Camera Triggering System

ECE 445 Project Proposal

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1. Introduction

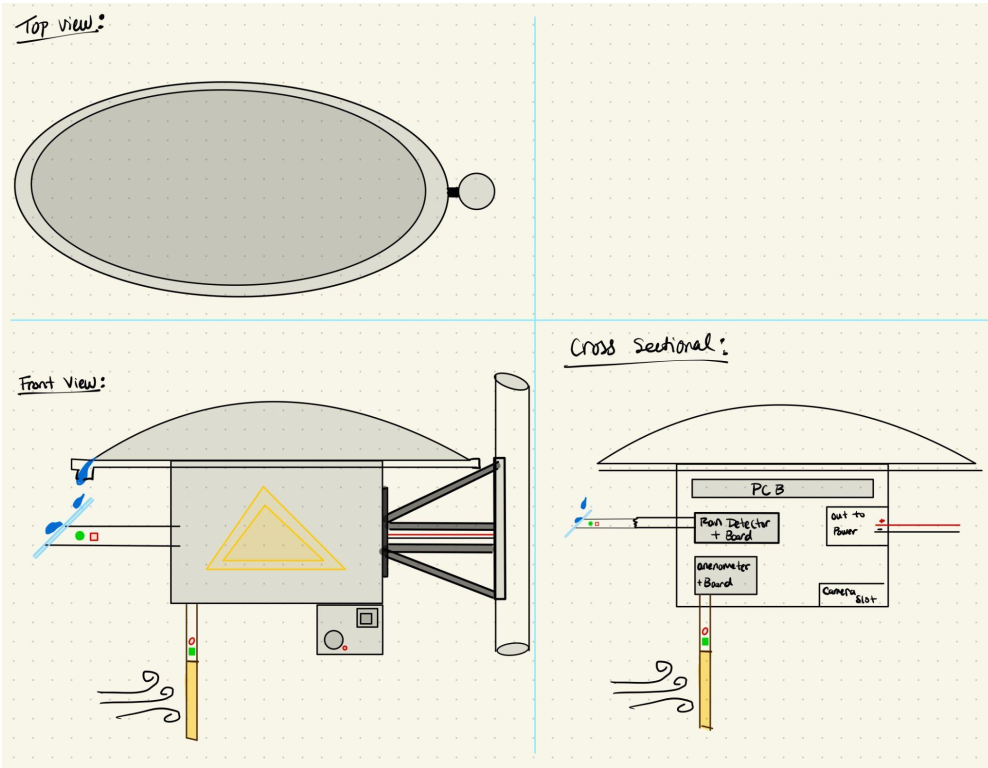
1.1 Problem

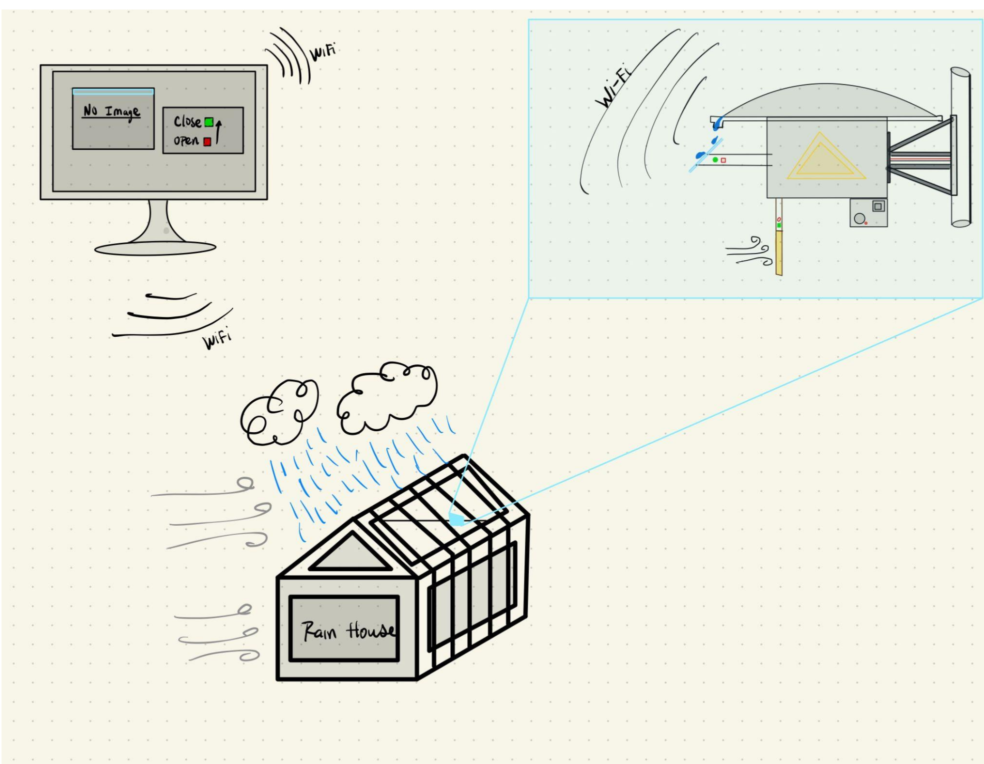
As time goes on, climate change keeps leaving its impact. Notably, it affects the development of plants (such as corn). To combat this the Institute for Genomic Biology at UIUC collects data in regards to the plants; such as, height, color, size and so forth. This is crop phenotyping and it is done manually by hand to be analyzed. The team led by John Hart has already developed an image processing tool, Computer Vision, to analyze pictures of these crops. The issue comes with the automation of taking the images. Go-Pro cameras being used take an image per hour, take images when crops are moving due to wind, or under inconsistent lighting settings. This results in not well taken images which the Computer Vision tool struggles to analyze. In turn, making analysis for the Agricultural Department difficult.

