Lake water quality in 3D

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Contents

Chapter 1

Introduction

1.1 Background

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, have 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.

1.2 Challenges

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.

1.3 Why 3D lake water quality matter

Researching lake water quality in 3D can contribute to many different areas and uses. The 3D characteristics of the lake can provide valuable information in observing the ecosystem from a sustainability point of view, as well as in managing freshwater reserve. The quality of a lake could provide details of how climate change affects both the ecosystem and water resources. It could contribute to the ability to respond to droughts, floods, and habitat loss. This information is useful for the government, engineers and researchers. The government can use the data to predict or analyze water supply, engineers receive information useful in infrastructure planning and researches get valuable insight of the ecosystems.

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 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. If the motor or electronics fail, a manual backup system should be available to recover the sensor. Other risks include waves and currents, which can disturb the raft of boat. This can affect the stability of the pulley system, the quality of the measurements, and may cause the raft to drift, which affects the exact location of the measurements and therefore the spatial accuracy.

Chapter 3

Project Management

3.1 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. First the plan is to achieve working sensors, which should be done 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.

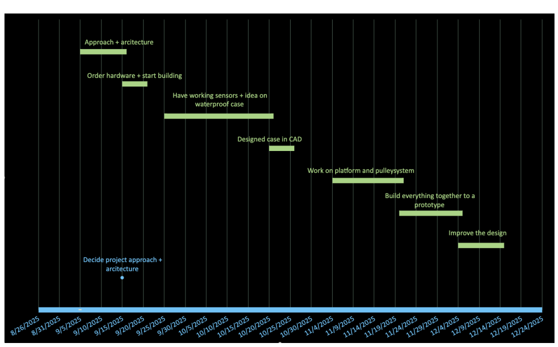

Figure 3.1: Gantt chart of the workflow.

Chapter 4

Components

The first step in this project was to decide on what to measure in order to quantify water quality. The time constraint of this project meant that we needed to narrow down which parameters we wanted to measure. Ease of measurement, calibration, and availability of sensors were considered, as well as compatibility with the micro-controller and single board computer that will be used in later stages. We ultimately chose turbidity, temperature, dissolved oxygen, pH, and Total Dissolved Solids (TDS).

4.1 Single Board computer

The selected single board computer is the Raspberry Pi 5. The Raspberry Pi 5 is well-suited for this lake water quality project due to its powerful multicore processor and high clock speed, which enable efficient handling of data processing and communication tasks. With built-in Wi-Fi, Bluetooth, and multiple USB and GPIO interfaces, it can easily interface with external devices and support wireless data transmission or remote monitoring. The Raspberry Pi 5 runs a full operating system, allowing the use of high-level programming languages, data logging tools, and graphical interfaces. Its expandable storage, strong community support, and compatibility with various modules make it a flexible and scalable platform for environmental monitoring applications.

4.2 Micro-controller

The chosen micro-controller is the Arduino due. The Arduino Due is well-suited for this lake water quality project because of its fast 32-bit processor and high clock speed, which allow real-time data processing. Its high-resolution analog inputs and multiple serial ports make it easy to read from and manage several sensors simultaneously. The Due is programmed using the Arduino IDE, which provides an easy and user-friendly environment for writing code in C/C++, uploading programs, and debugging. With large memory, native USB support,

Figure 4.1: Turbidity sensor by seeed [2].

and compatibility with plug-and-play modules, the Due offers a flexible, scalable, and reliable platform for environmental monitoring projects.

4.3 Turbidity sensor

Turbidity is a measurement of the haziness of a fluid by the volume of suspended particles. The particles are small enough not to sink to the bottom rapidly and is therefore defined as suspended. The turbidity is an indication of water quality since the suspended particles are often not desired in drinking water. The suspended particles reduce light scattering which affects water clarity [3]. Water clarity, in turn, affects the visibility for predator fish, which affects the whole ecosystem of a lake.

Turbidity is measured in Nephelometric Turbidity Unit (NTU). For water to be drinkable it has to have no more than 1 NTU [1]. Turbidity sensors come in different variants, and we discussed which is the optimal for this project. Since we want to test our sensor platform, we chose an LMV358 by seeed. This sensor is cost effective, which suited this projects limited budget. Furthermore, if something goes wrong with the waterproofing, the consequences will be minimal. As can be seen in Fig. 4.1, the sensor comes with a board which is compatible with Arduino which makes implementation easier.

