A Novel Photovoltaic Soiling Sensor

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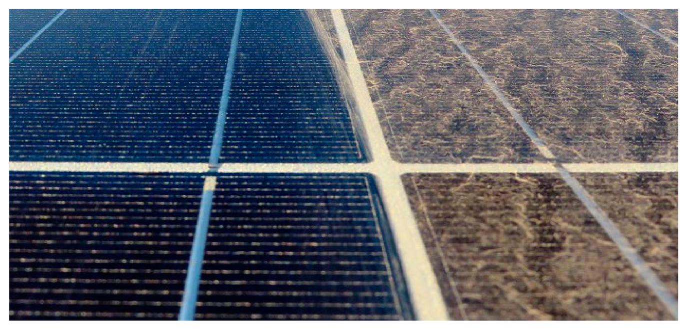
Introduction

Motivation: The globe is heating at an unprecedented rate due to human emissions. **Solar power** represents one of the fastest growing sectors of renewable energy worldwide; solar energy will increase from 2% to at least 10% of worldwide production by 2040.

Problem: There are various factors inhibiting solar panels' efficiency, namely different types of soiling. **Soiling** is the accumulation of dust and other particulate matter on the surface of a panel, leading to a **drop in efficiency**.

Goal: Team Banana was tasked with designing a **soiling sensor** to accurately **measure and communicate** the loss of efficiency of a solar panel due to soiling so that the user knows when the panels must be cleaned.



A photograph of a clean vs. soiled solar panel

Objectives

Design Objective	Target Value
Communication	Stores data ≥ 1 time per day; data is accessible in ≤ 5 minutes
Accuracy	Sensing error ≤ 5%
Creativity	Implements ≥ 1 unique idea for each of the 6 major components
Durability	Maintenance needed ≤ 1 time per month
Low-cost	≤ $250
Size	Requires ≤ 2 people to transport and assemble

Methods

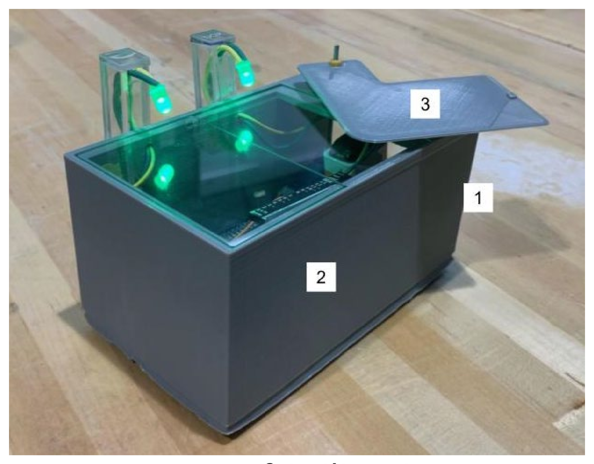
Overview: This project was split into two major parts: the sensor and communication device. Through filtering out and finding the best solutions for each part, we moved on with a design that combined both a set of photoresistors and LEDs, as well as uploading data to an SD card.

Process: We further split up each part of the project and worked in subgroups to take advantage of our varying skillsets.

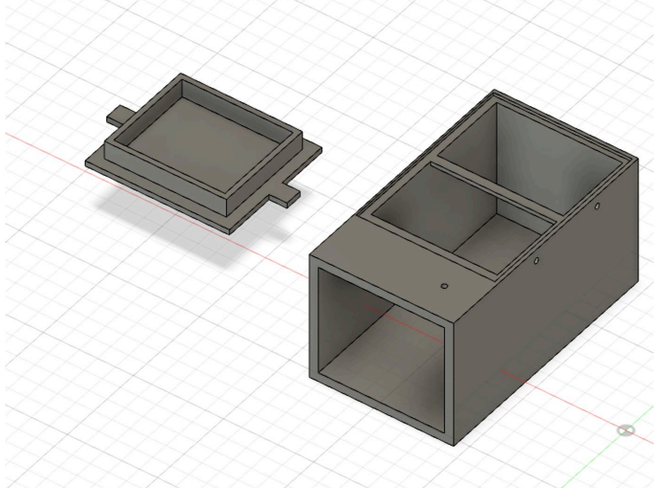
Prototyping: Through many lifecycles of low fidelity designs, we isolated and resolved potential complications for each component and slowly built up to our final prototype.

Results

Prototype: Compact soiling sensor split by control and experimental sides, using a pair of green LEDs and photoresistors to detect a difference in luminosity. Data input will be automatically analyzed and uploaded to an SD Card.



