aiming to use the least heavy materials for the collar tags. Also, we plan to compensate for the low power by placing a Fresnel Lens in front of it to diffuse light and make it visible to the camera system from a farther range.

2.2.1.1 LED Safety

LEDs are more commonly used in products and replacing other types of lighting. This is Pawsitive Pet Feeder as it will be used to determine which pet is approaching for food and when the pet leaves to close the lid. When it comes to LED emissions and the health effects on the eye, we are using visible and infrared LEDs for the design. These types of LEDs are considered safe, with no need for separate LED safety standards. Based on current exposure limits, most visible LEDs and infrared LEDs pose no acute hazard to the eye.

Risk Group	Philosophical Basis
Group 0 (Exempt)	No photobiological hazard
Group 1 (Low Risk)	No photobiological hazard under normal behavioral limitations
Group 2 (Moderate Risk)	Does not pose a hazard due to aversion response to bright light or thermal discomfort
Group 3 (High Risk)	Hazardous even for momentary exposure

Table 1: Exposure Assessment and Limits For LEDs

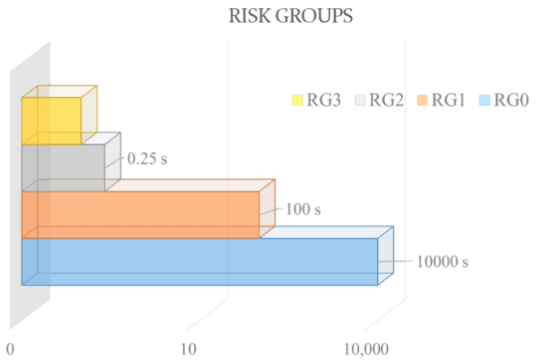

Figure 6: Risk Groups and Exposure Time (Courtesy of FireFlier)

As we are working with Animals, we will be working with LEDs within Risk Group 0. This risk group poses no photobiological hazard to individuals according to EN 62471: 2008 Paragraph 6.1. Exposure time for risk group 0 is approximately 10,000 seconds. It may pose a risk only when looking at the fixture continuously and directly longer for that. 10,000 seconds equates to 3 hours of continuous exposure. Therefore, with the activeness of a pet, it poses little threat to the animal. However, the design is aware of this and will ensure that the photobiological safety of the LEDs and the safety of the animals remains a priority.

2.2.2 Fresnel Lens

Fresnel lenses diffuse light by adjusting the beam light source to parallel light, this process significantly improves the brightness. This type of lens will be used inside the collar tags in front of the LEDs to improve its brightness. This is useful because the light from just the LED might not be enough for the camera system to detect the color from a far distance. With the fresnel lens, we can ensure the pet has its lid already open by the time it reaches the feeder. This lens is a low-cost alternative, as well as lighter weight compared to a regular lens. This is an advantage to our design because the pets will be always wearing this collar, and it will be easier for them if it's light. Some downsides to using this type of lens is that the image quality will decrease, but for our purposes of light diffusion, this is not an inconvenience.

2.2.1 Lens System

To choose the right Fresnel lens that will be located in the collar tag to meet project performance requirements (increase detection range to 2 ft) and constraints (1 inch diameter as this is the diameter of the 3V battery we are using to power the LEDs), we used Zemax.

2.3 Food Storage System

The Pawsitive Pet Feeder is able to store the pet's dry food supply that will feed directly into the Food Dispenser system. Food storage for the dry pet food must meet critical safety standards as it will be consumed by the animals. One of the main core features of the Pawsitive Pet Feeder is that there will be Food storage available for up to 4 liters of food.

2.3.1 Food Supply for Cats

For cat food, we have decided to use Meow Mix's serving suggestions for cats.

Weight of Cat (Ibs)	Dry Food Feeding Amount Per Day (Cups)
5 to 9	½ to 1
10 to 14	1 to 1 ½

Table 2: Serving Sizes for Cats [2]

The amount listed will provide the amount of food that a cat should eat for their size and their activity level. However, the volume of food a cat needs to eat depends on how many calories are in its food and the energy demands of the cat.

