E314 Lab 1 Report
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Light Sensor Project Design Document

Problem Statement

The Hoosier National Forest is trying to attain Dark Sky status from the International Dark Sky Association. To accomplish this, the forest needs to demonstrate sufficient occasional darkness to qualify and be designated a Dark Sky Forest.

The Forest Service is trying to obtain 'Dark Sky' status for the Hoosier National Forest in an effort to improve forest preservation and boost tourism. To obtain this designation, the HNF must provide an adequate number of low light-level readings to the International Dark Sky Association. Our goal is to aid the HNF's effort through the design and fabrication of an autonomous light sensor which will provide these low light-level readings over the course of a calendar year.

Objectives

Our objective for this project is to design a battery operated, long lasting light sensor to collect data for the Dark Sky Designation. The sensor will optimally be capable of operating for several years to reduce the required human interaction with the device. The device will be designed with fault tolerant software to prevent unwanted shutdowns or data gathering issues. The device will also be designed to survive in a variety of weather conditions and around the local wildlife over its deployment duration. The system design will be reproducible because the Hoosier National Forest (client) will be deploying more than one device to accomplish the Dark Sky Designation goal.

The objective of this project is the development of a low-light sensor that is capable of reporting its captured readings for use in obtaining 'Dark Sky' designation. The sensor will be battery operated and must be able to maintain operation for the duration of a full year. The sensor will be posted outside, in the midst of the forest, and must therefore be designed to weather any and all moisture it encounters. The design will also have to be relatively inexpensive as the Forest Service plans to deploy the sensor in the hundreds, and potentially thousands.

Constraints

As with any project, cost is a factor. While singleton embedded systems are often what one would consider cheap, the issue comes with the plethora of devices required to institute the overall infrastructure at proper scale. The Hoosier National Forest covers nine counties in Indiana (over two hundred thousand acres) and gathering light intensity readings throughout the

expanse requires thousands of light sensor systems. Minimizing the cost of individual sensors is therefore a crucial step in the design.

As follows from implementing low cost systems, there are a pair of constraints that go hand in hand: the necessary lifetime of the sensor and the battery power available to the system. Due to the previously mentioned budget constraints, battery power is a scarce resource that the overall system must manage carefully. In turn, every aspect of the light sensor design must take into account the power it will consume during its operation. The inherent interplay between cost, power availability and management, and the necessary lifetime will be the defining aspect of the project.

That is not to say that there are no other constraints present in the lifecycle of the light sensor system. The primary concern on the software side of the design is the nonexistent virtual memory. Virtual memory is an invaluable resource for modern multipurpose operating systems that offers much in the way of memory management. This resource will not be available to the light sensor system and most aspects of memory management will have to be done manually by the team. The limited memory available on board will pose many challenges as not only will careful management software have to be written to avoid overwriting memory that is already in use, but overall memory capacity will have to be accounted for when logging the data over time.

This leads to yet another constraint present in the design of the light sensor system: the capacity of the sensor for networking. This aspect of the design is important for two reasons. Firstly, networking capabilities make the data more accessible to those that will be using it. If the sensor can transfer data to devices using some form of networking protocol, eg. Bluetooth, then ease of access to data is vastly improved, making data collection and use more convenient. As well, transferring this data from the device will alleviate some of the potential concerns involving lack of memory.

Finally, there are environmental concerns which constrain the design process. As these sensors will be outdoors, in the forest, where moisture is abundant. As most know, any moisture that reaches the components of a microprocessor will surely damage it. The design therefore, will have to be waterproof such that continued operation, regardless of weather conditions, can be guaranteed. To this end, a waterproof enclosure for the device has been provided and the final design for the light sensor system must fit within it.

While there may be more constraints that become evident later during the design process, these are the ones that will surely dictate the design process throughout.

Available Systems & their Pros and Cons

Light data loggers can be found online for prices starting at $75 and going upward of $500. These systems offer similar data recordings of the proposed embedded system but many have additional features to justify greater costs. Some devices have cellular options as well as solar panel support to improve the duration of deployment on battery life. These systems often

feature additional instruments as well, with some equipped with barometers, thermometers, and other weather sensing equipment. The links below demonstrate some of these products which have similar capabilities.

https://microdaq.com/data-loggers/light.php
https://www.onsetcomp.com/products/data-loggers/light-intensity/

Challenges & Opportunities

Battery life and environmental factors represent the biggest challenges of this design. A single battery must stretch several years to make the device an effective embedded system whereas if battery life was not an issue, many other features could be added (i.e. Bluetooth, Speaker) to improve the Hoosier National Forest's experience with the product. Environmental issues greatly impact the design since temperature and humidity must be taken into account year round to effectively account for condensation. The end system will have to be unappealing to animals and park visitors to protect against its removal and prevent the data from being lost.

This system represents a unique learning opportunity to build an embedded system from start to finish as well as developing a product for a real client. Additionally, since this light sensor has been implemented in previous semesters and years there is an opportunity to improve upon previous design and implementation errors to create a more efficient and less error-prone embedded system.