1.2 Solution

The solution to this would be a camera triggering system that would be mounted on the rain intercept facility. This camera would be a GoPro enclosed system that will not be damaged by the weather elements. In order to minimize the number of pictures, it will be able to have variable time-lapse control. Based on the lighting conditions present, the camera will adjust camera parameters (ISO, shutter speed, aperture, etc) in order to maximize image quality based on surrounding conditions. This is where sensors will come into play and detect wind speeds and rain to adjust accordingly. In reference to wind speeds, this can cause blurry images and thus will cause delayed imaging. If possible, it can also interact with the rain facility itself and close the facility if dangerous wind levels are detected. Likewise, under heavy rain the imaging will pause until the rain has stopped. The procured images are then uploaded via Wi-Fi to then be analyzed by the Institute for Genomic Biology and Center for Digital Agriculture.

1.3 Visual Design





1.4 High-Level Requirements List

Provide variable time-lapse control of the GoPro camera. Time-lapse can vary from at most 24 images within a 24 hour span, to as little as just an image a day. The time-lapse function needs to be able to be interrupted by the received sensor data. To test this requirement, weather conditions will be ‘simulated’ in a closed environment along with the time-lapse feature to determine if the expected number of images were taken in a period of time (camera triggers per day)

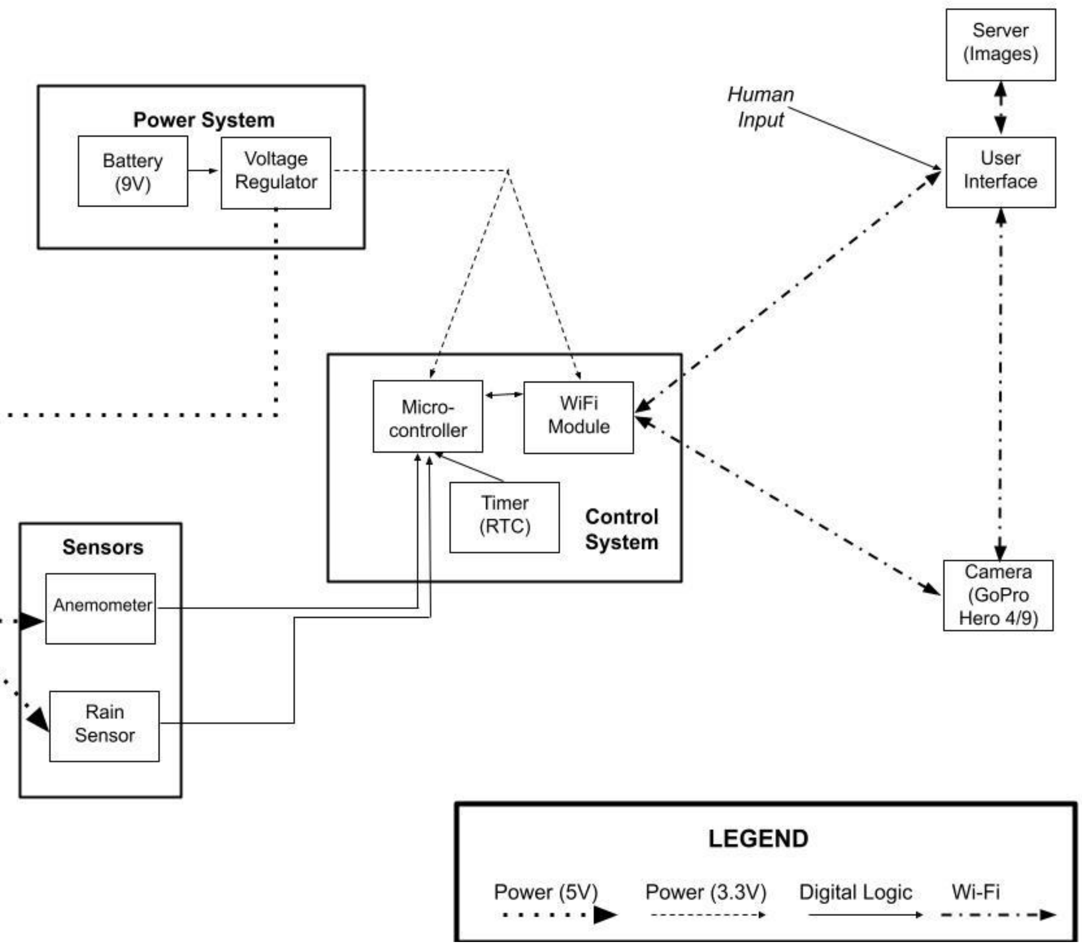
- User interface should display the camera settings and received sensory information (rain/wind), which is updated every 20 minutes. The status will be binary (1 On, 0 Off) condition for the rain and wind sensors. The camera settings will be pulled via the WiFi communication to display ISO, aperture, shutter speed, and so forth. The status of the battery will also be displayed and indicated via binary, if there is a need to replace them.
- Wind sensor (or anemometer) should be capable of detecting up to 20 mph +/- 10% wind speeds and relay the data to the control subsystem. Rain sensor should be able to qualitavely detect rainfall. In other words, if any rain (or liquid) is detected, the sensor will relay that information.