2.3.2 Food Supply for Dogs

For dog food, we have decided to use Purina's serving suggestions for dogs.

Weight of Dog (Ilbs)	Dry Food Feeding Amount Per Day (Cups)
3 to 12	⅓ to 1
13 to 20	1 to 1 ⅓
21 to 35	1 ⅓ to 2
36 to 50	2 to 2 ⅔
51 to 75	2 ⅔ to 3 ⅓
76 to 100	3 ⅓ to 4 ¼
100+	4 ¼ plus ¼ cups for each 10 Ibs of body weight

	over 100 lbs.

Table 2: Serving Sizes for Dogs [3]

When considering how much food to feed a pet dog, three factors should be considered: Weight, Activity Levels and Age. It is important that the user should adjust the amoutn of food that the pet is fed per day depending on these factors.

2.4 Food Dispenser System

The Food Dispenser must be able to dispense the desired amount of food with a target time of 60 seconds for 5 cups. Using a food storage system, the food will travel downwards towards a 3D printed feeder tube. Within the feeder tube, houses a 3D printed spiral connected to a Nema 17 motor that, when activated, will push the food outwards to the bowl. As a group, we have calculated that a single cup of food will require 9 rotations from the screw. This is helpful as the user input can change the amount of food needed per feeding bay.

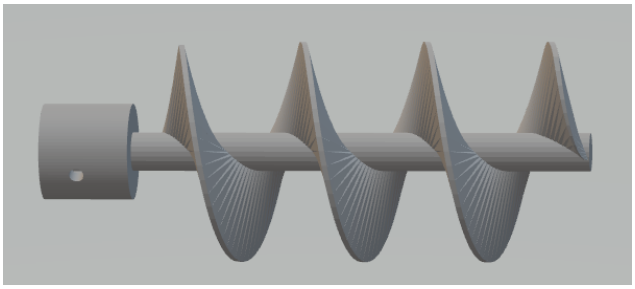

Figure 7: Food Dispenser Spiral

2.4.1 NEMA17

The NEMA17 is a stepper motor that we will be using for our dispenser. This motor has a rated voltage of 12V DC, a step angle of 1.8 degrees,200 steps per revolution, and a pull in torque of 3.2 kg-cm. The NEMA17 is able to push the amount of food from the storage area into the bowl with an assist from gravity.

2.5 Lid System

The purpose of the lid motor is to rotate the lid open and closed. As we are using 3 bowls, there will have to be a motor for each bowl's lid. Speed and responsiveness is important. Safety is a priority with the lid system as it will be the one system that will come in contact with pets. If the lid is too slow during the closing procedure, the pet may get hurt as they would like to get more food through the dispenser. If the lid is too fast, it has a possibility to injure the pet with the lid's force created by its speed.

2.5.1 HiLetgo ULN3003 4-Phase Stepper Motor

The HiLetgo ULN3003 4-Phase Stepper Motor is a speed down stepping motor that can choose external voltage for power supply via pins. The motor has a diameter of 28mm and a voltage of 5V. The stepping angle is 5.625 x 1/64, with a speed reduction ratio of 1/64. When the item is shipped to the group, it will come with the motor driving board that is welded and tested, and a 5V four phase five lines stepping motor. [5]

2.5.2. IR LED Detection

The IR LEDs will function alongside the Photodiodes to detect the pet's head and to tell the system when to close the lid. The LEDs that were chosen will be invisible to the pet and the user but are close enough to the visible spectrum that they can be seen with a conventional cell phone camera, which will add ease to the customer giving them a sense of comfort that the device is functioning properly. The LEDs will be placed far enough away from the food that they will never intentionally encounter excessive foreign debris such as pet food crumbs or shed fur but will be close enough that there will be no problem detecting the pet's head no matter the breed or size. The LEDs will also be protected by a thin plastic screen to further reduce any chance of being blocked out by foreign material. Below is a diagram schematic of the IR LED Detection system.

