2022 IEEE AP-S Student Design Contest Proposal: **The Self-maintained Aviator Lunch Locale Device (The SMALL Device)**

by the Bird Feeder Collective

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1 Introduction

Birds are wonderful creatures that bring song to our urban environments and provide a sense of wilderness to our cities. But the life of a bird is a harsh one, especially during the winter months. To help our feathered friends many of us put up bird feeders in our gardens. However, we can usually not be sure about the success of this honorable relief effort. We cannot be certain how many birds use our feeders and if the feeder is empty, we will not know whether the food went to blackbirds and robins or magpies and crows. Constantly watching the bird feeder is also hassle in itself.

Imagine a world where your bird feeder calls you to tell you that it has a visitor, a hungry bird. Maybe you want to come over and take look? Imagine a world where your bird feeder sends you real-time analysis of how successful it is, and how much more successful you could make it. Would that not be very convenient? Not to mention how much it would benefit our beautiful bewinged buddies. This is all possible with The Self-maintained Aviator Lunch Locale Device, or ”The SMALL Device” for short.

Our bird feeder is a simple IoT device which utilises an electrically small antenna [1] to communicate sensor data to the internet. The base structure is a bird feeder, with a heat-sensor connected so as to register when a small animal (i.e. a bird) comes nearby. The device is kept simple and straightforward for ease of construction and explanation, but could potentially be expanded for other use. Our design uses a meander-line antenna tuned to the 2.4 GHz ISM band [2] in order to connect via WiFi to the internet, and upload the sensor data. This data is then stored, analyzed, and displayed with the help of a web server to an end-user's phone or other device for easy access.

2 Design Setup

In the design phase of the project, the following demands were taken into consideration:

- The bird feeder should detect birds with high accuracy
- All bird detections should be registered and saved to a database on the internet, easily accessible to one's phone or other device
- It should be possible to have the bird feeder at least 50 m from your house
- The power demand should be low enough that 4 AA batteries can power the device for a week
- The bird feeder should work in all types of weathers, including snowy and wet conditions
- The entire setup should be kept fairly simple, to be easily understood and reproduced

To fulfill these demands, the bird feeder will need both some electronic device to detect the birds, and an antenna that sends a signal when a bird is detected. We will use a single-board microcontroller to control these components. Since Arduino is one of the least power consuming choices [3], we chose that one. The power supply could be either a battery or a solar panel. However, since the bird feeder should work also in a forest or when it is dark out, we chose the battery alternative. This makes it

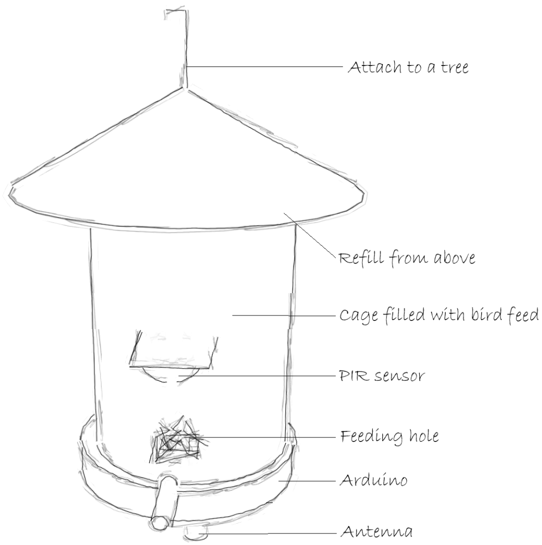

Figure 1: Sketch of the bird feeder.

even more important to strive for an energy efficient device so that the users do not need to change the battery more often than food needs to be refilled.

To detect the birds, a Passsive InfraRed (PIR) sensor will be used. This type of sensor detects the infrared light that animals and humans passively radiate [7]. An alternative would be to use some kind of pressure sensor or weight sensor. However, the risk of such a mechanical constructions is that they freeze during the winter and stop working. Also, many birds only weigh about 10 g [8], meaning it could be a problem to distinguish a bird from strong winds. Hence, the PIR sensor is the safe alternative even if it consumes a little more power [4] [5].

Since bird feeders are often close to one's house, we choose to send data from the bird feeder to a WiFi router. The design demands required for the antenna to send such a signal are described in the next section. The data will be uploaded to a web server and viewable as a web page in a browser.

Figure 1 shows a sketch of the bird feeder. The feeder consists of a box containing food, with a hole in the side by which birds would be able to access the food. It is against this hole that the PIR sensor will be directed. The Arduino itself will be kept in a water proof cage under the bird feeder, and the antenna beneath in a plastic cover, in order to protect it from rain, ice and snow.

The Arduino will be programmed in Arduino Programming Language, similar to the C programming language [9]. Using Arduino Integrated Development Environment (IDE), the code may be uploaded to the board via a cable connection [10].

2.1 Antenna design – Meander-line antenna for WiFi

The ISM band that we have chosen for our antenna to communicate on is the 2.4-2.5 GHz WiFi band [2]. By using this band we can make use of the commonly available WiFi connections that many people have, allowing our device to connect via WiFi to the internet in order to store data for later analysis and display. In this way we can fairly easily create a simple IoT device.