Prototype of Soiling Sensor

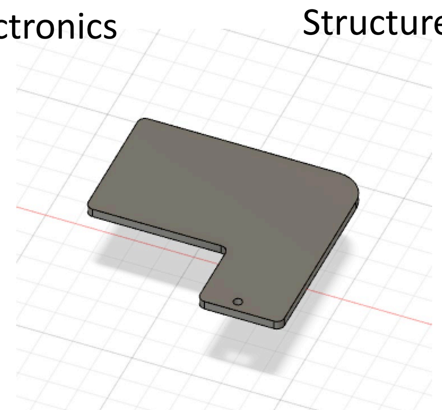


1. Door for Access to Electronics

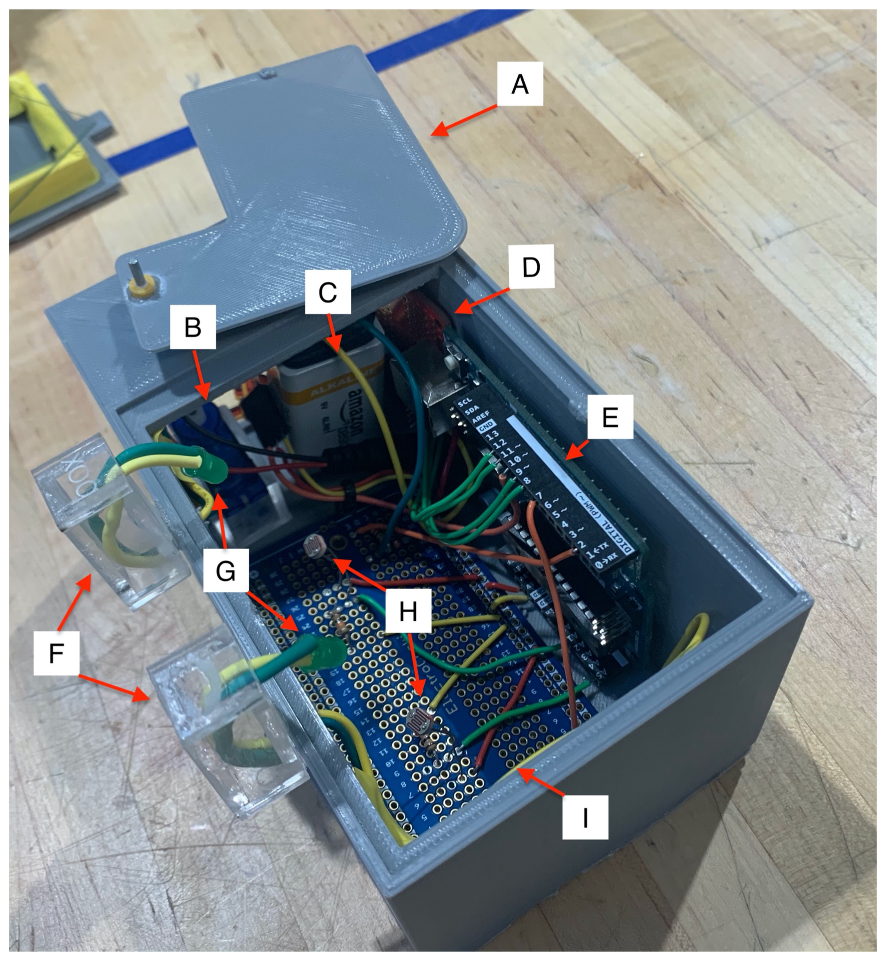
2. Main Box Structure

The prototype was mounted on a tripod to raise it to the height a solar panel.