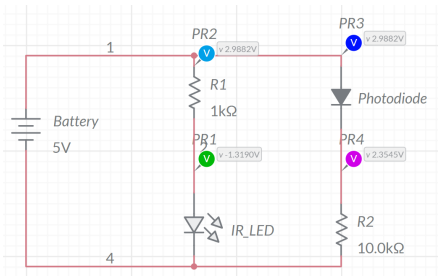

Figure 8: IR LED Detection Multisim

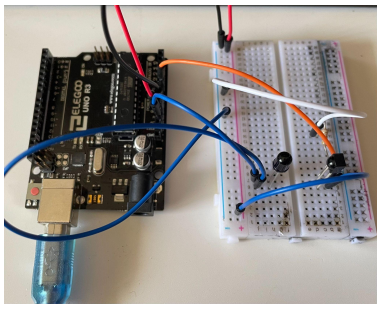

Figure 9: IR LED Detection Testing

2.6 Application

For the mobile application, we used MERN (React Native). The application can be run through Expo Go. The database (MongoDB) contains user info, and their pet images. We used react native to create login, signup, home, and many other pages. These pages use Express to access the database, and make the appropriate changes. We also use Redux methods to send alerts, and errors for the user and developer, if any such event arises.

We also use SendGrid for user verification through email. The user information is automatically deleted from the database if he/she/they do not verify their account within 5 minutes of creation. For security purposes, the password of the user is also encrypted using bcrypt, and is encrypted before the API call is being made.

We also use internal camera options of the mobile to access the user's front and back camera, as well their gallery. We have also connected to Raspberry Pi using Express to send information to the hardware through the mobile application.

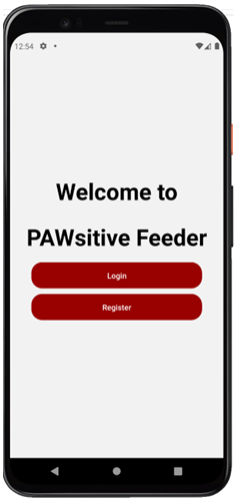

Figure 10: Welcome Page For Mobile Application

III. Exterior Housings

3.1 Project Housing

Our housing component was crafted using PVC sheets. PVC sheets were used due to it's easy finishing, durable but lightweight design. Additionally, it is impervious to moisture, mold, mildew, termites and insects. Importantly, it is ready to install with fasteners, nails and screws.

Figure 11: Housing of the "Pawsitive" Pet Feeder

3.2 LED Collar Housing

Our LED Collar housings were printed using the Texas Instruments Laboratory at UCF. We decided to include a lid in the design of the housing for the user to easily turn on and off the LED, as well as, replacing the battery when it runs out.

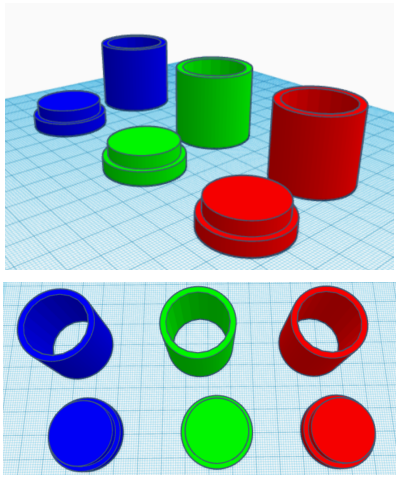

Figure 12 & 13: 3D Design of Collar Tags

IV. Testing

Several individual and combined tests were conducted on the system in order to integrate all the software and hardware.

4.1 Color Detection

To test the color detection we had the collar tags turned on within the distance range detection of the camera 10 times for each color. We made sure to repeat this at three different houses with normal ambient light.

4.2 IR LED Detection

To test the IR LED Detection, we made sure to have motion around the IR LED 30 times at each bowl. We made sure for each test, the photodiode received the light from the IR LED and transformed to a voltage that the processor would identify to keep the lid open. As soon as that voltage wasn't present, a countdown started to close the lid.

