Lake water quality in 3D

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Chapter 1

Introduction

This report is for a final year project course for student in engineering applied physics and electrical engineering, and data science. We had a choice between three projects, and we picked the one titled "Lake water quality in 3D". We all had an interest in the subject, and the technical challenge suited our capabilities. All the members in our group are from Engineering Physics and Electrical Engineering, and have therefore taken similar courses. Our group, however, has many different experiences from work and from different hobbies.

Our interpretation of the project as a whole is that it is an opportunity to learn more about something that we are interested in. We can therefore pick approach depending on our interests and skills.

Our understanding of the project "Lake water quality in 3D" is that we are to build a platform which could measure different parameters in a lake that determine its water quality. These measurements are to be taken at different points on the lake surface and at different depths for those points. With this we can create a 3D map of the lake to see how parameters like turbidity, dissolved oxygen, and salt level differ. Since this is a 4 months project we might need to narrow down the focus to building a part of the solution, like for example the platform carrying the sensors, or the sensor system itself.

There are several challenges to this project, which we will describe here, and, in the next chapter, suggest solutions to these problems. The first problem is to get the sensors out on the lake and to get the vehicle to systematically stop at each point. The next problem will be to get the sensors down below the surface to different depths. The sensors will need to be waterproof, and the device that reads from them needs to be in a waterproof casing. This data will need processing and later be plotted in a meaningful way.

Chapter 2

Possible solutions

2.1 Solution 1: Drone

One approach to 3D water quality monitoring in a lake is to use a drone equipped with a pulley system to deploy a sensor platform. This platform carries all the necessary sensors, such as turbidity, dissolved oxygen, temperature, and pH sensors, as well as a single-board computer for data logging and preliminary processing.

2.1.1 Workflow

1. Using the pulley system, the platform is lowered to different depths, allowing measurements throughout the water column.
2. The platform is deployed at multiple locations across the lake to capture spatial variations.
3. Data collected at each depth and location is logged and later processed to generate a 3D model of water quality parameters.

2.1.2 Advantages and Risks

The drone-pulley system allows measurements at any location and depth. Remote control, pulley positioning, and a protective sensor casing improve accuracy and safety. However, the risks are high: the drone requires precise control and strong stabilization, and turbidity measurements need time for the water to settle. Technical failures could also interrupt data collection or damage the whole system potentially causing high losses.

2.2 Solution 2: Submarine

Another approach to measuring lake water quality is to use a submarine with the sensor system attached to it. This solution makes it possible to easily reach desired positions and depths in the water, as well as monitor the surroundings with a mounted camera. The submarine would carry external sensors to measure temperature, pH, conductivity, turbidity, and other relevant parameters. An onboard computer inside the submarine would collect and log data in real time, enabling both storage and preliminary processing directly in the water.

2.2.1 Process overview

1. The submarine is deployed in the lake and navigated to different target locations.
2. At each location, it can dive to various depths to record measurements throughout the water column.
3. The onboard system collects and stores the data, which can be transmitted wirelessly to a base station or retrieved after the mission.
4. Using positional and depth data, a 3D model of the water quality distribution across the lake can be constructed.

2.2.2 Advantages and Risks

The submarine offers high flexibility, as it can actively move to any point and depth in the lake without the need for external lowering systems. An integrated camera allows real-time monitoring of the environment, which can improve navigation and situational awareness. Since the sensors are mounted directly on the submarine, stable and continuous measurements are possible during movement. However, navigation and communication underwater can be technically challenging and require robust control systems. The submarine may face mechanical or electrical failures, especially under high pressure at greater depths. Recovery in case of failure may also be difficult, posing potential losses of both equipment and collected data.

2.3 Solution 3: Raft or boat with Pulley System

An alternative approach to measuring lake water quality is to use a motorized raft or boat equipped with a pulley system that lowers a waterproof sensor container into the water. The waterproof container contains an onboard microcomputer and sensors to measure temperature, conductivity, turbidity, and other relevant parameters. The pulley system is operated by a DC motor and controlled by a microcontroller installed on the raft. A Hall-effect sensor is used to measure the length of wire released, ensuring accurate positioning at specific depths. Additionally, a sonar provides the distance to the bottom of the lake, allowing automated deployment of the sensor container to predefined fractions of the total depth (e.g., 20% and 50%). After a defined sampling period, the pulley retrieves the sensor case back to the raft.

2.3.1 Process overview

1. The motorized raft or boat is placed at the target location on the lake surface.
2. Sonar measurements determine the total depth at the current location.
3. The motor-driven pulley lowers the waterproof sensor container into the water.
4. Using the Hall-effect sensor, the system stops the pulley at the target depth (e.g., 20% or 50% of total depth).
5. The onboard microcomputer collects, stores, and possibly pre-processes the data from the sensors during a set time interval.
6. The pulley system retrieves the sensor container back onto the raft.
7. Data can be transmitted wirelessly to a base station or retrieved directly from the onboard computer.

