Underwater Sensor Arrays To Help Predict Harmful Algal Blooms

DESIGN DOCUMENT

Team: Sddec20-23

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Executive Summary

Development Standards & Practices Used

- Software version control
- Printed circuit board design
- I2C Protocol
- 1-Wire Protocol

Summary of Requirements

- Device must observe temperature, movement, and chemical analysis (i.e. chlorophyll, phosphorous, and nitrate levels)
- Device must be capable of transmitting and storing underwater sensor data
- Device must be waterproof
- Device must have low power usage
- Device must be able to operate for at least 24 hours
- The total cost of one sensor platform should be under $500
- At least 3 sensor arrays per platform to get an accurate set of data

Applicable Courses from Iowa State University Curriculum

- EE 201 - Electric Circuits
- EE 230 - Electronic Circuits and Systems
- EE 333 - Electronic Systems Design
- CPRE 288/388 - Embedded Systems I/II
- COMS 309 - Software Development Practices
- COMS 327 - Advanced Programming Techniques

New Skills/Knowledge acquired that was not taught in courses

- PCB Design
- I2C Communication Protocol
- Soldering

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1. Introduction

1.1 Acknowledgement

We would like to thank the client for immensely generous financial support and the students Chris and Vishal for continued technical support throughout this project.

1.2 Problem and Project Statement

Currently there is no accurate data on algal blooms and what conditions in which they occur. These algal blooms release harmful toxins into the water which is harmful to the surrounding environment. Many people from third world countries use lake water as drinking water, which can cause sickness if an algae has bloomed. In addition, many organisms in the water suffer due to the decreased oxygen used by the algae.

Our approach to solve this problem is to create a device, called a sensor platform, to collect various types of underwater data. We will use a variety of sensors and eventually analyze and interpret the data to find the conditions that cause an algal bloom.

The purpose of this project is to be able to predict when an algal bloom will occur. This will allow people to take action to prevent a bloom from happening or neutralize the harmful effects. This data would be beneficial for biologists, environmentalists, and the people who depend on affected bodies of water for basic resources.

We aim to create a device that can record all of this data and be able to predict an algal bloom from conditions in the environment.

1.3 Operational Environment

Our sensor array will operate in a harsh environment. Because part of our technology will be submerged underwater, it will need to be completely waterproof. There are also many outside factors like the weather and organisms in the environment that could disrupt the accuracy of our data or damage the platform.

1.4 Requirements

Functional Requirements:

- Device must observe environmental factors such as temperature, movement, and chemical concentrations.
- Device must be capable of transmitting and storing sensor data
- Device must be waterproof

- Device must have low power usage
- Device must be able to operate for at least 24 hours
- The total cost of one sensor platform should be under $500
- At least 3 sensor arrays per desired data to get statistically accurate data

1.5 Intended Users and Uses

Biologists: Can use the data to try and neutralize the harmful effects of an algal bloom
Environmentalists: Can use the data to decrease the chances of an algal bloom and protect the plants and animals that are negatively affected
Dependent people: Can use the data to determine when the water is unsafe to drink

1.6 Assumptions and Limitations

Assumptions:

- Device need not be resistant to wildlife interference

Limitations:

- Power consumption of the device must be low
- All sensors must be waterproofed

When designing a waterproof system it comes with many rules and extra necessities. Some assumptions we made when creating this device is that be it cellular, bluetooth, or other modes of communication that our environments will all be able to support the same type of communication. Along with this we assume that the devices will not need to withstand wildlife trying to break the device. Some Limitations of the design include the power consumption of the device. Since they will have to function on their own, the device will have to manage its power and be efficient where it can. Beyond this we will have to focus on sensors that are capable of being submerged into water or have a way to get their data through a medium that touches the water. Lastly water severely weakens wireless communication so we will be limited to how we transport the data from sensors back to the user.

1.7 Expected End Product and Deliverables

The goal of this project is to create a floatation device that both records and transmits the data for a user. This device must provide a floating surface to communicate above water. Next there will be a flexible array of sensor devices to pick up data about the water at different depths. To ensure the integrity of the data a single platform should be able to support at least three of these arrays to provide statistically accurate data. Next there should be a system setup to transfer the data back to the user. Lastly a software program to analyze the data retrieved and help to predict algal blooms will use all of this infrastructure. This program will most likely use machine learning.