Prototype on Tripod



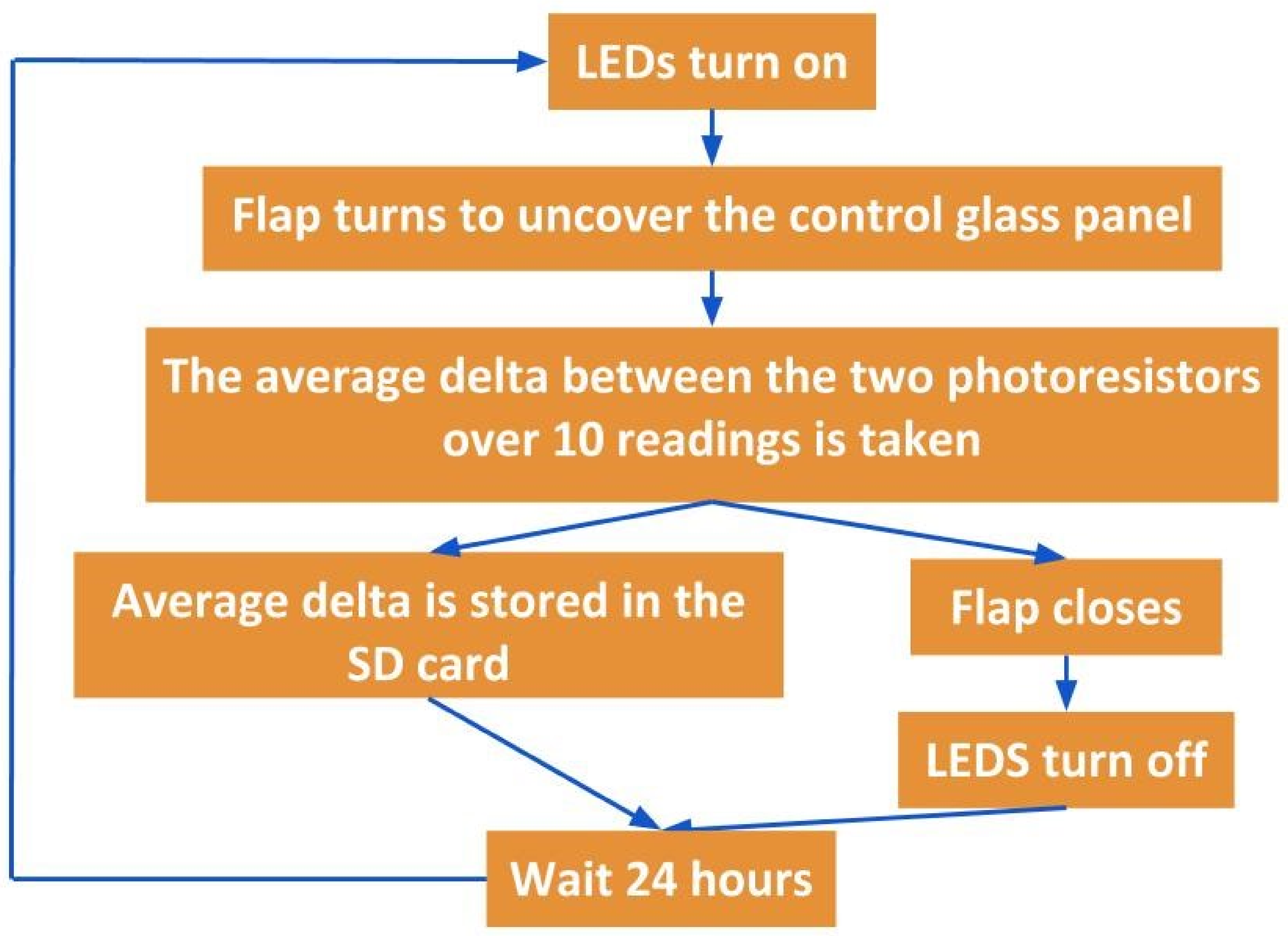
3. Cover Flap



Key	
A	Cover Flap
B	Servo
C	9V Battery
D	SD Card Reader
E	Arduino Board
F	2x Acrylic Casing
G	2x Green LED
H	2x Photoresistor
I	Protoboard

Labeled Components of Prototype

Code Flowchart



Testing

The prototype was tested to determine how effectively it fulfilled the design objectives. Based on its performance a ranking of pass (P) or fail (F) was assigned for each test.

Design Objective	Testing Results
Communication	P – Took < 1 minute to retrieve data
Accuracy	P – Correctly distinguished between 4 different amounts of soiling
Creativity	P – Client identified ≥ 1 unique idea in each major component
Durability	P – Some water leaked into container through the glass slides (now sealed with no leakage)
Low-cost	P – Total cost was $78.76
Size	P – Can be carried by one person using two hands

Accuracy Test Slides

Five different levels of soiling used for the accuracy test. Levels ranges from 1 (clean) to 5 (completely soiled) from right to left.

Conclusion

Summary

- Created a cost efficient and compact soiling sensor design, close to ready for commercial use.

Future Work

- Data Cloud Storage System
- Clamp to attach device to a regulation Solar Panel
- Swap Arduino with Adafruit Feather Board
- Use a more weather resistant outer shell

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