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Integrated Engineering Design Project 2 - Engineer 2PX3

Milestone One: Defining the Problem

Source Water Monitoring

T06 - Water 16

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2.0 Executive Summary

A source water quality system was required to be designed using image capturing from drones and machine learning algorithms to identify harmful bacteria within the water. After researching into Alberta's provincial regulatory services, we have identified that the nearby town of Bonnyville, nearby Fort McKay First Nations reserve, and Alberta's Lake and health services as stakeholders. Each one of the stakeholders have direct benefits from the source water monitoring system while other stakeholders have ethical concerns with the usage of the land itself. In terms of system identification, we have outlined the essential components of the system. We have gone for an environmentally friendly LiPo battery, efficient flight routes, and using a high-quality camera with a focus on accuracy, maintainability, durability, efficiency, and mobility. Our system is assumed to be deployed in ideal weather conditions, warm summer months, and can sustain its battery for 1 hour at a time. It will then collect data and transmit it to a nearby datacentre for machine processing and stored for future reference.

3.0 Introduction

Many communities throughout Canada rely on local water bodies as sources of fresh water, and so ensuring the regulation of water quality standards for these bodies is an important function that needs to be completed year-round. The current system for water quality regulation relies on experts making on-site visits to inspect water samples for algal blooms and other contaminants. Unfortunately, this process is not only inefficient and time consuming, but also expensive. This milestone is the first step in developing a new system for source water monitoring, using drone imagery combined with a machine learning algorithm that compiles existing data. The goal is to ensure maximum accuracy for a more economical design, while also weighing ethical concerns such as privacy laws and environmental issues. For ease of developing the design, Moose Lake in Bonnyville, Alberta was chosen as a placeholder location [1], [2].

4.0 Stakeholder Analysis

Our source water monitoring project based on Moose Lake in Bonnyville, Alberta would have a profound impact on the many groups and communities that rely on the lake.

4.1 Residents of Town of Bonnyville

The Residents of the Town of Bonnyville are affected by the project because of their use of Moose Lake as a recreational area and provincial park. There are also many who use Moose Lake as a potential source of drinking water either for hunting related purposes or personal use. Homeowners and bankers are also important stakeholders because improvements in water quality will increase the value of lakeside homes, contributing to the overall local economy [1]. We must consider related socio-cultural design decisions, these being the various ways our drone system may cause public disturbance and controversy while monitoring the lake. Our design must minimize noise pollution, and we must modify our flight path and data collection patterns in a way that will not infringe on the privacy of the locals at the lake.

4.2 Municipal District of Bonnyville

The Municipal District of Bonnyville is affected by the project since they are the governing body of Bonnyville, and thus Moose Lake falls in their jurisdiction. Improved water quality will have effects on the local economy and potential tourism which is generally governed by their administration [1]. Our project must abide by all laws and regulations of the town of Bonnyville. This will also affect our flight path decisions where we must not enter potential restricted areas or travel and specific heights.

4.3 Moose Lake Watershed Society

Moose Lake Watershed Society, a committee of volunteers, is affected by the project because they are the organization that address the health of Moose Lake, as well as increase public awareness, manage the general wildlife habitat, and fundraise for improvement of the overall water quality of Moose Lake [3]. Minimal Interference or damage of the environment of Moose Lake is a priority. This can be accomplished through performance aspects, such as the overall build of our drone and its flight mechanism must be managed in a way that mitigates drone crashing. In the event of a drone crash, there should be no everlasting impact of the crash on the

overall environment of Moose Lake. Data collected may also be shared with the society to further their community outreach opportunities in a joint effort to improve water quality of Moose Lake.

4.4 Alberta Health Services

Alberta Health Services is a health system organization that must be deeply considered when it comes to the performance aspects of our drone and especially data collection since AHS regulates the safety standards for drinking water and broadcast health advisories in Alberta [4]. Ensuring that data extracted is extremely accurate allows for AHS to promptly send health advisory warnings, therefore our system must have a process that easily and quickly transfers the data from the drone to the machine learning algorithm and then to AHS.

4.5 Fort McKay First Nations

Fort McKay First Nations are an important community that is affected by the project because of the cultural and ancestorial association they have with Moose Lake. The traditional land around moose lake is used by Fort McKay First Nations through various cultural activities. The community has voiced their many concerns of industrial efforts against Moose Lake, as well as the overall degradation of the water quality [5]. Similar to the residents of Bonnyville; we must not disturb their traditional values and wishes by mitigating noise pollution and respecting their privacy by altering our surveillance schedule. The drone must not damage the environment around Moose Lake in any way out of respect for Fort McKay’s culture.

5.0 System Definition

5.1 Input Parameters

5.1.1 Imaging Equipment

The source watering system utilizes a robust DJI manufactured camera system that can be modularly changed to match any given scenario such as thermal vision, heat vision, and different focal length lenses for situations where there are fast amounts of rainfall if our system chooses to operate in rainy conditions. These cameras have built in auto focus, can record video in 60 FPS, and have 12 Megapixel quality [6].