1.4.1 Optionally Requested High-Level Requirement

- The rain intercept facility that the Institute for Genomic Biology and Center for Digital Agriculture uses currently has the ability to control the roof. Thus to protect the crops, the roof closes in response to heavy rain or wind. Since the camera triggering system sends the information via WiFi to the user interface, it can potentially be sent to the facility too. That way, it will automatically close in response to the described conditions. *Note: This can only be demonstrated within the rain facility itself; the user interface status indication for rain/wind acts as its substitute.*

2. Design

2.1 Block Diagram



2.2 Subsystem Overview

2.2.1 Power Subsystem

Battery

A battery that provides sufficient power for all sensors and modules on board.
Requirement 1: Must power the device for 2 days of normal use
Requirement 2: Must either be rechargeable (lithium-ion) or easily replaceable (for example 9V PP3-style batteries)

Voltage Regulator

A regulator circuit that reduces the battery voltage to voltage ranges acceptable for application to all modules and sensors on board.
Requirement 1: Must be capable of reducing at most a 9V alkaline battery voltage down to 3.3±0.2V for typical V_{IN} values of microcontrollers and similar modules.
Requirement 2: Must be capable of reducing at most a 9V alkaline battery voltage down to 5V±0.2V for potential VCC values of sensors.

2.2.2 Control Subsystem

Microcontroller

A microcontroller to process the data received from the environmental sensors. It is responsible for the ADC operations of the sensor signals. Responsible for triggering the camera in calculated time intervals during every cycle of 24 hours in response to user specification, as well as delaying these triggers in response to the environment.
Requirement 1: Must have at least 2 8-bit ADCs.
Requirement 2: Must have at least 1 digital port (I2C).
Requirement 3: Must be able to calculate time intervals given current time left in the day and amount of triggers requested.

RTC

A Real Time Clock that keeps track of 24 hour time for the device.
Requirement 1: Must utilize I2C digital port connection.
Requirement 2: Must have its own power supply separate from the power subsystem.

WiFi Module

A WiFi module enabling the device to communicate with the server to convey current environmental data as well as to receive user instructions/specifications. The WiFi will communicate using TCP/IP via WiFi with two clients: the User Interface and the Camera. It will communicate with the device's microcontroller via a direct connection.

Requirement 1: Must be able to respond to requests to read environmental conditions and camera settings from User Interface

Requirement 2: Must be able to write requests from User Interface to the device and Camera

2.2.3 Sensor Subsystem

Anemometer

A hot-wire anemometer that detects and measures the velocity of the wind in the surrounding environment.

Requirement 1: Must require at maximum a supply voltage of 5V±0.2V.

Requirement 2: Must draw at maximum 40 mA of supply current.

Requirement 3: Must be capable of detecting and measuring wind velocities of 20mph at the minimum

Rain Sensor

A rain sensor that detects and measures, at least qualitatively, the rainfall in the surrounding environment

Requirement 1: Must require at maximum a supply voltage of 5V±0.2V.

Requirement 2: Must draw at maximum 10 mA of supply current.