Other alternatives we looked at had prices at inquiry, had long shipping times, and was not directly compatible with Arduino. Therefore we decided to start with the one by seeed.

(https://www.rikasensor.com/rk500-07-ss-turbidity-sensor.html) [(alt2)](https://www.electrokit.com analog)

4.4 Temperature sensor

The temperature in lake waters has many different impacts on water quality. It affects most physical, chemical, biological, and ecosystem processes in water environments. When water temperatures rise, they can lead to reduced levels of dissolved oxygen as well as increased solubility of metals and other toxic substances. source.

The DFR0198 has been chosen as the temperature sensor seen in figure 4.2. This is a waterproof DS18B20 digital temperature sensor for Arduino with IP68 rating, specifically designed for temperature measurements in wet conditions. The sensor has a wide measurement range with a ±0.5°C accuracy from -10°C to +85°C. It has simple connection, using a 3 wire interface, supply, ground and signal. (Note! this sensor requires a 4.7K ohm resistor between voltage and signal pin, see datasheet) In order to convert from bit to temperature, a code snippet is provided from the manufacturer here.

Figure 4.2: DFR0198 Temperature Sensor.

In the early stages of the project, we considered building the sensor ourself but realized that this approach would demand more time and resources than reasonable. We did not look into many options apart form DS18B20, as this sensor was both affordable and fulfilled the purpose.

4.5 Dissolved Oxygen Sensor

The SEN0237-A Analog Dissolved Oxygen Sensor from DFROBOT was selected to measure dissolved oxygen in lake water because it meets the project requirements. It is fully compatible with Arduino, waterproof, and can withstand pressures up to 50 PSI, which corresponds to a lake depth of approximately 35 meters. The sensor has a fast response time of up to 90 seconds, which is excellent for a dissolved oxygen sensor. This quick response is achieved thanks to the galvanic probe, which does not require polarization time, meaning it can provide accurate measurements immediately without the need for stabilization or warm-up.

The sensor includes a signal converter board with a wide operating voltage range of 3.3–5 V, making it fully compatible with the chosen microcontroller. The board outputs an analog signal between 0 and 3 V, which can be easily read by the Arduino. In addition, the signal converter has a Gravity interface, providing a convenient plug-and-play setup for quick and reliable connections.

The sensor has a detection range of 0–20 mg/L, which is ideal for assessing oxygen level in water. For reference, dissolved oxygen levels below 4 mg/L are considered poor for aquatic life, while levels above 6 mg/L indicate good water quality. This makes the SEN0237-A well-suited for monitoring lake water conditions. Calibration and set up information can be provided here

4.6 pH Sensor

The SEN0169 pH sensor is an industrial-grade sensor designed for Arduino controllers, ideal for online water quality monitoring. It features an industry-standard pH electrode with a BNC connector and PH2.0 interface, allowing for easy integration into various systems. The sensor offers a wide measuring range of 0-14 pH, with an accuracy of ±0.1 pH at 25°C and a fast response time of 1 minute. Its sensitive glass membrane and low impedance ensure accurate and reliable readings, with excellent thermal stability, making it well-suited for long-term use in lake water monitoring. The sensor is equipped with a power indicator LED and a gain adjustment potentiometer, which makes it durable, reliable, and easy to calibrate for continuous pH measurement. SEN0169.

4.7 TDS Senssor

The SEN0244 TDS sensor is designed to measure the Total Dissolved Solids (TDS) in liquids, indicating how many milligrams of soluble solids are dissolved in one liter of water. TDS is a crucial indicator of water cleanliness; higher TDS values indicate more dissolved solids and typically lower water quality. We chose this sensor for its cost-effectiveness, as it provides reliable measurements within a limited budget while maintaining good accuracy. The sensor offers an analog output ranging from 0 to 2.3V, and is compatible with popular microcontrollers such as Arduino, ESP32, and Raspberry Pi, making it easy to integrate into various control systems. It operates with a voltage input of 3.3V to 5.5V, providing flexibility for integration with different platforms. The waterproof probe is designed for long-term immersion, ideal for continuous monitoring in water quality applications like domestic water analysis and hydroponics. The sensor features an AC signal excitation that prevents probe polarization, extends its lifespan, and stabilizes the output signal. With a TDS measurement range of 0-1000 ppm and an accuracy of ±10, F.S. (25°C). SEN0244

