Bird. Initiated. Rubish. Disposal.

Healing the World Through Bird Power

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1. Executive Summary

1.1 Motivation

For decades, governments and societies around the world have attempted to discourage the act of littering. Some have implemented educational programs to educate the public and others enforce it by law and threat of force. In the United States, public programs to incentivize proper waste disposal have mostly worked, at least for younger generations. However, a non-negligible amount of trash is still generated in public spaces, whether due to inconvenience or neglect.

All current solutions for public clean up involve extensive energy cost. Whether using volunteers, convict labor, or salaried street cleaners, they all require active effort to keep streets clean.

The most optimum solution for this issue is to ensure that people themselves stop littering, either by increasing accessibility to and educating the public about proper waste disposal or incentivizing products to be reusable and non-disposable. In the absence of that, we believe that harnessing the omnipresence of birds would be beneficial for the health of our public spaces.

The B.I.R.D. project will be a device that can be used to train birds to pick up trash. Birds are very smart creatures and there have been many occasions where they have been trained with enough consistency. Since birds have such free access to many locations, they would be great candidates to picking up different bits of trash. The birds will bring in trash and be rewarded as long as they bring the right things in. This is a classical conditioning for birds to show them that depositing trash to the B.I.R.D. is beneficial for them.

This will be a great project to take on as this could very heavily benefit areas that are littered with trash around the world. Along with trash pickup there are many different fields of expertise that can come together in this project. This makes it the perfect opportunity to learn more about our respective fields of Photonics Science and Engineering, Electrical Engineering, and Computer Engineering. This also helps us learn to learn more about finding the experts and getting help from all different fields to come together.

1.2 Introduction

This project will design and build a device that will reward avian creatures to collect small sized trash from the environment around them into a temporary storage container for humans to collect and properly dispose of.

Using the theories on operant conditioning, we will design a bird feeder that will attempt to train birds to collect and submit trash in the housing for later collection. Operant conditioning refers to a psychological theory that proposes that behaviors can be learned through the use of and association with stimuli that either reinforce or discourage behavior. In our project we plan to use positive stimuli, such as food, to incentivize birds to repeat the behavior of submitting valid trash items into a designated terminal. In a sense, we are simply building a skinner box that rewards trash disposal for birds.

The birds will interact with the B.I.R.D. through two terminals. One allows them to deposit items into the analysis chamber and the another will deliver a food pellet as a positive reward to associate trash in the B.I.R.D. with food in the birds.

1.2.1 Competition and Inspirations

This project was originally proposed by our sponsor Justin Phelps. He saw a video of someone building a bird feeder that trained crows to collect and deposit coins into it. We of course have been influenced by similar projects, but to our knowledge, no one has tried to commercialize or mass produce such bird feeders.

1.3 Goals

1.3.1 Core Goals

For a conditioning machine to have a chance at training birds, the most critical element is quick and decisive activation of the reinforcing stimuli. The B.I.R.D. must be able to respond to a trash submission within a short period of time in order for the bird to associate the action of submitting trash with receiving food.

Another critical task is for consistent trash detection verdicts. It would be disastrous for bird conditioning for a valid trash item to not be rewarded or the opposite of a non-valid object being rewarded. Such cases could ruin the conditioning or form unanticipated behaviors.

Since the B.I.R.D. is meant to be placed outside in public spaces, the B.I.R.D. should be as weatherproof as possible. To the bare minimum, it should be able to survive rain and humid conditions. The most critical sections for weatherproofing are the food storage, so the food does not spoil, and the internal circuitry and mechanical actuators.

1.3.2 Advanced Goals

With the core goal of timely and consistent delivery of food secured, adding supplementary stimuli when the food is dispensed should help associate the B.I.R.D. with food, which in turn, associates food with trash delivery. Auditory and optical stimuli could easily be added to the system, such as bells or LED lights. However, the vibrations from the mechanical trash sorter and food dispenser should provide enough complementary stimuli.

For further reliability, the B.I.R.D. should be rated for extreme weather such as hurricanes and flooding. We do not expect the systems to operate during such conditions, but it should be able to withstand adverse weather.

