Smart Bird Feeder

EEL 4914 | Senior Design I | Summer 2021 | Group 7

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1. Description of Project

1.1 Introduction

The purpose of this project is to design and develop a solution for anyone who enjoys feeding backyard birds, without the hassle of squirrels eating the food set out for your birds. This project will incorporate many technical features that include computer vision to identify the difference between squirrels and birds, and a method of preventing squirrels from staying at the feeder, which includes utilizing a speaker and door. In addition to the features mentioned, the bird feeder will incorporate novel features such as image capture of the visiting birds provided in an application that can be easily used to view the pictures, and also check the amount of food left in the feeder.

1.2 Motivation

The motivation in developing this smart bird feeder device came from the continuous annoyance squirrels can bring to people that just want to feed their friendly visiting backyard birds. The idea came to us when one of our group members had a bird feeder in their backyard, and quickly found that squirrels kept scaring the birds away while trying to get to the feeder and continuously ate all the food before the birds could even eat most of it. Therefore, with some adequate research, we decided that as a group we could build a smart bird feeder that can house a small number of electronics to defend against pests like squirrels and support features to entertain us with a collection of images of the birds which visit and a way to stay updated with the status of your bird food dispenser levels.

1.3 Goals and Objectives

The goal of this project is to design and construct a fully functional bird feeder device which will dispense bird feed only to birds, detect the species/type of bird, capture high quality images, and notify the user when there has been a new image added to the album or if the feeder is low on food (bird feed). The main objective for designing and creating this smart bird feeder device is to bring to life a smart bird feeder that can handle itself against intrusions from squirrels, provide beautiful up close images of the visiting birds, and keep the user informed with the status of the feeder. Moreover, we aim to have a bird feeder that incorporates computer vision to not only identify the difference between birds and squirrels in order to defend the feeder, but also to distinguish bird species in order to label and categorize the images of the birds. In addition to the technical aspects discussed, we are aiming to create a lightweight and reasonably priced smart bird feeder that can easily disrupt the bird feeding industry. With this project, we are given the opportunity to satisfy every bird watcher's wish of having providing a sanctuary for local birds to eat in peace and provide them with a database of images.

2. Project Requirements Specifications and Constraints

2.1. Requirements

2.1.1 General

- The feeder box will be constructed from wood and plastic.
- A see-through container will house the bird feed, gravity will bring the bird feed into the feeding holes at the bottom of the bird-feeder.
- A housing box for the electronics will be placed under the roof.
- The electronics will be housed in a weather-proof casing in order to protect from the elements.
- A platform behind the feeding holes will provide a spot for image capture.

2.1.2 Hardware

- A solar panel will be connected to a rechargeable battery bank, which will supply power to the electronics.
- Connected components inside hardware box:
    - A machine learning processor
    - A custom PCB
    - Battery bank
- A servo will connect to a hatch, powered by the PCB, to rotate and limit access to feeding zones.
- A camera will provide a good vantage point to the feeding platform.
- An alarm system will deter feeder predators
- An ultrasonic sensor will provide information on low food level based on distance.

2.1.3 App and UI Integration

- The application will have an easy-to-use user interface, connecting the user with various feeder technologies.
- Notifications
    - Notifications for low feed level.
    - Notifications for feeding taking place.
    - Notifications for new images added to the library.
- Streaming
    - Access a stream of the bird feeding in real time.
- Memories
    - Save a picture of the bird feeding as a memory.
    - Filter memories by date or bird species.

2.1.4 Machine Learning Processor

- The machine learning processor should be in low power mode, until it scans movement.
- A machine learning processor will read camera data and discern bird species or other feeder predators.
- The processor will have a coded list of acceptable feeders, and provide an input signal into the PCB to signal the feeding mode or defense mode.
- The processor will send the video data to the PCB for transfer to the application.
- The processor will send a photo to the PCB to transfer to the application.
    - The photo will be the picture with the highest percentage of species confirmation.

2.1.5 WiFi Connectivity

- The PCB will connect to WiFi
    - *We need more information on the type of WiFi we will connect with.*

2.1.6 Power

- Powered by a rechargeable battery.
    - The rechargeable battery will be connected to solar cells facing the sun and a charge controller.