2.2.4 User Interface

The User Interface is a web application, accessible from the user's computer of choice, that communicates with the Server via WiFi.

Requirement 1: The user interface should allow for a user to specify the desired amount of camera triggers per day and send these specifications to the server

Requirement 2: The user interface should allow for a user to specify the desired camera settings instead of having the device decide them, and send these specifications to the server

Requirement 3: The user interface should display the current camera setting specifications as well as environmental conditions collected and processed by the Control Subsystem

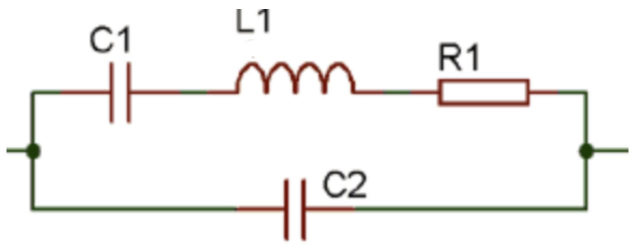
2.2.5 Camera(GoPro Hero 4/9)

The camera chosen by the Department of Agriculture to capture images of crops for study. The other subsystems are designed with this specific range of camera models in mind for compatibility. As such, no requirements necessary.

2.3 Tolerance Analysis

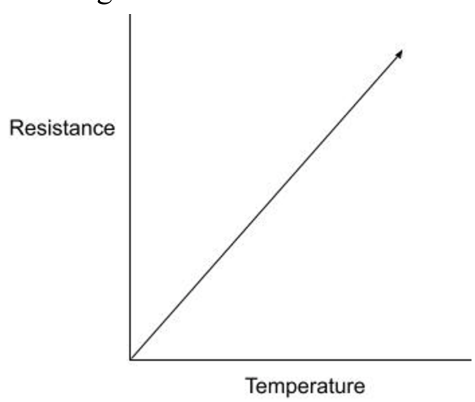
<u>*Microcontroller Failure*</u>

The main component that poses the greatest risk of failure is the real time clock (RTC) found in microcontrollers. These real time clocks are often made with crystal oscillators which can be modeled with the simple circuit below [6]. This circuit contains capacitive, inductive, and resistive elements.



Circuit Equivalent of Crystal

Aging of the crystal, characterized by multiple uses would cause the desired operating frequency to drift slightly. This can be detrimental for the operation of our microcontroller RTC, but the effect occurs over multiple usages (not probable with our case). Besides the aging of the crystal used in these oscillators for RTCs, there is the potential for it to be deteriorated by temperature. Resistance is proportional to temperature (either linearly or with a positive trend). This can thus alter the resistive component of the circuit, potentially altering the operating frequency. This can create an offset in the time-lapse timing.



Linear Relationship of Resistance and Temperature

The reason why temperature dependence is important is the implementation of the device. It will be installed in the rain facility which will be under sunlight and can potentially heat up the circuitry inside. This is dependent on the implemented microcontroller. Take for example, an Arudino which can withstand operating temperatures of up to 85℃ [7].

Electricity/Water Interaction

The other main factor that poses a risk of failure for the entire system is the interaction of water with electronic circuitry. As the Rain Sensor subsystem is required to qualitatively determine if it is raining, that indicates potential water leakage into the constructed device. This enforces the need for water-proofing the entire system. Working with and communicating internal PCB storage and device placement with the machine shop is necessary to leap over this possible failure.

3. Ethics and Safety

The ethical aspect of this project is mainly in regards to how safely we can implement the project. In reference to IEEE's code of conduct, Section 1.1 States "we must hold safety, health and the welfare of the public as our top priority, as well as strive for an ethical design and sustainable development practices, and disclose factors that might endanger the public or the environment".

One of the main concerns surrounding our project is the fact that we will be implementing a circuit to an area that is exposed to water/rain. Of course, as we know electricity and water do not mix, so it is our goal to try and make our project housing water resistant to avoid any type of short circuiting. This proves to be a challenge as we need to implement sensors that will need to be exposed to the elements to accomplish their tasks, and will make it difficult to make the casing entirely water resistant. This is ideal for the safety of whoever accesses the rain facility and the facility itself.

In addition to the proximity of electricity and water, we must also consider another possible hazard. Since we are to mount our project to a rod in the rain facility, we must ensure that it is properly mounted to avoid injury from a falling object and prevent damage to the product itself, as we want the client to get the most out of the project and not lose it due to a product failure. We must test the durability of our product and ensure it can withstand certain conditions. As we will be mounting the project onto a bar, we have to ensure the mounts are strong enough and find a suitable position for its purpose and easy maintenance, as we do not want injury to occur while servicing the project when it will be necessary.

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