# Avian-Bioremediation-Inator

EEL 4914 | Senior Design I | Fall 2023 | Group 12

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# 1. Description of Project

## 1.1. Introduction

The purpose of this project is to design and build a device that will incentivise avian creatures to collect small trash from the environment around them into a temporary storage container for humans to collect and dispose of.

The device would accomplish the objectives by releasing food pellets whenever a bird submits a valid trash item to hopefully condition the birds into repeating the desired behavior.

The device will make use of sensors to detect and exclusively service birds, another sensor to validate whether the submitted item is an acceptable trash item, and a simple motion sensor to enable higher level sensors in order to be more energy efficient.

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's trash. The other terminal allows food pellets to drop from a storage container to reward the bird upon successful delivery of trash.

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

## 1.2. Motivation

Garbage is something that has plagued us humans for a long time now. There are too many times that people are just throwing trash wherever they see fit, rather than finding the trash can. Not only that, but animals can often get into trash and just throw it all over the place. This can be detrimental to many different communities of both humans, and animals alike, as many different kinds of trash could be poisonous to certain animals if consumed. Trash is also just visually not appealing to communities. The quality of life goes down with trash being everywhere. But what if there were a way to help clean up all this trash?

With our Senior Design project, we will design a system 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 very easily. 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 bringing trash is good.

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.

## 1.3. Objectives

To design and build a system that detects whether a bird is ready to interact with the terminals of the device. A mechanical and electrical system that will unlock access for the bird to interact with the terminals and prevent any other animal from accessing the terminals. That system should also help waterproof the device while not in use.

To design mechanical and electrical systems to dispense a certain amount of food and another to collect or disregard submitted items from the trash analysis chamber. Preferably simple mechanical systems to avoid wear, maintenance, and function in most weather conditions.

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.

To design an image recognition software for the previously mentioned sensor inputs.

To design a power system that will supply all the subsystems in isolation for at least a week. And to integrate a solar array for continuous charging of the battery.

To design the control and processing units to coordinate and operate all the subsystems. Should be designed for ease of maintenance and should include a battery charge indicator, activity log, and perhaps a recorded image log.

## 1.4. Goals

The first goal is to keep everything as power efficient as possible. We plan for this system to be easily placed in different areas and to be able to run independently of any other systems around it. This means there will need to be a lot of smaller subsystems that are low power to be able to turn on the high processing systems when the time is needed.

Another goal is to keep things relatively cost efficient. This project is meant to train birds in areas to pick up trash. This means that there would need to be many different areas with this system so that they can learn to do so in more than just one location. Further into the document will be a list of project milestones and stretch goals that we would like to achieve.

# 2. Project Requirements and Constraints

## 2.1. Project Requirements

### 2.1.1. Housing

- The housing should contain all necessary subsystems, mechanical and electrical, and be weatherproof.
- Should be as compact and robust as possible.
- Should have at least two containers, one for food and another for accepted trash. These chambers must have a capacity that could service a moderate amount for a week isolated. The chambers must have ease of access in mind when designed.
- Should have a system for deterring any other animal from accessing and interacting with the terminals. Probably using a door system to open and close the terminals.
- Should be easily opened for maintenance, access to mechanical parts, and easy access to a communication port for the control system.
- Should have two terminals for the birds to interact with and ample space for them to wait for the processes of the device.

### 2.1.2. Hardware

- Outside of housing:
    - An infrared (IR) motion sensor in front of the doors to detect motion:
        - This will be a passive motion sensing system that, when triggered by an IR signature of interest, will activate a camera for active sensing
        - One IR motion sensor will be used to minimize cost of hardware, mirror may be used to increase field of view
        - Alternative to using an IR motion sensor would be using an ultrasonic sensor
    - A camera outside to turn on when motion is detected in order to determine if it is a bird or not.
        - The camera, along with our image recognition software, will serve as the active sensing system that will trigger the motor for opening the doors when a bird is recognized
        - The active sensing of the camera will only turn on when triggered by the IR detector in order to minimize power usage
        - This camera's lens system will be designed by our photonics engineers as a wide angle system that will suit the FOV and cost constraints for the system
    - A motor to open the doors to the housing to let the birds in
    - A solar panel on the roof of the birdhouse that will connect to a rechargeable battery to add operation time without the manual maintenance of charging the battery

- Inside of housing:
    - The battery that the solar panel is connected to in order to provide power to the system
    - An imaging system inside to identify the item dropped by the bird

    - A processor powerful enough to do image processing
    - Motor to turn platform to drop trash, and give food as reward
    - A low power processor that can give commands to turn on higher processing

### 2.1.3. Embedded Processing

- The system will be run on 2 different sets of processors. One that can very efficiently use power and another that can very efficiently process information.
- Low power processing:
    - The low power processor will be something that can stay in a low power mode and mostly interact with the system using interrupts.
    - This will be connected to all the sensors and keep track of if something has moved or not.
    - The processor will be connected to any motors that will be used as there is no need to use high processing to turn motors on.
- High power processing:
    - The high power processor will be something that is turned on when movement is detected and then processed to go back to sleep.
    - This will be on to do image processing of both the bird as well as processing the trash.

