Agriculture Data System

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1. Introduction

In this project we are trying to develop an efficient long-range and low-power information processing and control system for agricultural applications. Our main aim will be to develop a proof of concept for a limited number of features, with the intent to add an arbitrary number of features in the future.

2. Problem Description

The ability to send radio messages over longer distances (up to 10km) in such a way that uses very low power is something that is under-utilized. Therefore, smaller devices that shouldn't need to use large amounts of power may die sooner than they should. We want to create a network of devices that can efficiently carry out relatively simple tasks and processing with minimum power use in order to maximize longevity and cost-efficiency.

3. Proposed Solution

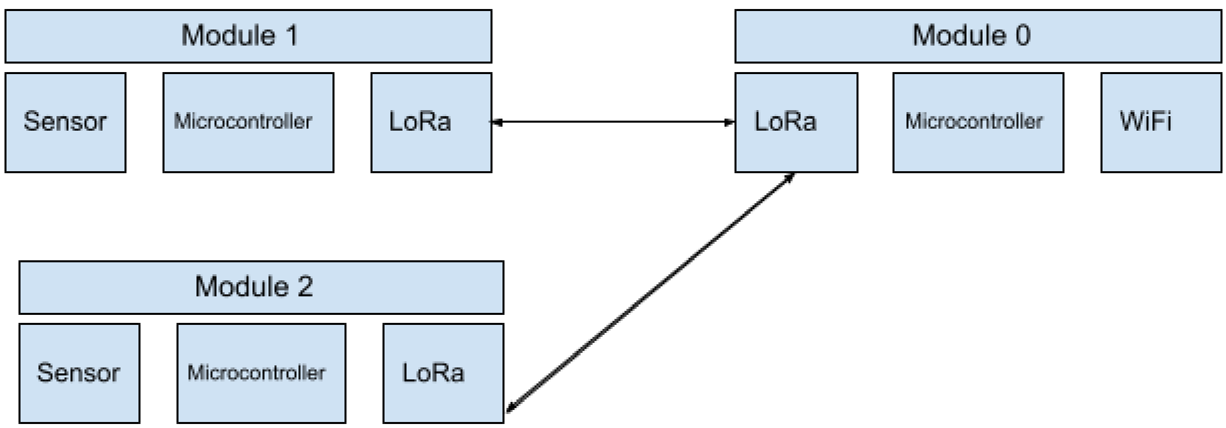
A control system with two types of modules. The first type module, Module 0, is the "control center" that communicates with the sensor/s out in the field, which belong to the Module 1 category. The Module 1 devices will contain (I) a means of monitoring the environment and (II) a means of communicating with the control center device when necessary.

I. In order to monitor the environment, Module 1 may have any combination of thermometers, barometers, pH meters, moisture meters, and photoresistors. Ideally, each Module 1 "field device" would be equipped with as many sensors as possible, allowing for as complete information as possible, though our device will initially only include one or two sensors to establish proof of concept.

II. The field device microprocessor can then periodically check that the environmental conditions are appropriate (as well as take interrupt-style inputs for serious environmental deficiencies), and notify the control center Module 0 device when conditions are unsatisfactory. With the communication from the field device, the control center 9 (Module 0) can then activate some other system or device to treat the unsatisfactory environmental condition, such as turning on sprinklers when moisture level is low. For our purposes, however, we do not plan on designing and building a third device to carry out these tasks, but rather plan instead on simply sending a confirmation message to the field device that the control module has received Module 1's message and actuated the proper remedy. We may simulate and display this process by Module 1 turning on an LED to indicate poor conditions, and then turning a different color once Module 0 has indicated reception and initialization of treatment, and then another color (and then off) once the proper environmental conditions are restored.

4. Demonstrated Features

a. Module 0 (Control Center)
    i. A microcontroller with LoRa capabilities that communicates with the microcontroller that senses data out in the field (Module 1). The microcontroller will also have a WiFi interface and can ideally transmit the data to a server/webpage, designed using HTML. It has to be able to store data without power (SD Card) and will transmit data and instructions to the devices out on the field.
b. Module 1 (Field Device)
    i. As mentioned above, Module 1 will also consist of a microcontroller with LoRa capabilities. It will have a pH and a moisture sensor. This module will also be equipped with LEDs in order to indicate poor conditions or if the proper control has been applied to the system (e.g. a command to turn on the sprinkler). As mentioned before, the code for this microcontroller will have regular polling (every couple hours or so) and interrupts in order to properly monitor for poor agricultural conditions and subsequently act on it. A library containing a well documented set of instructions corresponding to different inputs from the sensors will also have to be generated.



5. Available Technologies

a. LoRa- a low-power modulation technique that allows for packets to be sent over radio at great distances with low power. LoRa has restrictions on duty cycle and transmission rate, which is suitable for farming control and data collection because conditions change on the order of minutes or hours, not milliseconds. Packet sizes for farming data collection and control would be suitably low to use with LoRa, and enables the user to create an expansive network of sensor nodes.
b. Power- for field use, the battery must power the technology for a year or more. High capacity 18650 cells would help make this possible. The base station (Module 0) does not require batteries, since it is indoor.
c. I2C bus - for expandability and compatibility with many different types of sensors, the most accessible way of tying multiple sensors together to one module is through I2C. This expandibility will be helpful in reducing the

"unit cost" of the device, since it will add functionality to the field devices with a theoretical maximum of 128 devices per node.

