SOFTWARE REQUIREMENTS SPECIFICATION

for

The Underwater ROV Project

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1 Introduction

1.1 Purpose

This document is to provide detailed description of the Underwater ROV project developed for Professor Jonathan Nash, ROV referring to the term 'Remotely Operated Vehicle'. The document explains the scope and features of the project with additional information of the objectives, obstacles, and timeline of which the project should follow. This document is intended for those noted in subsection 1.3.

1.2 Document Conventions

The document follows the IEEE format. Bold font denotes sections and subsections. The requirements will focus on the mandatory functions and parameters the project must fulfill.

1.3 Intended Audience and Reading Suggestions

This document is meant primarily for the software developers, collaborating engineering teams, course instructors, client, and anyone wishing to continue the project beyond its original goals. This document may be publicly accessed during presentation and if requested directly. This document is organized in the order of introduction, project overview, specific requirements, and prospective timeline.

1.4 Project Scope

To be able to accurately measure the ice melt between the ocean and a calving glacier without putting humans at risk. Calving is where large chunks of a glacier separate from the body and fall into the water.The main target is the LeConte Glacier in Alaska, a 21-mile iceberg. It's has displayed significant increase in glacier melt and cannot be measured through the standard methods. One theory for the higher rate of melting is the presence of gas bubbles inside the glacier; these bubbles have been heard bursting through underwater sonar. This will be achieved via the BlueROV2, a Open Source ROV customized for the project's purposes.

1.5 Requirements Changes

Having updated this document since its original inception, these are the changes that have been made.

- The glacier-latching method has been updated to include the heating element method in further detail
- The recent epidemic of of COVID-19 has changed the end goal of the overall project. This project works with a team of college electrical-engineers, they were tasked with building the hardware of our system. The ECE Capstone Leadership has put most-if-not-all projects on permanant hiatus, instead focusing on building documentation for next year's team to solve. This, more-or-less, means that we'll be still be completing the software required, but they will lack the testing and eventual hardware implementation we intended.

2 Project Overview

2.1 Product Perspective

The roots of this project are in response to the increased glacial melt. The project is a continuation of the client's efforts to create an ROV capable of traveling underwater to a glacial surface. It works in tandem with the previous product, a kayak capable of autonomous movement in Arctic conditions. The ROV must be controllable through the kayak itself and be able to functionally use all mounted devices including motors, drills, and cameras. An additional requirement is to add wireless functionality to the kayak for us to communicate with.

2.2 Product Functions

There are mandatory functions the ROV must provide, these are as follows, note that all features must be available at all times:

- Be able to confidently control the ROV in all conditions including surface level, underwater, and high stress situations
- Be able to secure and re-secure ROV to ice structure both before glacial attachment and during glacial attachment
- Be able to create accurate images/structure of the ice structure using cameras, laser light sheets, and/or 'structure by motion'
- Be able to accurately communicate with the ROV using a boat as the middleman.
- Be able to safely submerge the ROV 50m underwater. (100m would be ideal)
- Leave enough documentation for future teams

2.3 User Classes and Characteristics

The product results are intended for researchers interested in another glacier measurement tool, this includes active shape and gaseous bubbles The control and use of the product is usable by all users familiar with 360 degree movement akin to an airborne drone. Separate from the ROV, completion of the communication between user and autonomous kayak should allow for future expansion into different prototypes.

2.4 Limitations

The following are similar to product functions, but are instead focused on individual aspects and design.

- Official motors from BlueRobotics are out of stock, replacements are required.
- The tether between the ROV and kayak must transmit data and be able to do so in Arctic oceans
- Testing in Alaska is costly, the ROV prototype must be ready before the move
- The ROV uses batteries, the ROV must be able to safely complete its task with a proper power budget.
- COVID-19 as stopped our ability to interface with the hardware significantly

3 Specific Requirements

3.1 Securing into an Ice Mass

The ROV must be able to, while underwater, attach itself to a large ice mass. It must also be able to detach itself as well. For testing purposes, we have the ability to create an ice block locally to test the efficacy of our design. The glacier is expected to melt while the ROV is attached to the ice, so we will need to be able to re-secure into the glacier. Sensors to detect this is considered a stretch goal, but we will need to be able to visualize our attachment with the live video streamed by the robot. There are two methods we have considered.