2.3.2 Advantages and Risks

This solution allows precise control of measurement depths, and the automated pulley system ensures reliable and accurate sampling. It is well-suited for long-term monitoring that requires data from different depths. However, there are risks such as wear on the pulley system, cable tangling, or water leaking into the sensor container, and disturbances from waves or currents. If the motor or electronics fail, a manual backup system should be available to recover the sensor.

Chapter 3

Gantt chart

Figure 3.1 shows the expected workflow from September to December. The plan is to have a clear solution approach and architecture by the middle of September. As that becomes clear, the hope is to order all needed equipment, such as microcomputers, micro-controllers, sensors and other necessary hardware. Most likely, some sensors will be built during the project and they should be working by the end of October. Since the project involves water, the hardware needs to be protected, which means creating a waterproof case. This will also be completed at the end of October. After the midterm presentation the plan is to start focusing on the pulley system. The pulley system is expected to be completed in early December. If needed, the design will be improved until the final report is due.

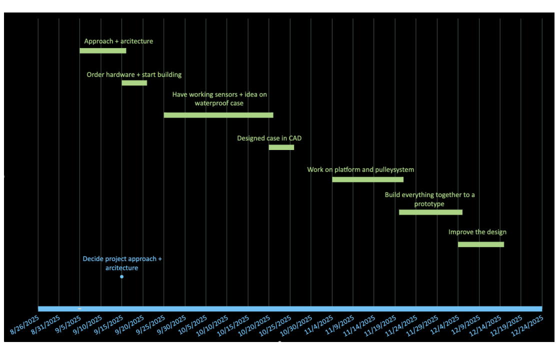

Figure 3.1: Gantt chart of the workflow.

Appendix A

Tilda Florén

I was born and raised in Luleå, Sweden, as the oldest of four siblings. During high school, I studied science while also competing in basketball, a sport I still play alongside my studies. After graduation, I tried a variety of jobs but quickly realized that I needed more intellectual challenges. That realization eventually led me to engineering, and after much consideration, I chose to pursue a master's degree in Electrical and Control Systems Engineering.
My interest in physics began in high school thanks to an inspiring teacher, but my curiosity for technology started much earlier. From a young age, I was fascinated by motors, cars, and motorsports. I also enjoyed taking apart RC cars, electrical toys, and other devices just to understand how they worked. That combination of curiosity, hands-on experimentation, and problem-solving has stayed with me ever since.

Alongside my studies, I work as an operating technician at a thermal power plant. This role has sharpened my skills in error-searching, improved my ability to handle real-world technical problems, and taught me the importance of clear communication between engineers and their customers. At the university, I have focused heavily on control theory and control systems, choosing every available course in the field.

I choose this project since it matches my interest in control systems and hands-on problem-solving, while also offering the chance to create something that can benefit nature. In our project, I will mainly contribute by working with hardware, measurements, and error-searching. I enjoy the process of troubleshooting and using both my hands and my mind to solve problems.

Appendix B

Emmi Hentilä

I was born in Finland but moved to Sweden when I was only three months old and I have lived here ever since. Growing up in a large family gave me independence and responsibility from an early age. My childhood was spent on an island, where my curiosity often led me into nature on countless small adventures. These experiences shaped me into a person who feels very connected to the outdoors and enjoys hiking, skiing, and almost everything that nature provides.

From a young age, I discovered that I had a talent for mathematics. This soon grew into a genuine interest, and together with my curiosity for science, it influenced my choice to study science in high school. Over time, my passion for both mathematics and science naturally evolved into a fascination with physics. My path into higher education in applied physics and electronics was somewhat unexpected, I had accidentally listed the program as my first choice when applying. However, this "mistake" quickly proved to be the right one, as I realized it was exactly the education I had been looking for.

Today, I am pursuing a master's degree in electrical engineering and control theory. This program strikes a rewarding balance between hardware and software, which suits my interests well. In this project, I will contribute by designing electrical circuits for sensor systems and developing programming solutions to extract and process data. I also expect to assist with the necessary calculations that support our results.

What excites me most about this project is how it combines my personal and academic interests. The study of lake water quality in 3D allows me to connect my love of nature with my enthusiasm for science and technology. At the same time, the focus on sensors and data collection provides valuable experience for the future, as sensors play an important role in today's society.

Appendix C

Tilda Johannesson

I grew up in Grängesberg, a small town in the middle of Sweden. I am the first in my family to leave this town to pursue higher education, something my parents always wished for me. Since first encounters with mathematics I have liked it, most because I found it very clear and logical. In gymnasium, I had a fantastic teacher who gave me even more motivation to continue with math. After graduation however I worked for one year, but soon realized that I wanted to return to study.

I started with a technical preparatory year, where I discovered physics and electronic circuit design. This quickly became a strong interest of mine, and I knew I wanted to study engineering in applied physics. Here at LTU I found the perfect program combined both applied physics and electrical engineering. Now I am in my fifth year, studying for a master's degree in control engineering and electronic systems.