4.8 Water-proofed Casing

The best option for the water-proofed casing is from BlueRobotics made in acrylic plastic. The casing can be customized to our needs and requirements. There were many different options available, but this was the most affordable option and had the best depth range. They also provide bulkheads that can handle 1000 m depth, which will be used to expose the sensors to the water. There are many options available with different materials and design, but they came at a higher price with less depth, which is why we decided not to choose them.

Chapter 5

System Powering

5.1 Distribution

For powering the system, we selected eight Nickel–Meta Hydride (NiMH) rechargeable batteries, each rated at 1.2 -1.4 V, 2.3 Ah. Connected in series, they provide a total of 9.6 -11.2 V.
A DC-DC step-down converter will be designed and implemented on a PCB, with integrated voltage dividers to regulate 3.3 V for sensor signal lines and data communication. The converter will also provide a stable 5 V output for the single-board computer (SBC), as well as the TDS, pH, and dissolved oxygen sensors.
Although the Arduino Due can be powered from the Raspberry Pi 5 via USB under low-current applications, this may affect the Pi's overall performance. So for a stable preference , both the Raspberry Pi 5 and the Arduino Due should be powered directly from the same regulated 5 V supply, with all grounds properly connected in common.
The temperature sensor is powered directly from an Arduino digital pin, with a 4.7 k pull-up resistor between the power supply and the signal line.

5.2 Buck Converter

A Buck converter's working principle is that the average voltage drops over the load. As can be seen in Figure **REF** the switch can be turned on and off at a certain frequency to set an output voltage which is lower than the input. The diode is used to prevent reverse current spikes since it practically only allows current in one direction.

Chapter 6

Data Acquisition and Processing

This chapter describes how lake water quality data is collected by sensors, handled by the Arduino and SBC, and then processed and modeled on a computer for 3D visualization.

6.1 Sensor-to-Visualization Data Flow

The sensors measure different water quality parameters and output analog voltage signals corresponding to each measurement. The Arduino Due reads these voltage signals and converts them into real values with proper units, such as NTU for turbidity, °C for temperature, mg/L for dissolved oxygen, and pH units. After conversion, the Arduino organizes the measurements into a structured CSV file. This file is then sent to the Raspberry Pi 5, which acts as the single-board computer (SBC). The SBC only stores the raw data. A separate computer is used for data retrieval, where the measurements are preprocessed, cleaned, filtered, and averaged and then used in mathematical methods to transform the discrete measurements into a continuous 3D model of the lake. The final visualization provides an intuitive 3D map of water quality, allowing easy analysis of spatial and depth-dependent variations (see Figure 6.1).

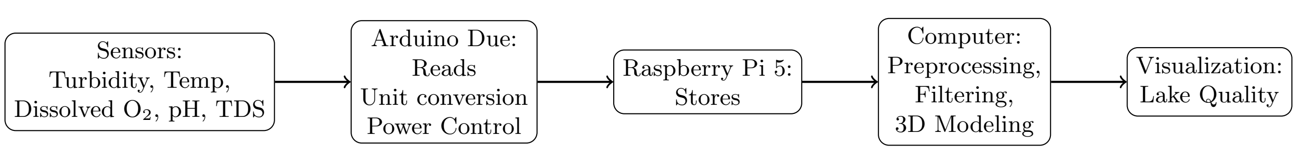

Figure 6.1: Workflow of Arduino–SBC data acquisition, processing, and visualization.

6.2 Arduino Due: Sensor Reading and Control

6.2.1 Sensor Signal Conversion and Calibration

This section outlines the methods used for sensor signal conversion. Depending on the type of sensor, the Arduino receives either digital outputs or analog voltage signals, which must be translated into physical units. In addition, calibration procedures are required to ensure measurement accuracy. Both the conversion and calibration processes are described and implemented in this section.