Since the B.I.R.D. is meant to operate outside for long stretches of time, the B.I.R.D. would benefit from being able to autonomously service birds for around a week. This would involve a power supply that is able to power all systems with a moderate amount of service for a week. Applying solar cells could alleviate the power demand during the day. And the last aspect for autonomous operation is that the storage units are large enough to hold a moderate amount of trash and enough food for such volume accepted.

1.3.3 Stretch Goals

Since training an image recognition software is challenging enough, we believe that for testing the performance of this project, the B.I.R.D. will be trained only to detect cigarette buds for their simple shape and consistency.

The Stretch Goal then is to design the B.I.R.D. to accept and detect multiple types of trash. That maybe pieces of plastic, bottle caps, plastic wrappers, etc. However, opening up to such a broad selection of items may prove challenging because of the different optical properties, not to mention increasing the chance for birds to submit something that may get stuck inside the housing or analysis chamber.

As with any ordinary bird feeder, aesthetics matter. If we have time, it would be nice to design the housing and external components to look visually appealing.

1.4 Objectives

In order to implement selective service to birds, we need a way to detect whether a bird is ready to interact with the terminals of the device. A mechanical and electrical system will unlock access for the bird to interact with the terminals and prevent any other animal from accessing the terminals. The bird then would deposit a trash item into the drop chute for the analysis chamber. Then the B.I.R.D. determines whether it's approved or not and reacts accordingly. It releases food if the item was approved and a stimuli could play if it an item was detected but not approved.

1.4.1 Housing

The B.I.R.D. will be designed as a structure that keeps the inner compartments safe from the weather. There will be enough volume within the structure to store food and trash compartments.

The birds will interact with the device via two terminals. One terminal allows the bird to drop items into a trash analysis chamber to validate whether it is a valid trash item. The other terminal allows food pellets to drop from a storage container to reward the bird upon successful submission of valid pieces of trash. However, the B.I.R.D. will need a way to discard not disapproved items separate from the approved storage.

The B.I.R.D. will have at least two storage containers for the accepted trash and food storage respectively. The B.I.R.D. is being designed for weekly maintenance for trash removal, food replenishments, and battery life without recharging.

1.4.2 Sensing

The device will make use of an optically designed sensor to detect and exclusively service birds, another optical sensor to validate whether the submitted item is an acceptable object, and a simple motion sensor to wake the B.I.R.D. from a power efficient sleep mode.

To give timely and consistent responses for the birds, we need to design sensor systems for image processing of trash and birds in the trash analysis chamber and outside the terminals respectively. The bird sensor should be weatherproof, low light or night vision, and disregard natural noise such as rain, fog, shadows, etc. There should be a more rudimentary motion sensor that enables the more energy intensive image recognition sensor to save power. The trash analysis sensor should be able to view the entirety of the chamber and be calibrated for the mostly constant image conditions inside the device.

Preferably both sensors will consume as little power as possible, but if not, the low energy motion sensor to wake the device should prove sufficient enough to save power.

1.4.3 Identification

As a natural extension of the previous objective, the B.I.R.D. will need an image recognition software that can approve or disapprove a submitted item.

The software being used will be trained models on their respective systems for birds and for trash.

1.4.4 Actuators

To get objects to where they are designed to go, we need to design mechanical and electrical systems to dispense a certain amount of food and to collect or disregard submitted items from the trash analysis chamber. Preferably simple mechanical systems to avoid wear, maintenance, and to function in most weather conditions.

And lastly, a mechanical and electrical system to close and open the terminals for use. Such doors should be designed to optimize weather proofness.

1.4.5 Power

For the B.I.R.D. to operate autonomously for weeks, we need to design a power system that will supply all the subsystems in on battery alone for at least a week. And to integrate a solar array for continuous charging of the battery.

As much as we would love a totally independent power source, the B.I.R.D. will need charging ports and access to power functions from the outside.

In order to achieve long lasting independent operation, the B.I.R.D. will initiate a sleep mode when not in use. Then, through the use of low power motion sensors, the B.I.R.D. will awake for higher level processing.

1.4.6 Embedded Processing

We will design the control and processing units to coordinate and operate all the subsystems. The B.I.R.D. will be designed for ease of maintenance and should include a battery charge indicator, activity log, and perhaps a recorded image log. For further ease of use, the B.I.R.D. should have externally accessible data ports to interphase with the processor for activity logs or error messages.

