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Towed ROV Progress 2022

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1 Introduction

This project and job is given by Ottar Osen. This project has been worked on in many years with continuous improvements.

The goal of this report is to give an overview of the progress done by a group in 2022. It is not a report for explaining the whole concept and project. It is assumed that the reader have background information about the project. All of this information can be found on the newly created Wiki page. This page has all the reports from the previous groups. The wiki also has much information on code, CAD, schematics, setup, construction, material documentation, todo-list etc. The wiki is a work in project page that can be updated by the next groups working on the project.

2 Motor

There has been made multiple changes on the motor system. The system made by previous group was far from finished. A lot of fine adjustments have been made.

A new system for over-pressure is created. The idea is to create an over pressure zone inside the motor casing. Over pressure will lead to liquids (oil) leaking out, instead of water getting in. The concept is placing a syringe housing through the wall of the motor casing. Pressing the syringe will create a bigger pressure on the inside. A lid was made to hold the syringe in place. Also, a ventilation hole was added to make oil filling and emptying easier.

The magnet holder had to be redesigned. The previous magnet holder did not fit with the rest of the parts.

The parts are printed with PETG instead of PLA. This material is more durable than PLA because it is not bio-degradable. It also has better layer adhesion, which should make the print more water tight. The surface of top part that holds the rubber lid, had to be fine sanded to make it water tight.

Two motor shafts was made. They are made with an aluminum rod. The machining was done on the small lab lathe. At first a hardened steel rod was used for the shaft. This material is extremely durable, and therefore very challenging to machine. The mini-lathe did not handle the strong metal. Also normal drills can not be used for making holes, as the rod is as hard or harder than the drills. The big disadvantage of using aluminum rod, is its outer accuracy. The surface is substantially more uneven than the steel rod. A big part of the aluminum rod was not usable because the ball-bearings did not fit.

More information on the motor, motor parts, shaft construction and assembly can be found on the wiki (under Motor Assembly).

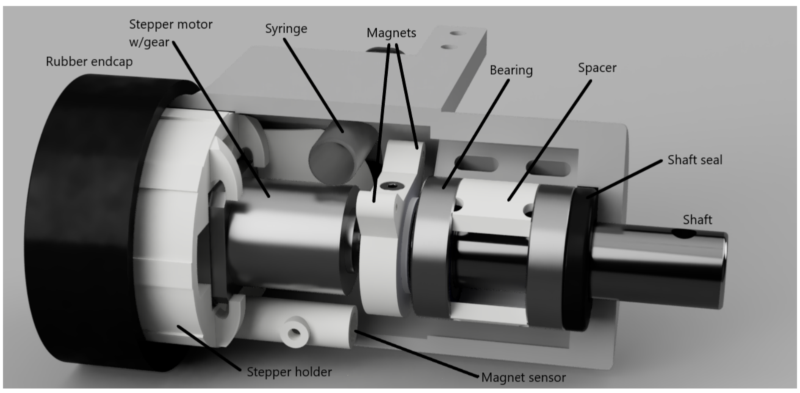


Figure 1: Model of inside the motor.

3 PCB

All electronics is connected to PCB boards. The boards are designed with EasyEDA. This a very good program for beginners.

The boards are ordered from JLCPCB. They had very fast delivery and high quality. The price on one PCB is very cheap, but the delivery and tax was expensive.

3.1 Power supply

Two PCB's are created. One in the suitcase and one in the towed rov.

Previous group used 6 car batteries for suitcase power supply. This is extremely overkill, as one battery alone can last for more than a day. A system was made where only one battery is needed. The voltage is stepped up from 12V to 46V with a DC-DC converter. High voltage is needed because of voltage drop in the long tether cable. A 12V to 5V converter is also used for supplying power to the raspberry pi. These two converters are placed on a PCB. Necessary capacitors and resistors was placed on the board. power switches, fuses and wire connectors was added to make the board more practical. DC-DC converters are directly soldered to the PCB. This proved to be problematic because the converters have a big heat sinks that cools down the soldering iron when soldering the pins. The solder pad would therefore not get hot enough for the tin to melt properly