Turbidity sensor

Temperature sensor

Dissolved Oxygen Sensor

pH Sensor

The pH sensor produces an analog voltage, which depends on the hydrogen ion concentration in the solution. The Arduino reads this signal through its 12-bit ADC. To make the values more stable, ten readings are collected, sorted, and the middle six are averaged. This average is then converted into a voltage and scaled to give an initial estimate of pH. Since this estimate is only approximate, calibration was required. Following the datasheet instructions, calibration will be carried out with different buffer solutions with known pH. By adjusting the offset and slope of the voltage-to-pH conversion, the measured values will be matched to the known buffers, which ensures that the sensor gives reliable and accurate pH readings.

TDS Sensor

The TDS sensor produces an analog voltage that is proportional to the concentration of dissolved solids in the solution. The Arduino reads this signal with its 12-bit ADC. The GravityTDS library is used to process the signal, which handles the reading, applies temperature compensation, and converts the result directly into parts per million (ppm). Calibration is performed by immersing the probe in a standard solution and adjusting the coefficients as described in the datasheet. This procedure, which requires the use of the temperature sensor and a dedicated calibration code, ensures that the ppm values reported by the sensor are both accurate and consistent.

6.2.2 Transmission of Data to SBC

Because the Arduino cannot store data, the system is designed to transfer the measurements to the Raspberry Pi 5, which is responsible for storing the data for later retrieval.

6.2.3 SBC Power Control via Arduino

6.3 Raspberry Pi 5: Data Storage

6.3.1 Retrieval of Data from Arduino

6.4 Computer: Data Retrieval, Processing, and 3D Modeling

6.4.1 Modeling of lake quality using Gaussian Process

Appendix A

A.1 Note

The personal contributions in this project is for us to document what we have done. Towards the end of the project, these will be structured to explain our contributions more holistically.

A.2 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.

A.2.1 Personal Contribution

Week 1 I contributed by making drawings of initial ideas and potential solutions for possible future problems. I also helped write section 2.3. In addition, I worked on finding solutions for our raft design, which we initially thought would be the main focus of our project. This included discussing how the raft could be built and considering what sensors would be needed.

Week 2 I was sick during the first part of the week, but I contributed by helping to look for and evaluate which sensors should be ordered.

Week 3 I was traveling and unable to attend in person, during this week I was in contact with the group to be updated on our progress, and helped writing the report.

Week 4 I've looked closer at our pH-sensor and it's datasheet to understand it better, and figure out how we will implement it, and calibrate it, as well as possible problems we may encounter.

Week 5 I've fixed Arduino-codes for both the TDS-sensor and the pH-sensor. I have tested the hardware connection and code with the Arduino for both sensors as well to make sure it works. These two sensors are now ready for calibration as soon as we have all the liquids we need. I've also helped Salma with starting to figure out how we want to process and visualize the data from the Arduino. Lastly I wrote about sensor reading and control for the pH-sensor and TDS-sensor in section 6.2.

A.3 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.

A.3.1 Personal Contribution

Week 1 I contributed with ideas on how this project could be solved. I have written the sections 2.2 and 2.3 about the submarine solution and Raft solution with a pulley system. Additionally I have made the time plan that we are following during this project. I selected the time plan to be divided into two parts, the sensors and waterproof case as the first part and the raft as the second part. This way, if the sensor system takes longer time than expected, the focus of the project could be shifted to only that. I wrote my ideas into the Project Managment section 3.1 and provided an additional gantt chart to make the plan clear.

Week 2 I was mostly sick, but I contibuted with presenting our ideas at the monday meeting. We had discussed different sensors we wanted to use, such as turbidity, pH, temperature and conductivity sensors. I missed the part where the actual sensors were chosen and ordered.

Week 3 I added section 1.3 on why lake water quality in 3D matter.

Week 4 I researched and looked at the temperature sensor, but did not test it.

Week 5 I have tested the dissolved oxygen sensor to see that it works and sends data to the arduino. I looked into how to calibrate it, but as for now we don't have everything needed for a calibration, therefore i haven't done that yet. We will need purified water, which Johan will provide us. I have started looking at a solution for the pulley system. As for now I have concluded that we need a dc motor, encoder, pulley, wire and a cable reel.

A.4 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.