2. Specifications and Analysis

2.1 Proposed Approach

The team began by gaining a better understanding of the end goal: to gather data on algae blooms. With this goal in mind, we worked to find sensors that could be used underwater to gather data. Some of the sensors we will be working with include: a temperature sensor, accelerometer, light and color sensors, and gas sensors. We will start by getting these sensors to work and send data. After a few sensors are working, we will add more and continue testing. Concurrently, we are working with our data transfer module on ways to send the data that our sensors are gathering.

2.2 Design Analysis

The first round of parts and printed circuit boards have been ordered and we look forward to testing in the upcoming weeks. ..what else should we say..? (Done so far, did it work, what are ideas on modifying/continuing, strengths and weaknesses)

2.3 Development Process

The team has created its own development process that is similar to Agile. Communication is great amongst the team, and each weekly meeting mirrors a scrum meeting. Everyone shares the progress they've made as well as upcoming goals and any potential obstacles. Through these meetings and frequent communication, the team has found an effective development process.

2.4 Conceptual Sketch

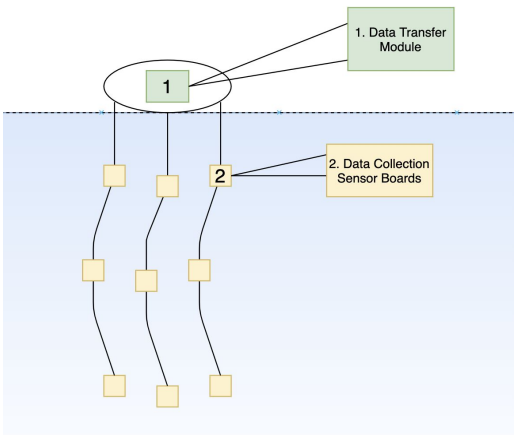

Figure 1: Top level design of sensor arrays.

Description

1. Float to keep the data transfer module outside of the water. This device will be used to store and transfer data from the sensor array
2. The sensor boards contains components such as temperature and accelerometer to collect data from the water
3. The sensors are placed at different depths to create a more robust and accurate set of data

3. Statement of work

3.1 Previous Work and Literature

There is not much data relating to the cause of these harmful algal blooms. Today drones have been used to measure the amount of green color in water, however this is not useful information because it means an algal bloom has already occurred and we would like to know how to predict them. Some of other

3.2 Technology Considerations

All of our data is going to be collected underwater. An important consideration would be how to protect our technology and ensure our design is completely waterproof. This is especially important for...

3.3 Task Decomposition

Tasks will be broken down in basic pieces and assigned to team members through GitLab so that we can tie the tasks to physical code that we write or boards we create.

3.4 Possible Risks and Risk Management

Some possible risks are damages to the boards and sensors once we attempt to waterproof the device. To mitigate this we are trying a few different types of enclosures/sealants to make sure we find the right one.

3.5 Project Proposed Milestones and Evaluation Criteria

- Milestone 1: Determine all sensors needed for the system
- Milestone 2: Create a working sensor board to retrieve data from water in a simple fish tank
- Milestone 3: Create a data analysis tool to make sense of the data
- Milestone 4: Scale up the system to communicate or store the data for usage in a lake
- Milestone 5: Create communication between units
- Milestone 6: Full Scale deployment of multiple units in collaboration

3.6 Project Tracking Procedures

Use GitLab issues to create tracking of individual tasks. Mark progress of tasks so that overall project process is easy to view. Lastly do regular reviews on current tasks and upcoming tasks.

3.7 Expected Results and Validation

The desired outcome of this project is to create a unit capable of collecting data from multiple depths in the water and use this data to predict aquatic life events(specifically algal blooms). The secondary goal would be to create a network of these devices to communicate across a large lake. To validate the unit we will test it in both lab environments and real world bodies of water.

4. Project Timeline, Estimated Resources, and Challenges

4.1 Project Timeline

4.2 Feasibility Assessment

The project will consist of an underwater sensor array connected to a wireless communication device or onboard storage. This project will undergo many challenges due to both the water based aspect of the design as well as the communication of data in a non-urban area.

4.3 Personnel Effort Requirements

4.4 Other Resource Requirements

Beyond Financial requirements, we will need a workshop to solder the components together, an environment to test the product in, and help with knowledge of the algal bloom situation, as well as some biological samples to acquire data.

4.5 Financial Requirements

While the total financial requirements to complete the project is unknown at this point due to speculative prototyping costs the goal for the final unit will be no more than $500 in total for a single unit.

5. Testing and Implementation

5.1 Interface Specifications

5.2 Hardware and Software

5.3 Functional Testing

5.4 Non-Functional Testing

5.5 Process

5.6 Results

6. Closing Material

6.1 Conclusion

6.2 References

6.3 Appendices