The intended use of our bird feeder device means that we cannot control its azimuthal rotation or its exact height when set up. It is intended to connect with a WiFi device situated somewhere roughly horizontally from the bird feeder, and as the bird feeder is meant to be exposed to the elements, we have made our design with that in mind. For this purpose we have chosen an omnidirectional antenna hanging below the bird feeder, oriented with its length pointed at the ground in order to radiate with a horizontal main beam. In this way the antenna will always be able to communicate with a WiFi router with gravity ensuring that it is pointed in the correct direction.

In considering antennas to fit these requirements, there were two obvious options: meander line, and monopole. Though simpler, the monopole seemed less suitable because it would radiate in a downward direction due to the small ground plane our bird feeder could hold [6]. The bird feeder might also be below a WiFi receiver or even angled slightly away. The meander-line design showed a more omnidirectional pattern, so our antenna design is a meander-line antenna situated on the bottom of the bird feeder, optimized to communicate within the 2.4-2.5 GHz WiFi band. A preliminary simulation of such a meander-line antenna is pictured below (Fig. 2), showing the omnidirectional radiation pattern. According to literature an electrically small antenna is one which can be contained in a sphere of radius a, where $a < \frac{\lambda}{2\pi}$ [1], thus with our maximum frequency being 2.5 GHz the antenna must be bounded by a radius $a < 1.91$ cm.

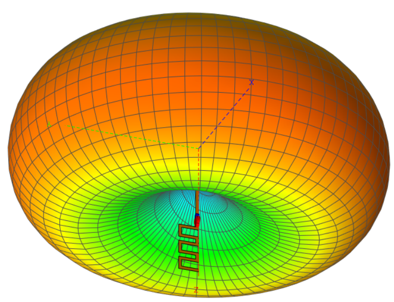

Figure 2: 3D plot of meander-line antenna far field at 2.45 GHz, simulated in FEKO. A small metallic sheet was included to simulate the electronic setup; in the image it is obscured by the radiation pattern.

2.2 Properties Measured and Analyzed

As a part of ensuring that our design works as intended, we would measure some of its working properties: the antenna connectivity, the sensor function, and our electronic/software setup. In our setup we have chosen an omnidirectional antenna that would be attached to the bottom of our device – firstly we would test the antenna as we build it, allowing us to tweak the geometry slightly to obtain the highest possible gain in the 2.4 GHz WiFi band. This would be done using an anechoic chamber at our university that we have access to. Following this, when our device is complete we would perform a practical test to measure the furthest distance at which a WiFi router can reliably connect to the device. Secondly we would test the PIR sensor, tweaking its sensitivity so that it would register when a bird comes within approximately 5 centimetres of it. We would also check that our electronic setup properly registers and communicates the activation of the motion sensor via WiFi, and that the Arduino is properly programmed to upload the information to be analyzed and displayed on a website. Finally, we would check the power consumption of the completed setup, measuring how long the setup can run without being recharged.

3 Budget

We have found a selection of representative parts that can be used to build our design; these are preliminary selections chosen to represent the cost of components.

To construct this project we would utilize laboratory facilities available to us at Lund University, using tools available there to supplement our construction.

Item	Price (USD)	Source
Arduino MKR Board	$45	Kjell & Company [11]
PIR sensor	$10	Kjell & Company [12]
Connection Cables	$30	Various
Antenna	$30	Lund University
3.7-5 Volt Battery + Charge Station	$40	Kjell & Company [13]
Battery Holder	$10	24.se [14]
Base Bird Feeder	$110	Amazon [15]
Web Server	$5	one.com [16]
Total Cost	$280	
Total Cost + extra	$340	

We have also added around 20% extra to the total cost (as above) in anticipated extra costs, since this would be an experimental project and we anticipate that we may make some mistakes, possibly breaking a component or realizing that we should get another one. This would also cover any small extra costs.

4 Team Members

The team comes from Lund University and consists of three members, with two mentors:

Alexandros Pallaris,	*alexandros.pallaris@eit.lth.se*	(first year PhD student)
Oskar Bolinder,	*os1444bo-s@student.lu.se*	(undergraduate student)
Simon Ljungbeck,	*si5126lj-s@student.lu.se*	(undergraduate student)
Johan Lundgren,	*johan.lundgren@eit.lth.se*	(mentor)
Mats Gustafsson,	*mats.gustafsson@eit.lth.se*	(IEEE mentor)

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December 22, 2021

Bird Feeder Collective

LUND UNIVERSITY

Department of Electrical and Information Technology
Mats Gustafsson

Dear Sir/Madam

I have been supervising the Bird Feeder Collective during fall 2021 together with Johan Lundgren. The team consists of the students Alexandros Pallaris, Oskar Bolinder, and Simon Ljungbeck all from Lund University, Sweden. I will also be happy to continue supervising the team for the final stage of the 2022 IEEE AP-S Student Design Contest.

Yours sincerely,

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