IRON RANGE ENGINEERING

Design Document

OpenROV Team Spring 2021

(Open Source Remotely Operated Vehicle)

Client:

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Director of Technology & Laboratories
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Facilitator:

(Spring 2021)

Team Members:

(Project Manager)

(Lead Design Engineer)

I. Problem Statement

The OpenROV team has been tasked with improving and building upon an Open Source Remotely Operated Vehicle (OpenROV). This ROV is to be used in local bodies of water. The client asked to have additions to the ROV presented by the end of the semester as well as tested in local bodies of water. This project is very open ended so there isn't a specific design that our client is looking for.

II. Design Objective

OpenROV is a community project that brings different coders and builders together working towards having a ROV that can explore bodies of water everywhere. The objective of this project is to create useful additions to improve the usability of the vehicle. As a team, we have to come up with the improvements we would like to make on this project. We want everything to be user friendly and so anyone is capable of taking it into the real world and using it to explore.

III. Requirements

The OpenROV team is improving upon last semester's underwater drone. Since our problem is open-ended this semester, here are the things the team has decided to improve:

1. Water-proofing the underwater drone
2. Testing the water-proofing
3. Adding sensors to the underwater drone
4. Adding an arm to manipulate the underwater drone
5. Coming up with ideas to improve the underwater drone that could add value to the system.

IV. Constraints

The constraints of this project are the ROV we already have to work off, the bodies of water, and the amount of money allocated.

The ROV has already been built so when we add features we need to design them as auditions not as full reworks of the device. It is a challenge to work from a spot where you didn't start and requires creative ideas to accomplish it.

Bodies of water can differ from size, visability, and currents. Minnesota is also a cold state so the lakes have been frozen over and are only going to be open in the spring. Our budget constrains us from adding any large scale improvements since batteries are expensive, as well as different sensors and supplies for other mechanisms will add to the total cost.Overall, the team has challenges with these constraints, but will work on them and create a great submarine.

V. Action Plan

For this project, our action plan for completion consists of fixing our propeller problem, finding sensors, and developing a grappling system. The propellers for our current design both have the same pitch and spin in the same direction. So the way we plan on fixing that is by reprinting one of the props with an inverted pitch and reverse the motor. This will allow the ROV to be

pushed straight instead of turning in one direction. Next, we plan on finding sensors that will relay the temperature and PH of the water. We can find simple sensors on hundreds of different websites so the real challenge will be finding the most cost-effective resource to acquire the sensors from. Next would be designing and incorporating a grappling system for the ROV. We will run through and design a few different concepts on SolidWorks before coming to a final decision on the design. After we've completed these initial objectives, if time allows, we plan on designing a way to determine the depth of the unit whether that be attaching a sonar device to a tether on the unit. Whatever decisions end up taking place, this action plan will not change.

VI. **Final Deliverables**

The final deliverables for our project consist of our required documents and presentation and the ROV implementations and upgrades if you will. We also have to decide on a power source, in other words, which type or size battery we would like to implement. We also must conduct an initial test of the ROV even if it is in a tub of water to see what we are starting with for handling, visibility, and overall operation. Organizing and finishing up enclosure organization that didn't get accomplished last semester, organizing wires, mounting electronics, and mounting the battery tray. We will also be conducting field tests and taking note of what occurs whether it be good or bad and video of the tests. For these tests, we will be putting our results and takeaways into a document for future reference and evaluation.

VII. **Timeline**

The timeline for our project consists of the full duration of the 2021 spring semester. We have our scoping presentation due 2/10/21, scoping document is due 2/15/21, we also have our facilitator meetings each Thursday during class. In these meetings, we talk with our facilitator to make sure we are keeping on track and making progress. By participating in these meetings it can help keep our team stay organized and efficient. We can use these meetings to share thoughts and ideas about what is the best way to achieve our goals in a timely manner to meet our deadlines.