2.2 Constraints

The group must balance the added features of development processing boards with the cost of those boards. For example, there already exists a board with strong bird-detecting functionality built in, however, it sits at nearly double the cost of the alternative option. Thus, price constraints limit the capabilities of equipment and add on extra working hours. Another constraint is the amount of memory offered by the development kit that we use, since any company that creates the AI development kit that we plan to use would only offer a finite number of kit models with a finite number of memory size options. Only once we have finalized the hardware and software designs for this project will we truly know what the memory requirements for our development kit will be.

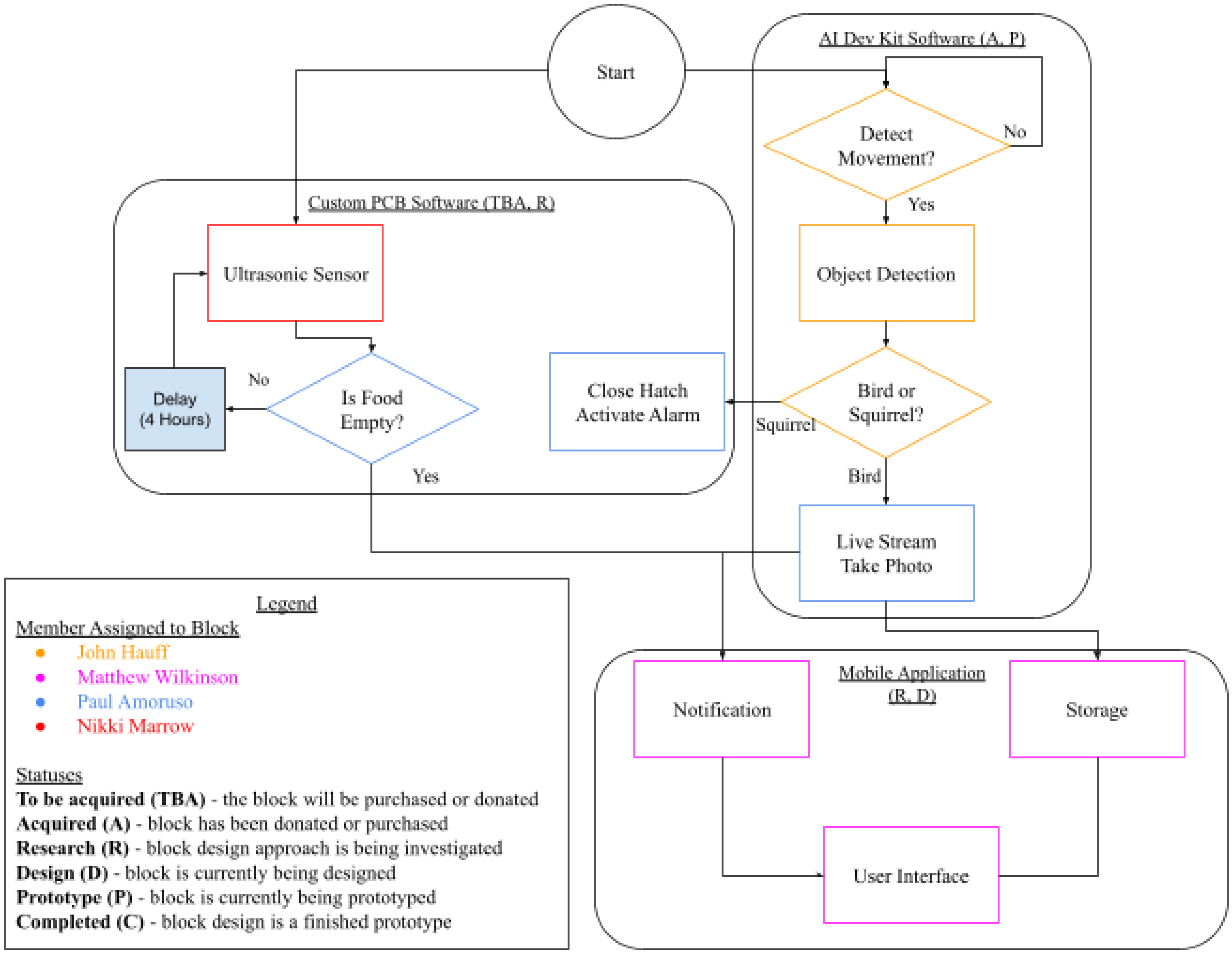
Time constraints create an interesting dynamic between monetary cost and the feasibility of our group completing certain aspects of this project, given our skillset. In situations where we find the time frame to be too short for our group to feasibly learn how to develop and execute original solutions for accomplishing our goals, the monetary cost of components may increase, since pre-built products and packages may have a higher overall monetary cost than most original do-it-yourself components. However, in situations where we feel that we are able to accomplish our goals in the given time frame, we may choose to develop some hardware/software components ourselves, which would save monetary cost by purchasing less pre-built products. We expect each group member will spend at least an estimated 13 to 15 hours per week working on this project, and our current monetary budget is $400 (see *Project Budgeting and Financing* for details). Similarly, shipping times and part availability also need to be considered, as some parts may not be available to order when our group requires them, or if they are available, the shipping time cost may be unacceptable. With regards to our machine learning object detection model, if we need to train our own model, or even retrain an existing model, the amount of time that we are able to put toward training/retraining a model will be a significant constraint on the number of bird species that can be detected, since it takes more time and resources to find data and train a model and the amount of data to find and use for training increases.