5.1.2 Power Source and Usage

The system will be powered by 12S lithium polymer batteries. They are a relatively environmentally safe option and are run the drone for around 1 hour [6]. A recharging station or stations are also required for lengthy flight paths of which the charging sequence will be automated.

5.1.3 Water quality data

Water quality data must be provided from testing different blue green algae concentrations. This data will be used for training and maintaining the machine learning algorithm so that it is able to match captured imagery with algae concentrations and determine dangerous algae levels.

5.1.4 Machine learning algorithm

Captured drone data will be analyzed by a machine learning algorithm for details about the algal bloom such as size, concentration, colour, and whether the lake must be treated. The algorithm will be trained and maintained from new and existing water quality data samples to ensure accuracy on identifying algal blooms.

5.2 Operating Conditions

5.2.1 Flight Plan

The drone must follow a path that does not disturb the locals who are interacting with Moose Lake and its nearby environment. Thus, the surveillance will take place at early morning to avoid privacy concerns and noise complaints. The path of the drone will be rectangular, allowing the

drone to capture images or video in efficient chunks. The path will also avoid wildlife. Charging stations will be placed at designated areas in case surveillance exceeds the flight duration of 1 hour.

5.2.2 Weather Conditions

The drone is designed to be mildly weatherproof in conditions such as light precipitation and wind. In the event of harsh weather such as rain storms the drone will not conduct surveillance. This will be determined through analyzing weather data via weather networking API. If the drone determines it is experiencing harsh weather conditions mid-flight, it will stop all surveillance and land at a nearby predetermined safe point location.

5.3 Outputs

The system will be outputting captured data during the drone's scheduled surveillance periods. Data will be transferred through Wi-Fi to the host computer and analyzed by the machine learning algorithm. Analysis results will be shared with the Alberta Health Services if algal blooms are at a harmful concentration, as well as the Moose Lake Watershed Society if requested. Previously analyzed data and results will be compressed and archived for logging and potential troubleshooting purposes.

5.4 Assumptions

Some assumptions that have been considered to narrow down the scope of the project include: having flight paths that do not trespass on any private property, operation of drone and thus extraction of data only occurring during clear and visible weather, having drones return to home-base during inclement weather, having a maximum of 1 hour charge for battery of drone, and ensuring that drone would fly in conditions with no high elevation obstacles such as trees or birds.

5.5 Constraints

It can be assumed that the drone battery can last around 1 hour between charges, which limits the possible flight plans that can be utilized. A drone of this caliber would cost around $19,000 CAD, which can be used as a placeholder.

Moose Lake is known to have moderate amounts of rain in the summer (May to August) which may halt surveillance schedules. The system will also stop all monitoring efforts during winter when the lake freezes and there is no surrounding activity. The system must mitigate drone crashing and related system failures; in the event of a malfunction and the drone invades the surrounding wildlife, there must not be any pollution to the environment from the drone, meaning we must have an eco-friendly design expressed through the drone body's material usage and battery type.

5.6 Measurement of Performance

The system's performance will be measured with 5 key objectives:

5.6.1 Accuracy

It is important that our system is highly accurate in its data collection, i.e., water body photos. Our machine learning algorithm should also be highly accurate in determining the concentrations of algae per photo so that we are getting the most correct data possible.

5.6.2 Durability

When we speak about durability, we are referencing the body of our drone and its components, and its ability to withstand disturbances. These disturbances include harsh weather conditions and general degrading over time.

5.6.3 Maintainability

It is important that we can easily service the system if there is any issue during its lifetime, having high maintainability would allow for the system to have a longer lifespan, reducing overall cost as the system can be repaired instead of fully replaced.

5.6.4 Mobility

It is important for the system to be able to operate in various conditions, whether that is in windy environments or areas with lots of trees it is important for the system to be mobile such that it can be used in various scenarios.

5.6.5 Efficiency

It is important for the system to be able to collect data efficiently such that cost, and resources are minimized, and consequent savings can be used for furthering of the system, whether that is in quantity or quality.

5.7 Ethical Considerations

The monitoring system must preserve the natural wildlife that surrounds Moose Lake; minimizing drone malfunctions and proper flight pathing should help maintain the natural environment. The system should also respect the privacy of all locals visiting Moose Lake and the culture stemmed from the Fort McKay First Nations. The surveillance should be out of sight and hidden to the best of its ability.