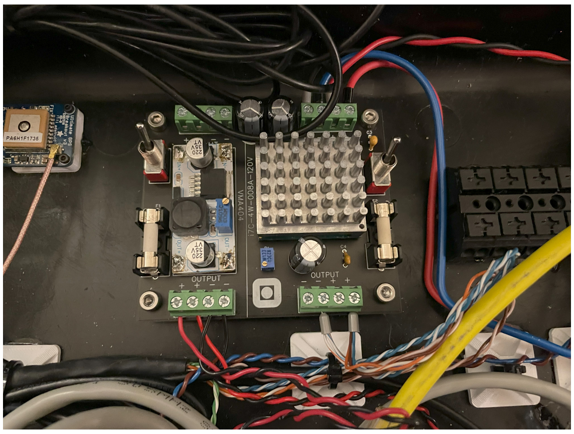
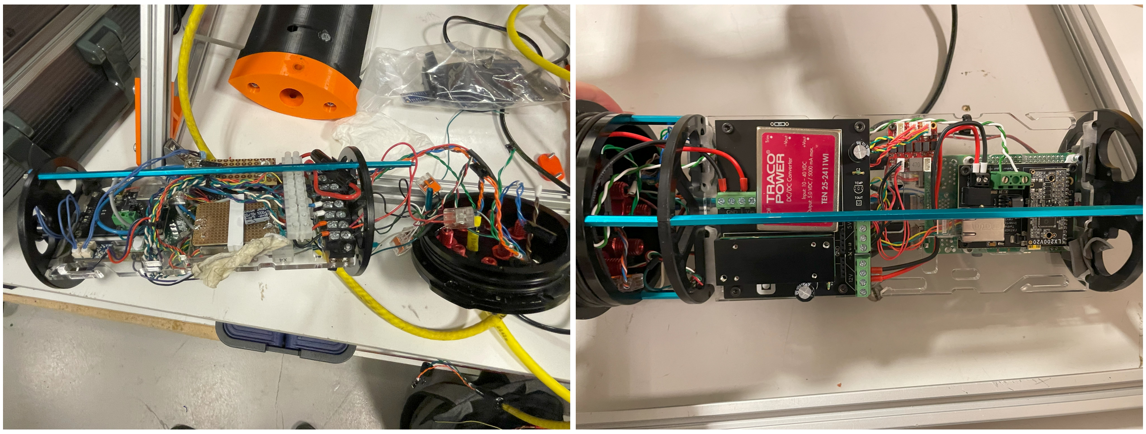


Figure 2: Picture of the power supply in the suitcase

The power-supply in the towed-ROV also has two converters. One is for 46V to 12V, the other one is from 12V to 5V. 3.3v supply is from internal circuits of the Teensy microcontrollers. This board also has the necessary capacitors, resistors and wire connectors. Both header pins and screw terminal was added for ease of use and future expansions. A digital thermostat is also added. This is to check if the temperature inside the electronics tube gets too hot during operation. The DC-DC converters are not soldered directly to the PCB board. A better solution is to use PC-pins. These pins are similar to header pins, but fits the pins of the power-supply. The pins are relatively easy to solder on the PCB, and the converters are simply pressed down on them.