Since the smart bird feeder device belongs outdoors, power also stands as a concern. Our current plans are to avoid the user recharging the device inside, if possible, and to be able to power the entire smart bird feeder device for up to 3 hours or more on a single charge. We are currently investigating self-charging options such as solar power. Also, the battery supply must be large enough to power the processor and peripherals, and this total power needed can only be determined after the system components have been chosen. Depending on the size of our bird feeder, and the total power consumption, a constraint may arise when trying to incorporate a solar panel and battery that are powerful enough for our system, while also being small enough to physically attach to our device. To mitigate this concern, we are looking into low-power modes for the processor so that power consumption can be reduced, but more investigation is required to know how much power and current the entire smart bird feeder device will draw, which will reveal to us how large our battery must be. Environmental constraints are also produced as a result of our smart bird feeder device being made for the outdoors. Our bird feeder and the electronics within it must be fitted to withstand the weather conditions common to the area in or around Orlando. This means that the device should be waterproof, substantially shock-proof, and overall able to avoid any damage or loss of materials due to external weather conditions which could cause corrosion, shorts circuits, etc.

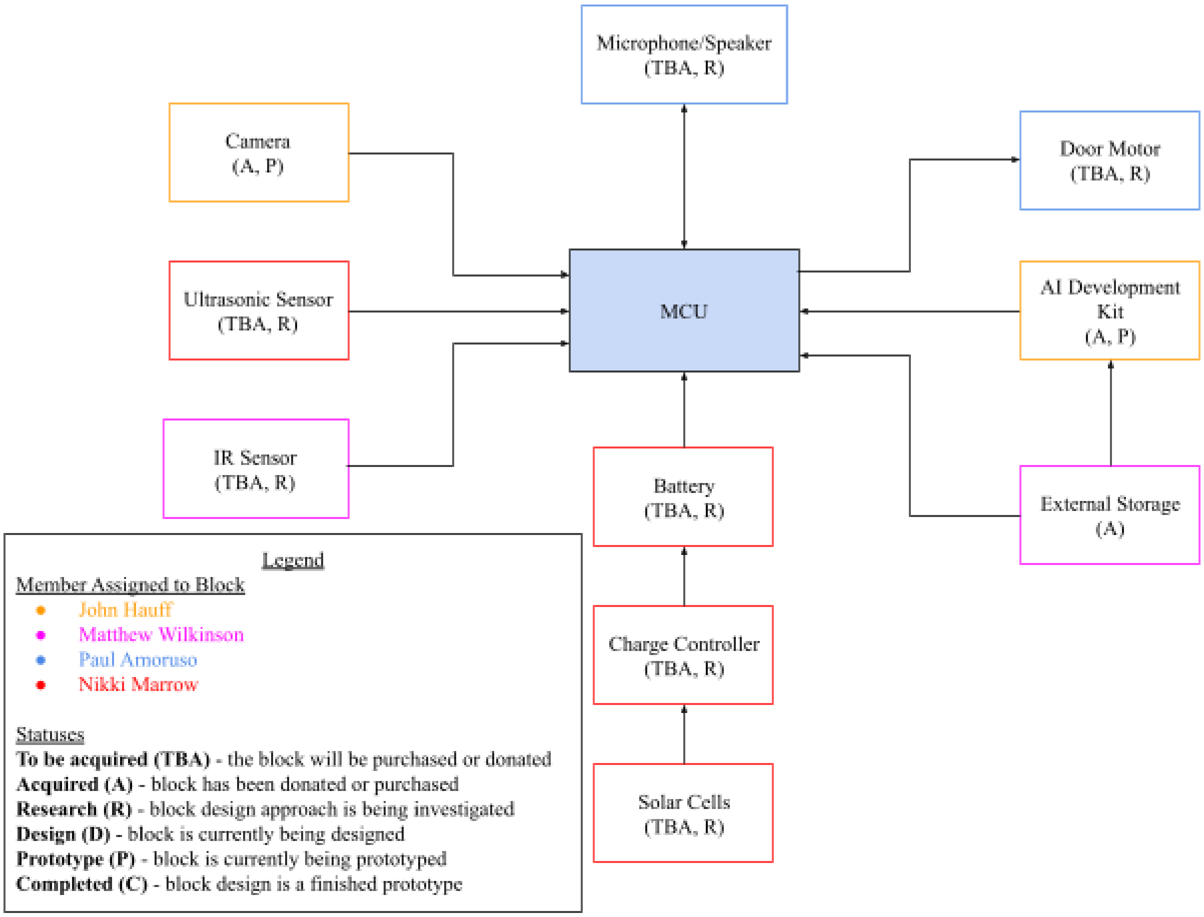
Other variables that will surely be constraints for this project are the birds and squirrels that will interact with the bird feeder. We cannot directly control most, if any, of the actions of live birds or squirrels, so we will be under a constant constraint in terms of testing and demonstration which is controlled by the personal choices of the birds and squirrels. They must first choose to make their way over to the bird feeder before our device can be tested.