Along with battery charge indicators, there should be some indicator for food running low and trash being full. This could easily be accomplished with a transparent section on the storage units or with a more complex electrical sensor and display.

To be able to handle the heavy computational cost of image recognition software, the B.I.R.D. will operate using two sets of processors. One energy efficient central processor that will manage and control all subsystems and a higher power processor for the image recognition.

1.5 Required Components

1.5.1 General Summary

The primary consumer of the B.I.R.D. is intended to be local governments and large universities in a densely populated area. To meet the needs of the consumer, part specifications are given. The overall housing unit is still in the design phase; however, the electrical and optical hardware constraints are shown.

Table 1.5.1.1. Electrical Component Specifications

Component	Parameter	Specification
Power Supply	Charge Density	Power all functions for a week
PCB	Central Control	Low power draw
Solar Cell	Charge Amount	Enough to charge the sleep draw
Motors	Reliability	Operate without fail 95% of the time
Image Processor	Computational Power	Deliver a verdict within 2 seconds of taking the image.
Status Displays	Human Interface	Simple, cheap, and weatherproof

Table 1.5.1.2. Optical Component Specifications

Component	Parameter	Specification
Objective Lens	Focal Length	150mm
Transmission Grating	Groove Density	1200 grooves/mm
Focusing Lens	Focal Length	50mm
CMOS Sensor	Frame Rate	40-70fps
Fish eye lens??		

1.5.2 Project Constraints

We want this system to be easily placed in different areas so the size must be compact as possible. With this compact design there needs to still be enough space for birds to enter. There also needs to be enough surface area on the roof of the design in order to hold solar that is efficient enough to charge a small battery. To keep up with its versatility of placement it needs to be lighter weight in order to be placed anywhere.

Power constraints in our project call for designs that allow for this unit to operate outdoors. With the information processing we are trying to accomplish, solar panels may be utilized to run as many non-processing subsystems as possible. The power source must be able to handle two separate image processing systems.

Time constraints present obstacles to completing our project that will need to be heavily considered. One major time constraint to completing the project is the amount of data sets that will need to be created for birds in the image recognition process. We will more than likely need to simplify our data sets to match the most common species present on UCF’s campus, and then a stretch goal would be a larger database for birds common in other areas or campuses. In addition to this constraint, the data sets associated with our trash recognition process will be even more challenging to implement given the amount of time for our project. There may need to be a similar and possibly more dramatic simplification of trash data sets to account for time.

Another anticipated time constraint will be the time required to capture evidence of birds interacting with the system. The housing and operations will need to be tested for a fairly large amount of time if footage is to be captured. Therefore, proof of concept will be our main focus, and an actual demo outdoors will be secondary and serve as a stretch goal that we could plan time for later next semester.

Lens systems as well as boards that can be used for this project already exist; however, due to cost constraints and our specific designs, we will build our own imaging systems and design our own PCB. Complicated bird housing units have been created in the past, but adding in the feature of birds collecting trash will change our designs significantly from previous works. Due to this, we must select every element specifically to reach our goals and meet our budget.

The system needs to be appealing for birds to want to enter and get food. In order to attract birds we need to have a design that is inviting for birds, meaning that we will need to have a small amount of bird psychology to get them landing in more. There needs to be some way that the birds can see that there is food inside to be rewarded with so that they feel more inclined to bring things.

1.5.3 Budget

Table 1.5.2.1. Budget

Item	Price	Quantity
Microcontroller	$10	1
Image Processor	$50-$150	1
IR Sensor	$50	1
Motor	$10	5
Battery	$23	1
Solar Cell	$50	1
LEDs	$5	10
Objective Lens	$50	2
Collimating Lens	$30	2
Focusing Lens	$50-$100	2
Diffraction Grating	$20-$30	2
CCD	$150-$200	2
Custom PCB	$20-$30	1
Housing Material	$20	1
Total	$548-$758	