4.3 Food Dispenser

The test for the food dispenser motor is the time taken for the motor to dispense the maximum amount of cup for the pet to eat. In this case we tested for 5 cups and ensured that the time taken for the motor to dispense the food was less than 60 seconds.

4.4 Lid System

The test for the lid system is the time taken for the lid to open or close during activation. As the lid system is determinate of the IR LED detection, the test will start from when the lid motors receive the signal. As for our goals and objectives, we are targeting a completion time of under 30 sections to open or close the lid.

V. Results

4.1 Color Detection

The camera successfully detected the three different colors from the collar tags from a 2 ft. distance range.

4.2 IR LED Detection

The systems successfully increased the signal transmitted from the IR LED to the photodiode when motion was sensed around the bowl to keep the lid open. In the same way, when the signal dropped the lid closed.

4.3 Food Dispenser

Upon our testing we found that it takes about 49 seconds for the feeder to dispense 5 cups of food. This means any food dispensed by the user will take less than 60 seconds. Which is in-line with the requirements of our design.

4.4 Lid System

Testing the lid system was a success. The lid quickly opened within 1 second on testing. However, the plastic was not attached at the time of testing so it is still variable to extra time needed. To aid this, we can decrease the speed for more torque, allowing the motor to lift the plastic cover for the pet to access the bowl.

VI. Conclusion

We recognize that there are automatic pet feeders out there, our design would like to take the best features from existing products and integrate them into one.We took into consideration constraints to avoid or improve on problems during our development. The"Pawsitive" Pet Feeder will be able to recognize a color assigned to a pet, open and close the assigned feeding bay's lid, and dispense at a designated feeding time.

Biographies

Isabella Pardo is a senior at the University of Central Florida and will graduate with a Bachelor Degree in Photonic Science and Engineering. Currently, Isabella works as an intern in Hyperspectral Imaging at NASA and will work as systems engineer at Lockheed Martin upon graduation.

Ervin Dupuis is a senior at the University of Central Florida and will graduate with a Bachelor Degree in Computer Engineering. After graduation, Ervin plans on pursuing a career in Computer Engineering.

Jocelyn Ignacia is a senior at the University of Central Florida and will graduate with a Bachelor Degree in Computer Engineering. Currently, Jocelyn works as an intern in Florida Space Institute and plans to continue in the electrical engineering industry after graduation.

Ayush Shashikant Pindoria a senior at the University of Central Florida and will graduate with a Bachelor Degree in Computer Engineering. He has focused on developing scaleable and well documented hardware code and learning about digital electronics. He enjoys working collaboratively on projects and aims to work with his colleagues to provide serves that are beyond reach to the people in his country.

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References

[1] Lemonade, Team. “These Pet Ownership Statistics From Around the World Shed Light on the Most Common Pets, Costs of Owning a Pet, and the Rise of Pet Health Insurance.” *Lemonade Pet*, 4 Sept. 2022, www.lemonade.com/pet/explained/pet-ownership-statistics.

[2] “Cat Feeding Tips | Meow Mix.” *Meow Mix®*, www.meowmix.com/cat-care/cat-feeding-tips. Accessed 3 Nov. 2022.

[3] “Dog Feeding Chart: How Much Should I Feed My Dog?” *Purina*, https://www.purina.com/articles/dog/feeding/how-much-should-i-feed-my-dog.

[4] Pendergast, Robert L., et al. “Complete Guide for Ultrasonic Sensor HC-SR04 with Arduino.” *Random Nerd Tutorials*, 7 Oct. 2021, https://randomnerdtutorials.com/complete-guide-for-ultrasonic-sensor-hc-sr04/.

[5] *Amazon.com: Hiletgo 5pcs uln2003 28BYJ-48 4-Phase Stepper Motor with 5V ...* https://www.amazon.com/HiLetgo-ULN2003-28BYJ-48-Stepper-4-phase/dp/B00LP