A.4.1 Personal Contribution

Week 1 I was unable to attend in person but stayed in contact with the group to keep updated on the progress and wrote on the report.
Week 2 I created the GitHub repository. I also helped to look where to order the sensors from to gather all into one order. I have looked into more detail of the temperature sensor and wrote the section 4.4 in components. I researched the water-proofing of the sensor platform.
Week 3 I present what we had achieved in week 2 during the weekly meeting. I added the GitHub workflow in section B, as well as 4.8. I continued researching the water-proof casing and sensor bulkheads to expose the sensors to water.
Week 4, I researched more how the sensors work. I read the turbidity datasheet to understand how to implement. I also discussed some with the group regarding battery choices, SBC and other smaller design choices with the Arduino for example.

Week 5, I started by sorting the Github repository into folders and such, I also created the project section in git with the help of Emmi. I started designing the Buck converter. looked into power solution.

A.5 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.

A.5.1 Personal Contribution

A part of my personal contribution has been discussing the possible solutions for measuring lake water quality in 3D. I focused on identifying which parameters are most important to determine whether water quality is good or bad. In particular, I concentrated on the pH sensor and wrote the section 4.5 about the dissolved oxygen sensor as key indicators.

I have also explored the concept of representing lake water quality in 3D and reviewed several research papers to understand how others have approached this problem. This included examining which parameters are commonly considered critical for assessing water quality. Furthermore, I discussed the potential data structure for the collected measurements, proposing a table format that clearly organizes the data, including parameter types and measurement locations, to facilitate later analysis and visualization.

More recently, after conducting additional research and consulting with the professor of system identification, I plan to apply Gaussian Process Regression (GPR) to model the spatial distribution of water quality in the lake. The idea will be to use the available measurement data to construct a continuous representation of the lake's water quality across both location and depth. To prepare for this, I have already generated synthetic (fake) lake data, which will serve as a testing ground for training and evaluating the Gaussian Process model. This approach will allow me to investigate how well the method can interpolate and generalize from sparse measurement points, with the ultimate goal of producing a continuous 3D map of the lake's water quality parameters.

Since I am mainly focusing on the software and programming aspects of the project rather than the hardware side, I will also take primary responsibility for the embedded systems tasks related to the Single Board Computer (SBC). This includes programming the Arduino to control the power supply to the SBC, managing how measurement data is stored on the SBC, and implementing an easy and reliable method for retrieving the stored data onto a personal computer.

A.6 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.

A.6.1 Personal Contribution

Week 1 was mostly dedicated to discussing ideas and coming up with a rough plan for the project. I contributed by writing the sections 1.1 and 1.2.

Week 2 we ordered the components. We did research on different alternative components. I made a Bill Of Materials on GitHub which we used to get everyone synced on which component we chose. I also wrote the section 4.0.2 about the Turbidity sensor.

Week 3 we continued the discussions on possible waterproofing solutions, while waiting for components to arrive.

Week 4 the components arrived and we started building the platform. I tested the temperature sensor to validate that it produced reasonable values.

Week 5 I helped design the buck converter used for efficiently stepping down the voltage from the batteries.

A.7 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.

A.7.1 Personal Contribution

In Week 1, I suggested the idea of collecting water samples and sending them to the labs at our university for analysis. To support this idea, I researched available tools and found the NISKIN water sample bottles. I presented this solution on monday meeting and discussed its advantages and disadvantages in the context of our project.
In week 2 the main focus was on starting writing the report and planing with the team.
In Week 3, I contacted Rika Electronic Company via email and WhatsApp to inquire about the price offer for the turbidity sensor. They quoted a price of 179 USD for the sensor, with an additional 69 USD shipping fee.

In week 4, I designed an initial power distribution flow chart to gain a clear understanding of how all the components will be connected and powered, as well as to identify what needs to be ordered and what needs to be designed. In week 5, I explored the sensors in more detail, reviewed their datasheets, and identified which ones require calibration and which ones are ready to use. I also checked the calibration solutions needed for certain sensors and began working with the turbidity sensor, performing initial code and tested it.

Appendix B

GitHub Workflow

In our project, GitHub is primarily used for storing and sharing project materials, such as the bill of materials (BOM), Gantt chart, and reports in PDF formats. We are not using GitHub for writing the report itself, since we are using Overleaf which keeps us in sync. The repository is used to allowed us to keep track of references and project-related links so that the whole team can access the most recent information.

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