VIII. **Design Process Description**

The design process for our team started with making a list of what we would like to implement and bringing the list to our client and asking what his preferences on the list what they thought would have the greatest impact to the ROV. The grapple and sensors were chosen. As our group changes as time went on we have had to re-evaluate these. Due to our capabilities we have chosen to implement sensors to collect data throughout an exploration and lights to improve visibility in dark waters. As we continue the project and semester we would like to test the ROV and make changes with what we learn from them.

IX. Option 1 (Grapple)

Our original plan was to research, design, and build a grapple or manipulator of sorts to move or pick up objects found on exploration. This would be mounted to the front of the rov still in view of the camera. This design would require adjustment to the keel weight distribution to allow either tilt forward or counterbalance the tilt due to added weight to the front of the ROV. The grapple would be powered by a servo for each direction of motion (up and down, left and right, in and out, along with the actual grab)

X. Option 2 (Sensors)

The second option we'd like to implement would be sensors to collect water temperature, Ph, gps, and depth/pressure. This data would be collected and stored on the rov until the end of an exploration. An arduino would be our brain for the system taking up little room and using little power. The sensors would be stored on an added piece to the rov 3d printed and mounted on either the bottom in an enclosure wither just holding the arduino with the sensors in different locations to get accurate readings for temperature or mounting the enclosure to ensure this.

XI. Decision Matrices

Decision matrices have helped us as a team come up with what we will be using for our different electronics and as well as what we will continue with designing in our ROV. A couple of the criteria topics are more of a bias so as a group we all rated them and gave them scores according to how we felt we could do in the specific area the criteria is talking about. Below is the decision matrices that we used to decide what we will be continuing forward with.

	Grapple	Depth Sensor	Temp Sensor	Lights
Capability (3)	1	2	3	5
Cost (1)	1	1	3	4
Enhancement (2)	5	3	2	5
Fabrication (2)	2	3	3	5
Scores	16	19	22	39

Figure 1 - Continuation Decision Matrix

XII. Decision Process

Our team was tasked with improving an underwater vessel. We chose designs that we felt will add lots to the ROV and be capable of doing with the tools and resources we have at IRE as well as the limited manpower we now have. Our team prepared to make many changes and improvements but we then had to rework our scope to make realistic changes with our new constraints. Currently, we are in the assembly phase of our improvements and will continue on to the test phase.

XIII. Modern Tool Usage

We will be using 3D printers as well as arduinos for this project. There will be lots of solidworks parts we will be designing and printing to add our components to the ROV as well to fix little problems with the last semester design. We will be using the arduino to add sensors and lights to the ROV which will give it more functionality.

XIV. Future Work

For our future work we will be adding the temperature sensor and lights to the ROV. We will also begin testing it in a large body of water and making minor improvements from there. If there was to be another continuation, possible things that could be added would be a depth sensor or a grapple device. The grapple device could have many different styles or functions and be able to perform different tasks underwater.

Research Appendix

Motors

Description of Topic:

For our project we required 3 outrunner brushless motors to propel our ROV. The motor will have props attached and be mounted 1 on top of the ROV, one on each side of the ROV.

Drawings/Sketches/Images:

Applicable Equations:

N/A

Application to Project:

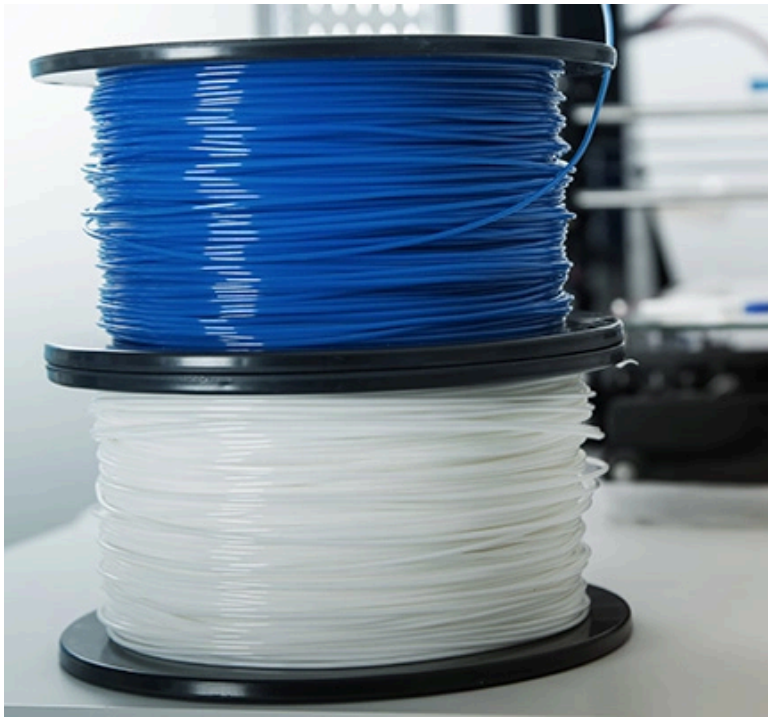
These motors will propel our ROV. There are a total of three motors on the ROV, two in the back which can turn and propel the ROV forward or backwards. There will also be one on top to change the depth of the ROV while it is in the water.