- Implement motorized drills capable of penetrating the wall. The drills must be able to remain usable in Arctic conditions.
- Implement heating element method, using a heated piece of metal to melt into the ice and secure itself that way

3.2 Wireless Communication

The ROV will be tethered to the kayak for communication purposes. Networking software capable of sending data to and from the central ship to the kayak and from there, the ROV, is mandatory. This data includes GPS and Videofeed in particular.

3.3 Active Videofeed

Implement software capable of sending active videofeed from the ROV to the users controlling the device. This must travel through the communication system noted above.

3.4 Archival of Video Footage

Video recorded from the live first person view of the ROV, as well as recorded from any other mounted cameras on the robot intended to be processed from structural analysis of the glacier, will need to be transmitted in full quality to persons controlling the rover. This will require both high quality transmission over the ROV's tether to the autonomous kayak above the surface, as well as a method for long-distance wireless transfer of footage from the kayak to the main ship. This will most likely require a system on the kayak to store information directly from the ROV with the ability to transfer that footage after control of the ROV is finished, or a broadcast system separate from the control of the ROV.

3.5 3D Modeling the Glacier

There are two methods considered at the time, only one will be implemented.

- Implement "Structure From Motion", a photogrammetric technique capable of estimating three-dimensional structures from two-dimensional images. The photos are to be taken while attached to the glacier.
- Implement "Light-Sheet based Topography", a technique using two laser light grids that shine on the object and while doing so, take pictures of this grid using two stereo cameras.

3.6 Expected Real-time Execution

Be able to efficiently attach/detach, take photos, communicate, and model in a short timeframe once in real time conditions.

3.7 Full Control of System

Implement a ROV controller to handle all required functions. If required, map additional controllers until all functions are set.

4 Other Nonfunctional Requirements

4.1 Performance Requirements

This project is defined by the rigorous environment the ROV is meant to be deployed in. The ROV will need to be able to stand up against operating in a cold, high-pressure, salt water environment, and as such special considerations need to be made for the performance of our project.

- For control of the robot, the live video feed and responding controls need to be low enough latency and high enough quality for the operator to sufficiently control the robot in order to respond to currents under the water and the shift in weight of the robot as it is positioned near a glacier to attach to it.
- The stored video footage from any of the multiple cameras on the ROV will need to be archived in sufficient quality to process any interesting information. This means that, physically, the cameras used will need to be able to record at least 1080p footage, and will need to be supported by onboard lights that can highlight a wide viewing angle in front of the ROV. Ideally, this footage will be stored on the cameras themselves or an external drive placed on the middleman boat.
- The software system to analyze video footage to process using a structure by motion algorithm needs to be able to find sufficient resolution from the stored footage we retrieve from our ROV. This means that it needs to be able to process video even in a partially dark and obstructed environment and still create a reasonable quality surface model of the glacier we are studying.
- The battery life or power system of our ROV needs to be able to maintain a sufficiently long life. When the glacier is melting fast enough to force us to move the rover every 20-30 minutes, we need to be able to handle multiple attachments for each deployment of the ROV.
- The system we create to drill into the iceberg needs to be effective and flexible. It needs to work on many differently shaped surfaces, since the surface of the glacier we target is not guaranteed to be flat.
- Our ROV needs to be mobile enough that we can control it to face a glacial surface regardless of ocean currents or shifts caused by the movement of the robot. We need to be able to control the ROV well enough that we can easily face it towards a glacier and shove into it to attach.

4.2 Safety Requirements

This project is meant to be deployed far away from people, in order to keep people out of the dangerous environment it's operating in. This means that the majority of our safety concerns will be during the manufacturing and testing process for our robot. We need to ensure that we construct the robot in such a way that we are not exposing ourselves to any dangerous electronics to avoid shocks, especially when testing in water. This will mean making sure we have electronic safety measures in place to ensure dangerous voltages are sealed away from any team members.