6.0 Conclusion

In this report, the fundamental aspects of this engineering design project have been outlined. A thorough analysis of stakeholder perspectives, ranging from the residents of Bonnyville to the Alberta Health Services, is provided to widen the scope of this project beyond purely engineering. In addition to this, ethical consideration such as the impacts on First Nations communities and environmental issues have been summarized. However, the bulk of this project will revolve around developing a system for monitoring source water quality for isolated bodies of water, such as Moose Lake (Bonnyville, Alberta), utilizing drone imaging and machine learning technologies, while balancing the socio-cultural concerns mentioned earlier. To accomplish these end goals efficiently and affordably, several innovative technologies have been considered and will be further analysed in future milestones. These include lithium polymer batteries, auto-focus cameras, charging stations and more. Moving forward, a greater emphasis will be placed on specifics regarding both drone hardware, as well as the underlying software elements.

7.0 References

[1] “Moose Lake Initiative - proposed pilot project for an alum application.” https://algaecontrol.ca/mooselake/ (accessed Feb. 05, 2022).

[2] A. B. Prepared, C. Prather, T. Charette, and J. White, “STATE OF THE WATERSHED ENVIRONMENTAL INVENTORY REPORT FOR MOOSE LAKE: SUMMARY OF CURRENT INFORMATION PREPARED FOR: THE MOOSE LAKE WATER FOR LIFE COMMITTEE,” 2005.

[3] “Moose Lake Watershed Society (MLWS) - LARA | Lakeland Agricultural Research Association.” https://laraonline.ca/project/moose-lake-watershed-society-mlws/ (accessed Feb. 05, 2022).

[4] “Blue Green Algae Health Advisories | Alberta Health Services.” https://www.albertahealthservices.ca/news/bga.aspx (accessed Feb. 05, 2022).

[5] “MOOSELAKETOGETHER.CA.” https://mooselaketogether.ca/ (accessed Feb. 05, 2022).

[6] “MATRICE 300 RTK - Specifications - DJI.” https://www.dji.com/ca/matrice-300/specs (accessed Feb. 05, 2022).

8.0 Appendix: Team Charter

Basic Info

Member	Full name	Preferred name	Email
Team Member 1	Mashroor Rahman		Rahmam83@mcmaster.ca
Team Member 2	Aadil Rehan		rehana4@mcmaster.ca
Team Member 3	Ahmed Sahi	Ibrahim	Sahia8@mcmaster.ca
Team Member 4	Yuvraj Sandhu		Sandhuy@mcmaster.ca

Team Portrait

Team Goals

Develop necessary engineering skills and learn about topics and concepts that are not normally taught in our respective streams i.e., Machine Learning Algorithms for chemical engineering, identifying quality of water through machine learning for software/computer engineering. Additionally, finding a unique solution to the problem at hand is a product that will motivate us throughout the term.

Team Member 1: Mashroor Rahman

Strength	Example
Communication	In the 1P13 course I believe that I possessed strong communication skills, being able to converse with groupmates, other students, and TA's regarding our engineering related work.
Conflict Management	During one of my group projects in one of my previous electives, there was a disagreement between two other team members, and I was able to step in and mediate the discussion so that both parties were satisfied with the outcome.
Work Ethic	In any tasks I am given, especially tasks that involve groupwork, I try my best to complete the given task, and do it to a level, such that I am proud of my work. This was particularly evident in the previous 1P13 projects.

Area of improvement:

Leadership is one area I would like to improve, usually I wait for other people to take the lead, and therefore I'd like to improve this area as I want to be proactive into taking lead in groups and starting initiatives without waiting for others to do so.

Team Member 2: Aadil Rehan

Strength	Example
Problem Solving	When I am approached with a problem, I am relentless when it comes to finding the solution. Sometimes I may not find the most elegant/efficient solution, but I always find an answer which satisfies the solution.
Programming	I have a fair bit of experience with programming languages. I can work with code effectively and am able to adapt to new coding challenges quickly.
Team Cooperation	I am always readily available for contact and personally think that I am very cooperative when it comes to group work. I communicate as much as I can and am able to freely share my thoughts and consider the thoughts of others.

Area of improvement:

My researching skills when it comes to topics that I am not knowledgeable or interested in is severely lacking. It is difficult for me to research on topics that I don't have background knowledge on, and my researching skills in general are lackluster so I am hoping to improve this skillset during this project.

Team Member 3: Ibrahim Sahi

Strength	Example
Blunt Honesty	I tell my team when I don't want to do something, or when what they did is bad.
Small Talk	I'm good at small talk. I talk to my team all the time even when they clearly are busy with productivity.
Funny	I am hilarious, my teammates cannot stop laughing. (This is true, I am teammate)

Area of improvement:

Work ethic and discipline. Focusing on the problem at hand.

Team Member 4: Yuvraj Sandhu

Strength	Example
Experienced	I have done a lot of work in different area's and have a wide skillset. Such experiences would include animating, CAD designing, machining, and software development.
Creative	I'm able to think "outside of the box" and come up with differing solutions to problems.
Detail Orientated	I am very specific on making sure certain details are dealt with and are perfected

Area of improvement:

Being able to stay on task and complete assignments on given deadlines.