Research Information Found on Topic:

https://www.amazon.com/DYS-Brushless-Outrunner-Multirotor-Quadcopter/dp/B077HH9B8S/ref=sr_1_15?dchild=1&keywords=800kv+motor&qid=1602698668&sr=8-15

The Motor we will be using.

Drawings/Sketches/Images:



Interaction with other "Systems/Sub-systems/Components/Concepts" in the Project:

The motors will be connected to the ESCs (Electronic Speed Controller). The motors will also be on the outside connected to the actual ROV body. The body is the 3D printed pieces attached to the enclosure.

Sources:

PLA (Poly Lactic Acid)

Description of Topic:

For the project, the team selected PLA printable material for the printers. This material was compared to others and we saw roughly the same things from each including the pores, sturdiness, and connecting of the parts once printed. They all were very similar, while this one was cheaper than the rest, but also slightly more workable with how the project could be molded with these parts.

Application to Project:

With this project being mainly 3D printable parts, this has the biggest contribution to the project than the rest. This is the shell and also the propellers of the design we chose and we saw it deemed very important to this design. This 3D printable material had to be sturdy enough and be able to hold together well and be accurately fitted as it needs to be waterproofed.

Research Information Found on Topic:

https://www.sciencedirect.com/science/article/pii/S2214785318301858
We looked into its properties and saw how it could be incorporated into the project. This article described how and what PLA is and helped us grasp a better understanding on why this would be a good fit into our project, like being environmentally friendly and safe to use.

Amazon

This link is the 3D printable PLA we used in our project. It is durable, does not make the printer overheat, and runs smooth prints. We were happy with this as the parts came in as durable as they were.

Interaction with other "Systems/Sub-systems/Components/Concepts" in the Project:

This is incorporated with everything in this project as this is the base of the project. Without the 3D printers, we could not have chosen this design and would have gone in a different direction of the project, like our first option with acrylic.

Sources:

https://www.sciencedirect.com/science/article/pii/S2214785318301858

ESC (Electronic Speed Controller)

Description of Topic:

For the OpenRov we needed ESCs (Electronic Speed Controllers) that would be able to control the brushless motors in both directions. The standard ESCs that are used for quadcopters and drones cannot be reversed because of this we researched different ESCs and found that with a specific kind of simonk ESC we could modify the firmware and add the reverse function

Drawings/Sketches/Images:

Applicable Equations:

N/A

Application to Project:

This project uses three brushless motors one reversible ESC is required for

each motor to control the speed and amount of power sent to the motor

Research Information Found on Topic:
https://www.rcgroups.com/forums/showthread.php?3150439-ESC-30A-SimonK-how-to-reprogram-it-to-have-reverse-gear-for-the-boat
This shows how the ESCs and what type of ESCs can be reprogrammed to add the reverse function

Interaction with other "Systems/Sub-systems/Components/Concepts" in the Project:

Ther ESCs are connected between the battery and the motors and they control the speed direction and the power going to the motors without them the motors would not function

Sources:
https://www.pixelelectric.com/drones-parts/controllers/speed-controllers-esc/30a-simonk-esc-with-bec/