5 Perspective Timeline

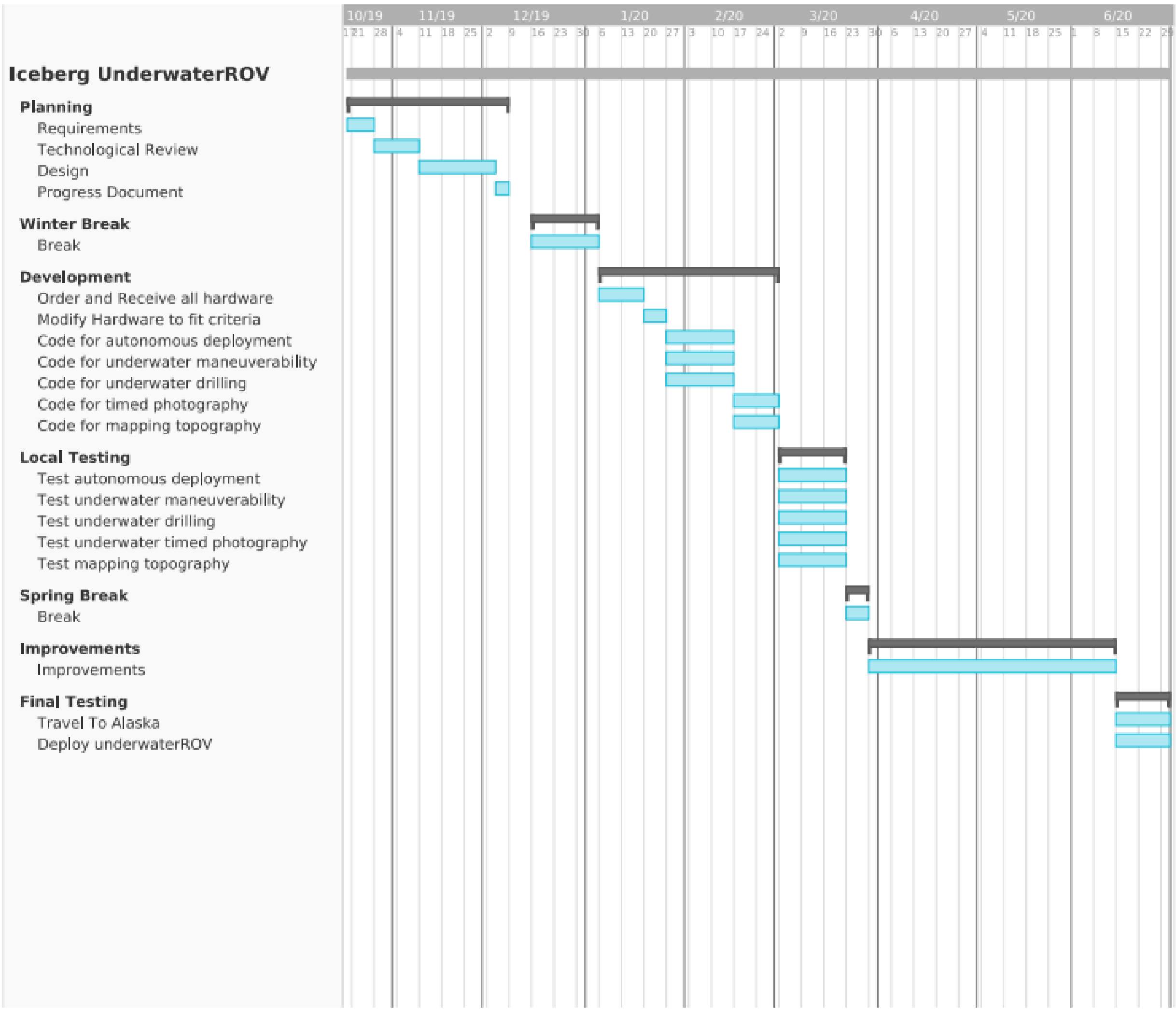

Figure 5.1: Gantt Chart

6 Appendix

6.1 Glossary

ROV: Remotely Operated Vehicle

Calving: (of an iceberg or glacier) split and shed (a smaller mass of ice)

Photogammetry: the science of making reliable measurements by the use of photographs

Structure From Motion: a photogrammetric technique for estimating three-dimensional structures from two-dimensional images

Light-Sheet: A grid used to create a topography of a 3d object.