3. Project Block Diagram

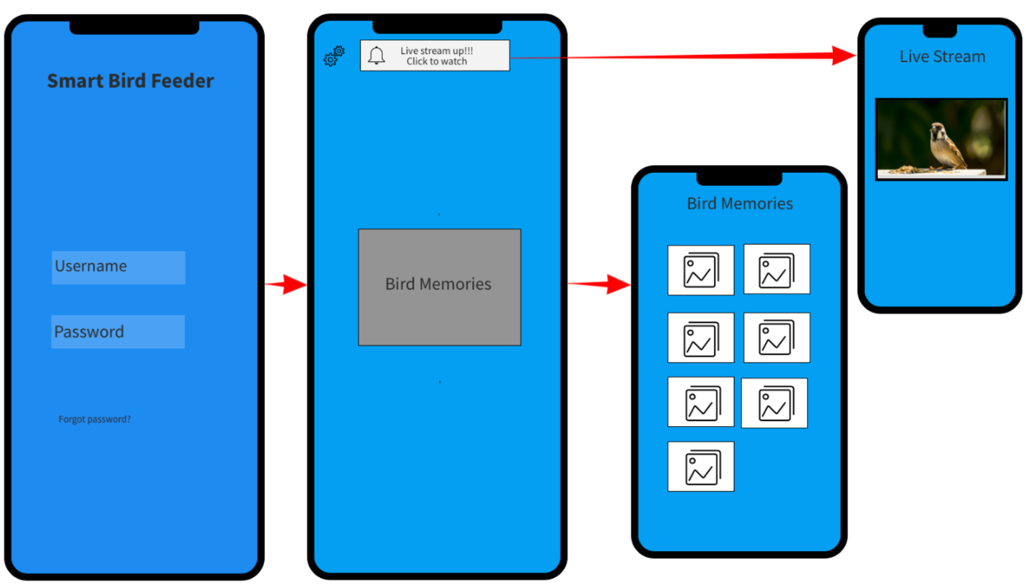
3.1 Software Block Diagram



3.2 Hardware Block Diagram



3.3 Mobile Application Design Diagram



4. Project Budgeting and Financing

Currently, this project is being financed entirely by our project members. The maximum budget for this project is currently $400 USD, split evenly among the four project members. Prices are estimations, and it is possible for the budget to vary in the future.