### 2.1.4. Software and Application

- The software being used will be trained models on their respective systems for birds and for trash.
- The system will need to interface with a system through bluetooth to send out notifications.
- The system will need to have a safety protocol so that no bird can get trapped inside of the housing.
- Notifications:
    - Low food level
    - Trash compartment is full
    - Battery level is low
    - Maintenance
    - Safety feature has been activated

### 2.1.5. Power

- The system will be powered by a rechargeable battery that will be connected to a solar system that can charge while in a low power mode.
- The system should be able to run independently for a week on battery alone.

## 2.2. 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.

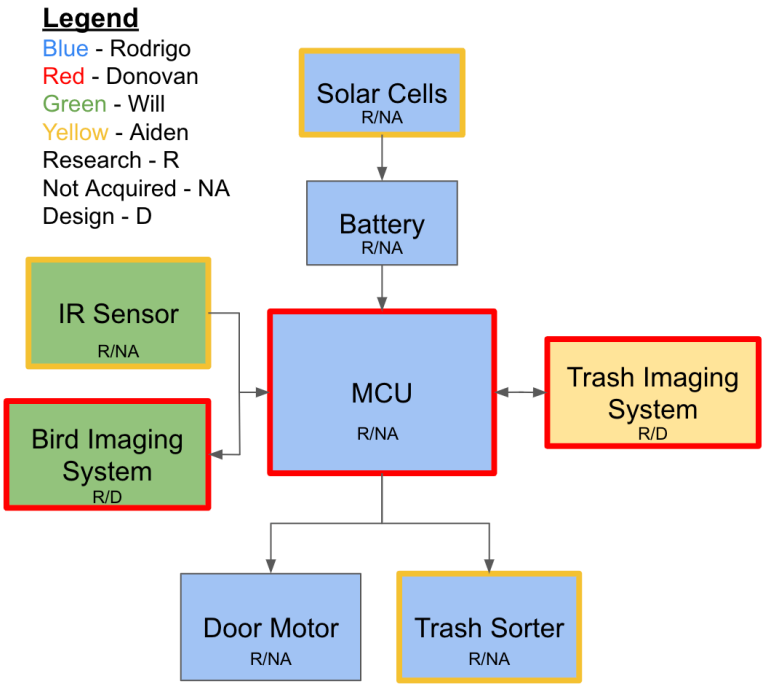
Another anticipated time constraint will be the time required to capture evidence of birds interacting with the system. The housing and operations will need to be tested for a fairly large amount of time if footage is to be captured. Therefore, proof of concept will be our main focus, and an actual demo 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.

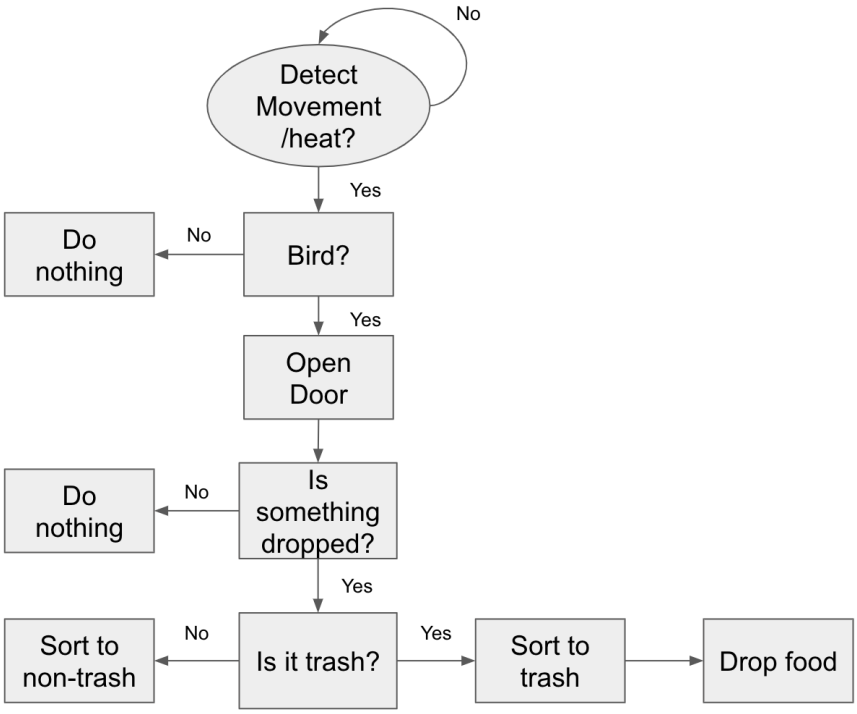
The system needs to be appealing for birds to want to enter and get food. In order to attract birds we need to have a design that is inviting for birds, meaning that we will need to have a small amount of bird psychology to get them landing in more. There needs to be some way that the birds can see that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

# 3. Block Diagrams

## 3.1. Hardware Block Diagram




## 3.2. Software Block Diagram



# 4. Project Budget

| Item | Price | Quantity |
|---|---|---|
| Microcontroller | $10 | 1 |
| Image Processor | $50-$150 | 1 |
| IR Sensor | $50 | 1 |
| Motor | $10 | 5 |
| Battery | $23 | 1 |
| Solar | $50 | 1 |
| LED Light Source | $15 | 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 | $558-$768 | |

# 5. Project Milestones

## 5.1. 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. |

## 5.2. 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 |