(a) Picture of the old power supply

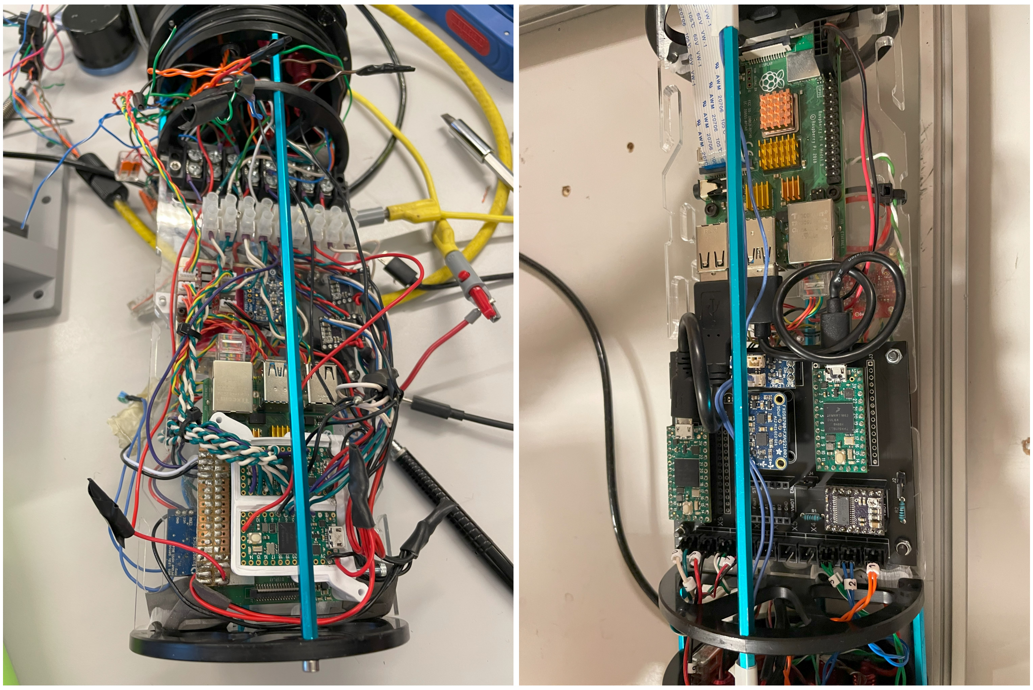
(b) Picture of new Power supply

Figure 3: Old vs new power supply

3.2 Main board

The mainboard is based on the schematic from the previous group. Most of the connections are the same as before, but now on a PCB instead of wires everywhere. The main components are mounted using header pins. This makes it easy to replace components or reuse them later on other projects. A lot of additional holes are made on the PCB. This opens up for changes and added component and features. Connecting external components are done with Molex connectors instead of soldering wires directly to the board. This makes is possible to connect and disconnect all external components. The connectors only allows the plug to be inserted the right direction. Wires and connectors are also marked with corresponding numbers. The mainboard gets power from the power supply with header pins going through the middle plate. Both boards are placed on the opposite side of the middle mounting plate. This PCB also has an added temperature sensor, so temperature of both side of the ROV are checked.

The board are mounted using nut and screws going thorough the middle plate. The holes on the main board corresponds with the holes on the power supply.



(a) Picture of the old electronics

(b) Pictrue of new electronics. Note: Second motor and driver is not connected on this picture.

Figure 4: Old vs new electronics

4 Code

The code can be found at a Github link on the Wiki.

4.1 Arduino code

Both Arduino codes for stepper and sensor has been edited. They have been converted to support Teensy microcontroller. A new library is created for the stepper motor control. This is to simplify and clean the main code. All stepping and position data is stored internally in a class. This library has a new calibration sequence. The calibration now works from any start positions, instead of only within the two magnets. More information on the calibration can be found on the wiki.

The code for the Teensy running the sensors are also refactored and bug-fixed.

4.2 Raspberry pi code

The code for finding which Arduino that is connected to which usb-port, was very unreliable and chaotic. This code is re-written. Now there is a request-response functionality where the Rpi sends a message to all open ports. The message is asking for the device name. A Teensy will respond with either "Sensor" or "Stepper" based on which Teensy it is. The Rpi can then simply remember which port it got answer from and which device was answering. The message is sent on different baudrates as well.

This was the main change on the Rpi code. There has been some minor bug fixing and refactoring.

4.3 API code

Some bug fixing and refactoring had been made on the API code, but most of the functionality remains the same.

4.4 GUI code

The GUI code made by the previous group was working as expected. The biggest problem with the GUI is a very challenging setup. There was a lot of errors when the programs was installed. Most likely the problems are caused because of version mismatch. A setup guide is made on the wiki to make it easier for the next group.

5 Other

Many smaller changes had been made. A bouyency tube was created with sewage pipe, caps and epoxy. The ropes for connecting the tether to ROV is fixed. The tether is fixed and connected on both sides. A Wifi router is added to the suitcase. This makes it possible to remotely connect to the Raspberry pi's from a laptop. A new camera made for underwater low light is added. Together with a servo that controls the angle of the camera. Mounting for lights are designed and printed. The lights are connected together to each other. There also may be some small changes done in spring 2023 that are not covered in this report.

6 Result

The towed-ROV is dry tested on land. It has not been tested in water as of writing of this report (summer 2023).