During my studies I have worked with both hardware and software. I especially enjoy projects where I can combine these, like designing autonomous systems, robotics, electronics etc. My strengths are in electronics and hardware design, but I can also contribute with software development, troubleshooting, and other required problem solving in this project. I enjoy working in groups and think discussions are important to find good solutions.

This project interests me because it connects to my background and future goals. Growing up in the Swedish forests gave me a strong love for nature, even if I do not have much experience with water systems. I look forward to learning more about them. At the same time, the project gives me more practice with sensors and combining hardware with software, which is something I want to continue working with in the future.

Appendix D

Salma Matoussi

I was born and raised in Stockholm, Sweden, where I grew up in Rinkeby, a district in northern Stockholm known for its cultural diversity but also for its socioeconomic struggles and frequent presence in the news. My parents are originally from Tunisia, and growing up with both Swedish and Tunisian influences gave me a strong sense of cultural identity and openness. Because I grew up in Rinkeby, I was surrounded by many cultures, which often showed up at the dinner table. One day it could be injera, another day Ayran, sambosa, or freshly baked za'atar bread. And of course, no multicultural childhood would be complete without a full debate between Moroccans, Algerians, and myself about whose couscous is truly the best. Naturally, the only correct answer is Tunisian. This environment provided me with a unique perspective on resilience, adaptability, and community, which has shaped the way I approach challenges in both my studies and personal life. Despite initially facing difficulties in school, I discovered the value of education over time and decided to pursue engineering. This turning point set me on a path that eventually led me to Luleå, where I am now studying applied physics and electronics.

During my studies in applied physics and electronics, I developed a strong passion for mathematics, control theory, and system modeling, as well as for mathematical programming, which allows me to implement abstract concepts in code. While the "Lake Water Quality in 3D" project is not exactly my main area of interest, I am drawn to it because of my love for fishing and my concern for aquatic ecosystems. In this project, I will focus on handling and calibrating sensor data, troubleshooting measurement errors, and supporting my colleagues in their tasks, while also contributing to some hardware work. I see this as an excellent opportunity to broaden my skills while contributing to a project that aligns with my interest in the environment.

Appendix E

David Norberg

When we got the alternatives for this project, the Lake Water Quality in 3D stood out to me. I have always been interested in natural ecosystems and how water quality affects them. My passion for the environment comes partly from my hiking interest. I enjoy hiking in nature reserves and national parks especially around lakes or the sea. Assessing water quality to better understand what a lake needs can significantly help the entire ecosystem of a park since all life is dependent on water.

Since we are using a sensor system instead of sending the samples to a lab, we need to measure different parameters in the water live using sensors. This means having at least one device like an Arduino or a Raspberry PI to read from the sensors and store the data. I come to this project with experience, and an interest, in electronics. My contribution will likely be to design electronic circuits which are needed for driving the sensors and reading their data.

Another problem which we will encounter is plotting the data in 3D. This summer, when working at Tetra Pak, I used Python to build a model of a packaging machine. This experience could help me contribute by programming the plotting function, and the visualization using either libraries, or building from scratch.

I come from a background where listening to others and discussing problems is important. I believe I will contribute by keeping a living discussion in the group and letting everyone be heard. Furthermore, I have a background in working with computers and have learned troubleshooting from a young age. This will contribute to the project since the set up of the sensors will likely be far from smooth.

Although I have always been passionate about the environment, I do not have any experience in water quality measurements. I will use this project as an opportunity to learn more about measurement systems and how they can be used in a challenging environment.

Appendix F

Rana Zaher

I'm Rana, born and raised in Yemen and currently pursuing my college studies in Sweden. Moving between places has made me naturally curious; I like to explore the world and learn by seeing things up close. Travel taught me to be adaptable—new languages, new systems, new ways of thinking—and that adaptability has become the thread that runs through my academic journey and the person I'm becoming.

I grew up in a family where medicine is more than a profession—it's a shared language. My mom and both of my brothers are doctors, and my younger sister studies dentistry. I even started as a first-year medical student before realizing it wasn't me; my spark is in numbers, problem-solving, and those moments when physics clicks and systems behave as predicted. Leaving medicine wasn't easy in my family, but it was the first real risk I took for myself.

I chose a direction that fit how I think. I'm now a fifth-year student in physics and electrical engineering. Along the way I've completed courses in mathematics, physics, electronics, automation, and control, with some robotics as well. I'm especially drawn to robotics and control because they sit at the point where theory becomes behavior—where models meet sensors and actuators, and where good reasoning turns into reliable motion. To support that interest, I'm actively strengthening my programming skills so they match the level of the math and systems thinking I enjoy.

In this project course, I have chosen lake water-quality 3D modeling because it requires building a complete system that combines hardware and software—from designing circuits and integrating sensors to gather data, to applying programming skills for processing and visualizing the results in a 3D model. I have always enjoyed building things from scratch and seeing them come to life, and I can contribute to most of these areas. At the same time, I am continuing to strengthen my programming and data processing skills to support the project as needed.