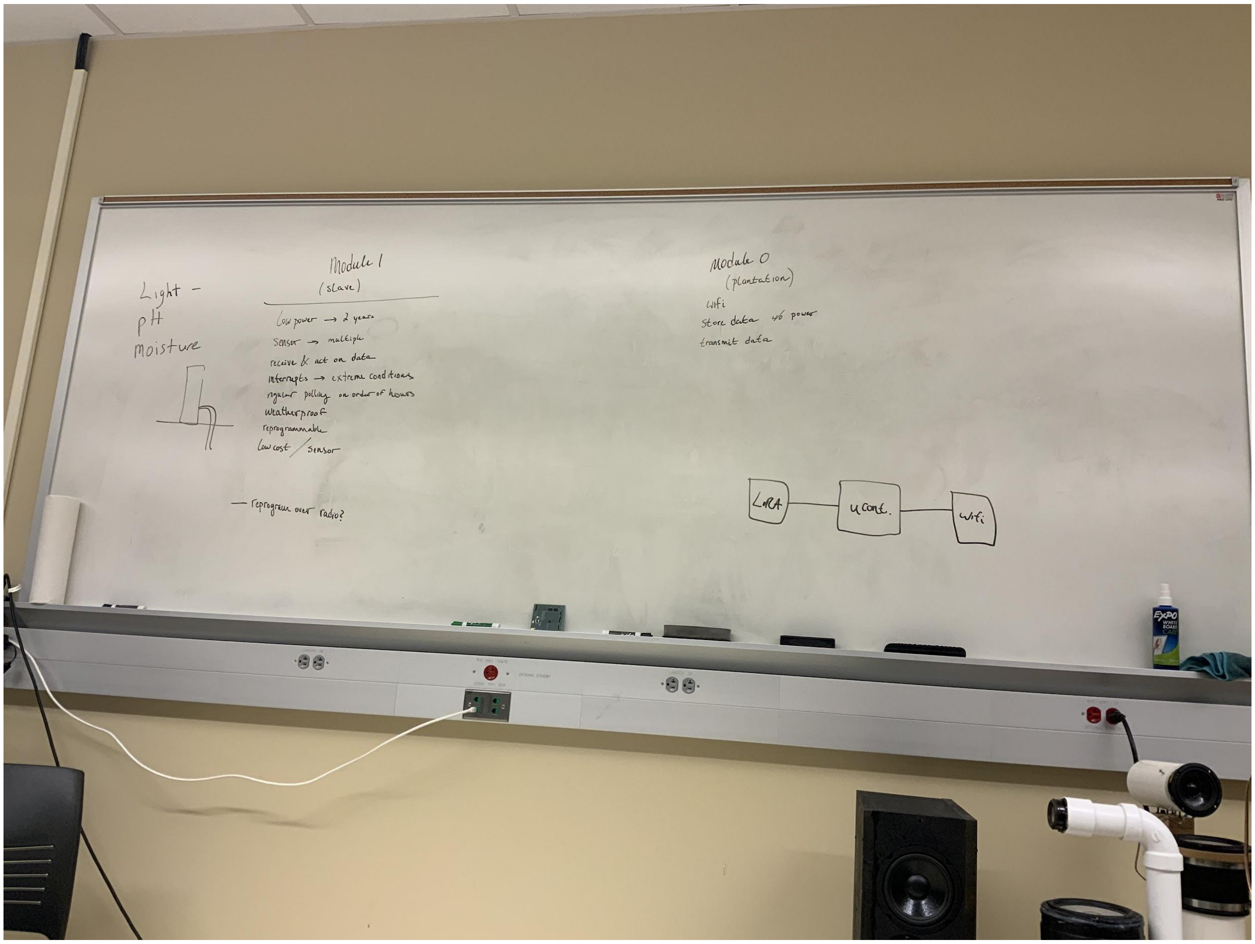
d. Sensors to interact with the environment can collect data that is useful for farming, such as temperature, soil moisture, light intensity, and more. These values can help small farmers because it gives them a vast amount of information about why crops turned out the way they did based on location, and can help him design controls to create an optimal environment for the plants.

6. Engineering Content

For this project, we need to design at least 2 different PCBs (one for Module 1 field devices, and another for Module 0 control devices). Module 1 needs a long lasting supply of power, as well. We also need to ensure smooth integration of the sensors and microcontroller in Module 1 to allow in order to minimize erroneous or insufficient communication with Module 0. Similarly, we need to ensure that Module 1 and 0 can communicate with each other succinctly, but without sacrificing any accuracy or detail in the communication. Module 0 needs to be able to handle multiple and/or simultaneous without mixing them up or "forgetting" to address any one of them. We need to ensure that our Module 1 device can withstand the conditions of whichever environment it is monitoring, which may include some sort of waterproof casing to protect circuitry, and possibly some means of affixing it in one place such that it can not be moved accidentally. We also need to create some means of user interface with the system to be able to understand and troubleshoot the communications between Module 0 and 1. To test our design, we plan to use multiple pots of soil that will either be under different conditions from the outset or whose conditions we will manually change during the test (e.g. pouring in water). First, we will see whether Module 1 can successfully transmit its data to Module 0 using its LoRa capabilities. We will then see if Module 0 can take this received data and store it in a desired location (SD card or HTML webpage) for further processing. Finally, we will test to see that Module 0 can successfully transmit over LoRa an instruction to Module 1 that is then completed, such as turning on an LED or releasing more water into a pot of soil.

7. Conclusions

We believe this project will teach us much about wireless communication systems, as well as the entire engineering design process. We hope that our work will allow us to implement similar technologies on our own properties in the future.


Light -
pH
moisture
Module 1
(slave)
low power → 2 years
sensor → multiple
receive & act on data
interrupts → extreme conditions
regular polling on order of hours
weatherproof
reprogrammable
low cost / sensor
— reprogram over radio?
Module 0
(plantation)
wifi
store data w/o power
transmit data
LoRA
uCont.
wifi
EXPO