Item	**Price (USD)**	**Quantity**
Camera	$14.99 to $49.99	1
microSD Card (64 GB)	$9.99 to $19.99	1
Developer Kit for AI Computer Vision	$59.99 to $99.99	1
Microcontroller	$1.00 to $3.00	1
Misc. Parts for PCB	$9.99 to $19.99	1
Bird Feeder Frame	~$49.99	1
Bird Feed	~$19.99	1+
Microphone	$1.18	1+
Speaker	$4.60	1+
Micro Servo Motor (6V)	$11.95	1
10W Polycrystalline Solar Panel Charger	$29.99	1
IR Sensor	~$9.00	1
Solar Charge Regulator	$21.99	1
6V Rechargeable Battery	$22.22	1
Total	**$256.88 to $343.88**	**–**

5. Initial Project Milestones for Each Semester

5.1 Semester I (Senior Design I)

Week #	Dates	Milestone Description
1	5/17/2021 - 5/23/2021	Begin forming a project group and think about project ideas.
2	5/24/2021 - 5/30/2021	Study previous semester group projects and listen to idea recommendations to better form an idea for our project.
		Start working on the Divide & Conquer (D&C) report, and get a consensus on who wants to be in charge of each block in the diagram.
3	5/31/2021 - 6/6/2021	Attend first and second ABET lectures.
		Agree as a group on an idea to move forward with.
		Complete a large portion of the initial Divide & Conquer (D&C) Version 1.0 report.
4	6/7/2021 - 6/13/2021	Finalize the initial Divide & Conquer paper and submit it.
		Begin working on D&C Version 2.0 by updating the initial D&C document.
5	6/14/2021 - 6/20/2021	Attend the D&C Version 1.0 meeting with the assigned instructor(s).
		Continue working on D&C Version 2.0 document.
6	6/21/2021 - 6/27/2021	Finalize the updated Divide & Conquer version 2.0 document and submit it by Friday.
7	6/28/2021 - 7/4/2021	Work on the 60 page Draft Senior Design I Documentation.
8	7/5/2021 - 7/11/2021	Finalize the 60 page Draft Senior Design I Documentation, then submit it.
9	7/12/2021 - 7/18/2021	Receive feedback on our 60 page Draft Senior Design I Documentation.
		Work on updated 100 page report.
10	7/19/2021 - 7/25/2021	Finalize the 100 page updated report and submit it by

		Friday.
11	7/26/2021 - 8/1/2021	Work on the final 20 pages of the report and prepare it for the final submission in the next week.
12	8/2/2021 - 8/8/2021	Ensure that the documentation is finalized and perform any last minute corrections and finalizations.
		Submit final documentation report by Tuesday.

5.2 Semester II (Senior Design II)

Week #	**Dates**	**Milestone Description**
1	8/23/2021 - 8/29/2021	Ensure that bird feeder structure and electronic components designs are finisalized for assembly of version 1 of our device.
		Order parts for the first completed version of our smart bird feeder design.
3	9/6/2021 - 9/12/2021	Start collecting and testing all the received components that make up our project.
6	9/27/2021 - 9/3/2021	Bird feeder structure should be complete and all electrical components are ready or close to ready to be installed.
7	10/4/2021 - 10/17/2021	Install the bird feeder in a testing location outside and perform testing to ensure it functions properly.
13	11/15/2021 - 11/21/2021	Perform any last-minute tweaks to the smart bird feeder so that it is ready for presentation.
		Prepare the presentation so that it can be adequately demonstrated with the proper amount of information and functionality to prove that our project was successful.
15	11/29/2021 - 11/5/2021	Final project presentation and evaluation.

6. Conclusion

In adding various sensors and electrical components to our bird feeder, we will develop an innovative smart bird feeder that takes advantage of computer vision and machine learning to distinguish between birds and squirrels visiting the feeder. This system will actively deter squirrels from accessing the feeder, which will promote the arrival of more feathery friends. We also take advantage of the ML camera for other uses, such as capturing memories of birds' visits and storing the memories to be viewed in the application. The main goal we all have in mind is to bring to fruition an easy-to-use bird feeder that is lightweight, reliable, and reasonably priced to compete in the marketplace. In our preliminary design for the feeder, we aim to house a series of electrical components with the ability to process the frames taken from the bird feeder, and identify the existence of birds or squirrels in these frames. With this capability, our device will be able to determine whether or not the servo motor must be utilized to close the hatch, in addition to capturing photos of the birds, storing them in memory, and sharing them over WiFi to our app. In addition, there will be a solar panel on the top of the roof of the feeder with the purpose of charging a battery used to power the system. Finally, in addition to closing the hatch on the feeder, we will also add a speaker that plays random sounds to discourage the squirrels from hanging around the feeder. In conclusion, this preliminary feeder design offers a great opportunity to make our smart bird feeder device stand out from the rest, by adding a variety of features to communicate with our application for an enjoyable user experience.