Both motors are rotating and calibrating as it should. There is however significant backlash in the gears. This makes the wings wobbly when rotation direction is changing. This should in theory not be a problem. The wing should always be pressed in one direction due to the nature of towing it. The Rov will be dragged upwards, therefore the wings has to constantly push downwards, with varying force. This should keep the backlash on the gears always on the same side.

There are still some oil leaking from the motors. The leakage is from small printing defects and from some inner corners. The over pressure systems also contributes to the leaking. Oil is pushed through the cable into the electronics tube.

The electronics are mostly functioning as expected. The biggest problem is high start current. The power supply in the suitcase are rapidly connecting and disconnecting (making clicking noise) when it is first turned on. Turning the power switch on and off a few times seems to fix the symptoms. It runs well when it has managed to properly start.

Using PC pins instead of directly soldering the converter worked very well. It was easier to solder.

The code works fine. The gui gets most of the telemetry data from the sensor Teensy. GPS data is also working. Sending commands from GUI functions correctly. Moving and calibrating the wings from GUI works as expected. Automatic mode with height control and PID does not work. Also the database does not seem to store sensor data. Camera feed is not available through the GUI. However it can be used by connecting to the raspberry pi with VNC, and starting the camera.

7 Discussion

There are a lot of improvements that can be made on the motor. First a different motor system should be considered. Using servomotors may be better. A DC motor with encoder and worm gear can also be an idea to explore. Generally the current motor system is big and not compact. A more compact design will also reduce the need on a lot of oil. A better quality and expensive oil can be used if just a little bit is required. Using food grade oil is a bad idea, because it will eventually turn rancid. Silicone lubricant or other marine-safe oils should be considered. To prevent the oil leaking, a layer of marine epoxy could be added to the outside of the print. The epoxy has to be slightly flexible to reduce the chance of cracking.

The over-pressure system should be tested to check if the extra complexity gives any advantages.

There are some other ideas that can be interesting to explore. The ROV could be redesigned to be more hydrodynamic. This will make it possible to drag the ROV faster, and cover a bigger area in a shorter time.

The high start current in the converters may be due to high capacitance in the system. All of the DC-DC converters has big capacitors for filtering. Removing or shrinking some of the capacitors may fix the problem.

The current software setup is very inconvenient. It is only accessible for persons with technical knowledge. Creating a user friendly system will make the ROV available for other peoples to use. One method to make the ROV more user friendly is to have all setup locally on the Raspberry pi's. A user should be able to connect to a local wifi router. The user interface can then be a web-server hosted by the raspberry in the suitcase. It should also be possible to download the database from the website, or to a USB-stick connected to suitcase-Rpi. This solution makes it possible to use a cheap watertight tablet as user interface, instead of using an expensive personal laptops. It is also possible to integrate the user interface as a screen connected to the suitcase.

The tether should have watertight connectors instead of directly connected. This will make transporting much easier when the tether and ROV can be carried separately.

8 Reflection

This project has been interesting and educational. There is a lot of different topics that can be explored. Including electronic design, 3D-modelling, 3D-printing and manufacturing, sensor systems, actuators, underwater physics, programming of microcontrollers and computers, control theory and more. There is also other skills that can be improved, like finding sources, independent research, time management and more.

The biggest upside of this project is being able to freely explore interesting technologies while getting paid for it.

The biggest drawback of this project is the lack of feedback, and loneliness when no one else is working on the project. Having two or more people focusing on one project would be more interesting and fun, than two peoples working on different projects. A clearer project goal may make the process more enjoyable for some people. Some team members was not motivated to work when there was no clear goal or tasks for them.

9 Conclusion

There has been a lot of progress in 2022. The big improvements are in the motor, electronics and code. The motor has been finished with a refined design. It has gotten a new over-pressure system and new aluminum shafts. All electronics has been redesigned on a PCB. There is a new power board in the suitcase delivering 5V and 46V. The ROV also has a new power board delivering 15V and 5V. Most components in the ROV has been connected together on a common PCB. The code has been improved. Especially the codes for sensors and steppers on Teensy has seen big changes. The system has been dry tested, with most of the functions working. The motors are still leaking a bit. Power board in suitcase has some problems with high start current. There are some ideas for improving the systems, like a different motor and gearing system and a web-page user-interface. Overall, the project has been educational. However there has been some drawback like the lack of feedback and too few group members.