1.6 Project Milestones

Table 1.6.1. Milestones for Senior Design 1

Milestone	Start Date	End Date	Milestone Description
Form Group	8/22/23	8/22/23	Begin the process of forming a group and beginning to set up proper communication methods.
Brainstorm Ideas	8/22/23	8/28/23	Brainstorm ideas that will meet the scope of engineering projects for senior design.
Project Selection	8/28/23	9/1/23	Selecting one of the projects from the list of prospective projects from brainstorming.
Divide & Conquer	9/1/23	9/15/23	The official presentation of our project idea and a small list of requirements, parts, and general ideas of our plans.
Website	9/1/23	12/5/23	Setup up the website that will have all of our supporting documentation, as well as some extra introductions and descriptions.
Divide & Conquer Meeting	9/20/23	9/20/23	Meeting with committee and senior design professors to discuss our proposal.
Divide & Conquer Revision	9/20/23	9/25/23	Make revisions to our proposal and any other details that will be transferred to the bigger paper later.
60 Page Draft	9/20/23	11/3/23	The draft of what will come to the final paper. This will include some of the needed topics from the final paper requirements.
100 Page Report	9/20/23	Unknown	This will be the final meeting to go over any formatting issues before the final submission of the report.
Final Paper	9/20/23	12/5/23	This will be the final project report and will have all of the design specs, philosophies, and research that we did as a group.
Prototype	11/1/23	12/5/23	This will be a working prototype of our design that will showcase what our design can do.

Table 1.6.2. Milestones for Senior Design 2

Milestone	Start Date	End Date	Milestone Description
Order Parts	1/8/24	1/15/24	This will be the time to finalize all the parts we need and make sure everything is ordered and on the way.
Build Subsystems	1/15/24	2/15/24	This will be time to get all the subsystems working independently of each other
Integration	2/15/24	3/15/24	Bring all the subsystems together to work out what does and doesn't work together
Testing	3/15/24	4/15/24	After getting all the subsystems together this time will be meant for testing everything together and seeing how it works in practice.
Presentation Prep	4/15/24	4/24/24	Getting all the necessary materials ready for the presentation of our materials
Final Presentation	4/24/24	4/30/24	This will be the final presentation for Senior Design 2 marking a finished working product

Figure 1.5.2. Hardware Flow Diagram

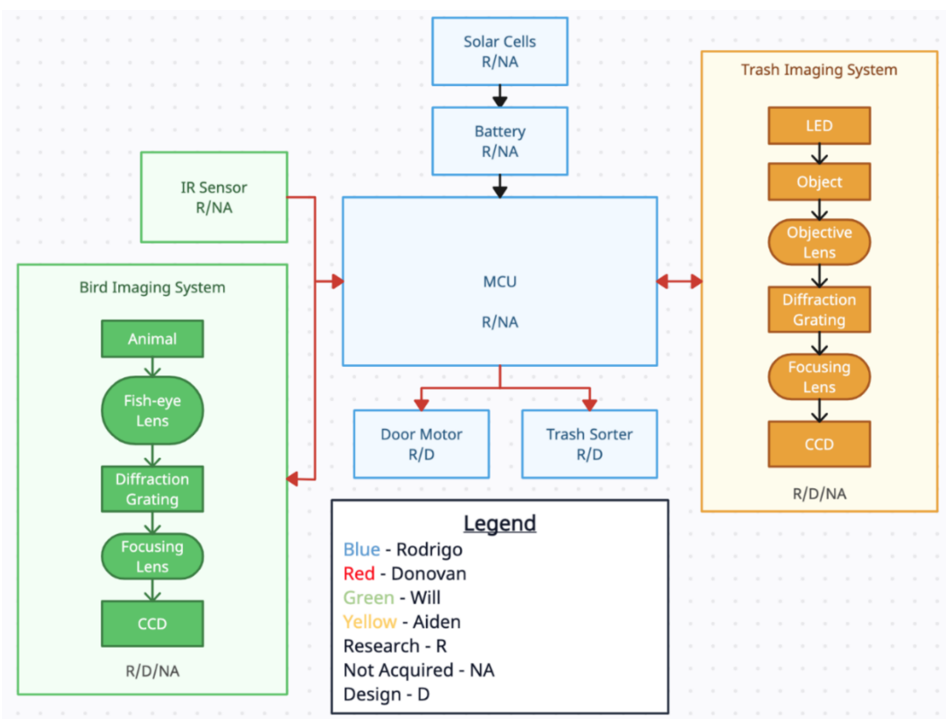

Figure 1.5.3. Software Flow Diagram