Team 31: UAV and Lora Network Based Lake Champlain Water Quality Sensing and Mapping

The University of Vermont

Nathaniel Cassidy Abdoulaye Ira
Andrew Knowlton Kaseya Xia

The University of Vermont
COLLEGE OF ENGINEERING & MATHEMATICAL SCIENCES

Introduction

Background

The majority of beach closures on Lake Champlain are the result of Blue-Green algae. Currently the sampling of lake water quality is performed by people using boats to collect and test water samples. It can take up to two days for sample analyses to be completed, so the worst of conditions often pass before results are available. **Clients Dr Xia and Dr Huston would like team 31 to build something better to solve this problem**.

What's wrong with current means of Sampling and Testing

- **Sampling using boats:**
  - Need a lot of personals and time to sample the lake water
  - People might be interacting with contaminated water while authorities are waiting results from the lab.
  - Cannot be performed regularly
- **Sampling using Buoys:**
  - They provide information about a specific location of the lake
  - It will be costly to cover the lake with Buoys at about $62 each
  - Lot of Buoys on the lake will interfere with boats traffic

Proposed Solution

An UAV equipped with a sensing system and a LoRa Transmission system to measure Lake Champlain water quality in real time.

Benefits

- Early warning about the presence of algae in the lake
- Frequent monitoring of lake water quality
- Protection of people practicing activities such as swimming, water skiing, windsurfing and sailing.

Analysis Results

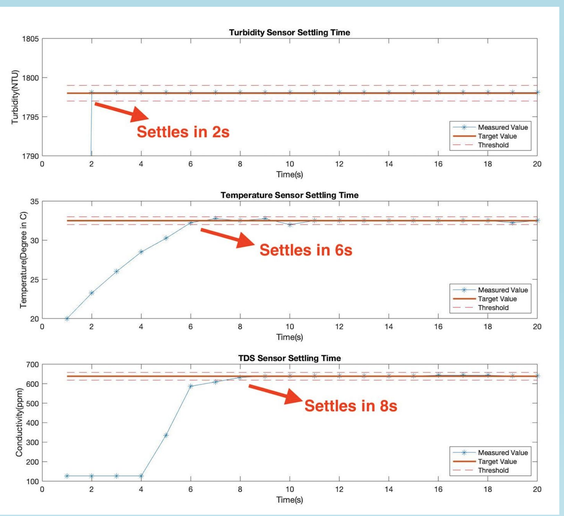

Figure 1: Sensor Response Time

Sensor Response Time

The number of locations for water quality sensing is determined by the overall UAV flying ability and speed of data collection at each site. Our team has picked sensors (turbidity, temperature, TDS) that have a response time of less than 10s to optimize the number of data points collected (Figure 1).

Working Design

Design Requirements

- Can generate a color map of the collected data
- Low cost to purchase and to operate
- Works for a wide variety of user's experience
- Low weight and small size making it easy to transport
- Can only use LoRa Transmission Protocol
- Can only be an UAV
- Safe to use for lake environment

Design Concepts:

- Custom Built Drone
- 3D Printed sensor box
- Three sensors:
  - Temperature
  - Turbidity
  - Total Dissolved Solids
- Detachable Sensor harness
- GPS for data mapping
- Digital camera for water quality

FIgure 2: The Built Drone

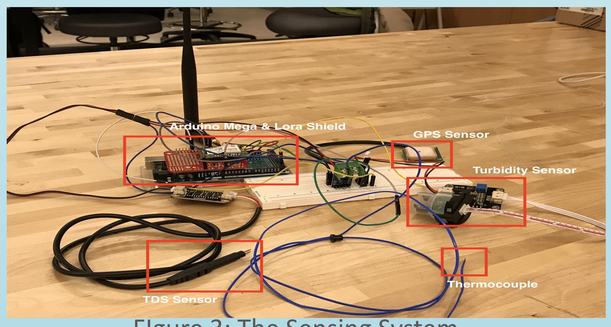

FIgure 3: The Sensing System

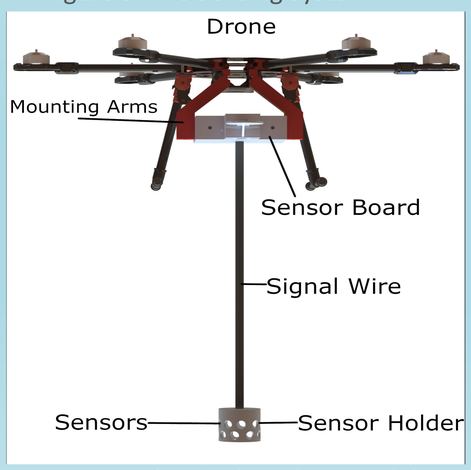

FIgure 4: The Final Product Model

Contact Information

Scrum Master: Abdoulaye Ira, Abdoulaye.Ira@uvm.edu

Verification Results

Proof of Transmission

The payload below represents data transmitted during testing via LoRa gateway. It is in Hex-format.

The payload decoded, would read:
Turbidity value, Temperature value (in C and F), Total Dissolved Solids value, and GPS coordinates as shown below

```
15:08:43.466 ->  Turbidity: 999.89 NTU Temperature: Deg C = 22.25Deg F = 72.05  TDS Value:129ppm
15:08:44.642 ->  Turbidity: 999.89 NTU Temperature: Deg C = 22.25Deg F = 72.05  TDS Value:129ppm
15:08:45.866 ->  Turbidity: 999.89 NTU Temperature: Deg C = 22.50Deg F = 72.50  TDS Value:129ppm
15:08:47.182 ->  Turbidity: 999.89 NTU Temperature: Deg C = 22.50Deg F = 72.50  TDS Value:129ppm
```

How the design solved the problem?

- The Blue-Green Algae is known to trieve in a temperature range of 20C to 30C
- Its presence in the water increases the turbidity of the water
- Its presence will also change the color of the water

This design will use the Temperature, the Turbidity, and the Picture of the water to indirectly determine the presence of the Blue-Green Algea in the water. It is also a very cheap option since a good algae sensor cost around $3200 (YSI 6210 Total Algea PC Sensor for instance)

Conclusion and Recommendations

Conclusion

- Test flights of the drone were promising, most of the design requirements were met
- The drone is stable with the added payload and capable of prolonged hover for sample recovery
- The transmission system is capable of transmitting data
- Sensors successfully collected data along with location information
- System is modular, with ability to connect up to 5 sensors and mount to different drones.

Recommendations

- Waterproofing of sensor box and electronic components
- Reduce size of and materials used in sensor box
- Improve design of sensor holder
- Design a more reliable transmission system
- Upgrade the device so it can sample at different depth of water

Acknowledgements

Special Thanks to:

- Prof. Dustin Rand, Professor and Advisor (UVM CEMS)
- AJ Rossman and Eric Hall, Hardware and software support (IoT Conduit)
- Dr. Tian Xia and Dr. Dryver Huston, Clients and advisors (UVM)