Beijing National Day School

Beijing, China

DeepDive BNDS

Technical Report / 2019

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Content

1 Abstract

The Remotely Operated Underwater Vehicle (ROV) Sentinel designed by DeepDive BNDS from Beijing National Day School is capable for completing a wide range of tasks in the marine environment including detecting and repairing damaged structures, transporting living organisms to designated areas, conducting the underwater archaeological excavation, and etc. As a result of half a year's unremitting efforts of 14 members within the company, the Sentinel was designed under rigorous science and safety concerns, so that its excellent performance and desirable stability is guaranteed.

The main supporting structure of the ROV is made of acrylic boards and is constructed in a way that ensured the durability for long-term use and ease of assembly. In order to assure the underwater maneuverability of the ROV, 4 propellers are distributed on both sides and the top of the Sentinel, providing sufficient propulsion for accomplishing all designated tasks. A multifunctional mechanical arm is attached at the front of the Sentinel which is tailored accordingly to all potential situations.

Plus, a micro ROV is also built to carry out certain tasks in cooperation with the Sentinel. In terms of software design, the ROV is regulated by The BattleStation which is a mission control software, and a shape detection AI is built-in the system to increase its availability. The pilot can operate the ROV with a control box which is consist of a handle and a screen.

The following technical document provides a more detailed description of the design, construction, and testing of the Sentinel.

2 Safety

2.1 Safety Philosophy

Our ROV is designed to bring benefits to lives, so safety is the one of the most important things of the core concept of our company. During the meeting, security is an item to be reviewed every time. After every meeting, ROV will be improved to be better and safer. Employees learn about each other's work and plans to reduce the possibility of danger. If any safety problem occurred, the ROV will be checked for several times before its next test.

2.2 Safety Features

Our main power supply is 12-volt alternate current, and Anderson Powerpole fuse is used in our circuit. We ensure that six 15-amp Anderson Powerpole are connected within 30 cm from the main power point, and that value exceeds the ideal net current by 1.5.

Figure 2.2.1: Notice for safety in the lab

One of the most important safety features of our ROV is how it prevent the leakage of electricity. For the electronics hub, we used flange and rubber ring to make a first step of seal up. After that we used Vaseline to do the further dip seal. As for the wire, we have them run through the perforated screws and seal up with vulcanizate afterward. A shield was fixed on each motor to make sure no water will get into the electrical system and wires.
To avoid short circuit or false connection in our control box, we deliberately organize our wires inside the control box. We not only seal the wires properly so there's no exposed wires, but also labeled in order to distinguish different wires.

Figure 2.2.2: The tether has strain relief

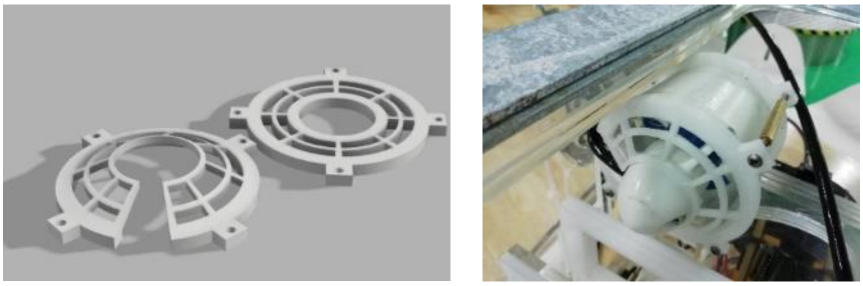


Figure 2.2.3 & 2.2.4: The shield of the propeller

In order to ensure the safety of the team members when carrying the ROV, all the sharp edges of the acrylic plate in our robot is curved to a smooth arc. At the same time, all acrylic plates, PVC tubes and 3D printed materials are polished to ensure their smooth appearance wouldn't cause any damage to our team members. The upper board, side boards and bottom board consist of 2pieces of acrylic board that's 5mm thick. For each supporting board, two pieces of acrylic board with thickness 5mm are supposed to ensure that overall structural rigidity will be enough for underwater operation as well as above-ground transportation.
Our team is fully aware of the concerns from hydraulic or barometric equipment, and we avoid all related problems by simply not using such kinds of devices.

2.3 Operational Safety Protocol

Company provides a safe work environment to the employees, workplace has tool placement area, material placement area, work area, ROV assembly area and test area. The employees who operate machines or using tools will be trained by professional employees how to use it safety and correctly. The workplace is always equipped with fire extinguishers and first aid kits. One or two fire extinguishers and a first aid kit are placed in each area.

When we test the ROV, we borrow the school's swimming pool. Life jackets was prepared on the shore in case anything happened. Before the test, we make sure that the wire isn't broken and is tidily organized. We make sure that no leakage will happen during the test. There must be no one in the swimming pool when testing. All the members who helps with the tools must be working kneeling not bowling.

When the test is finished, we make sure that team members only move the ROV after it stopped steadily. If any emergency happens, the electricity can be cut off directly by our control box.

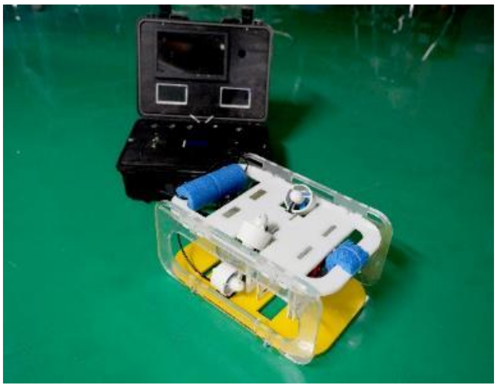


Figure2.3.1: The ROV and the control box

3 Structural Design Rationale

3.1 Overview

When designing Sentinel, we laid out a philosophy of form follows function. The structural design focused on three main objectives: task completion, ROV maneuverability, and ease of assembly.

Designs start out from rough sketches, and concepts are modeled using Autodesk® Fusion 360™ to better visualize and revise. The concepts underwent through a close examination for practicality and achievability: How long will it take to make, how hard will it be to assemble, will it break easily, etc. After one concept is chosen and approved, the main frame and supporting structure are fleshed out via CAD.

The frame is cut out from acrylic boards using our laboratory's laser cutting machine. Complicated parts such as connection links and the robotic arm claw are modeled using Autodesk® Fusion 360™, and manufactured through the use of 3D-printing. Once manufactured, the parts are then assembled by hand along with the central hub and all the electric system needed to operate the ROV. After complete assembly, the complete ROV Sentinel has a mass of 10.58 kg and a dimension of 25 cm * 40 cm *80 cm, which fits well with the competition requirements.

3.2 Frame and Support Structure

Frame of Sentinel consists of two side boards connected by a bottom support board and an upper board. The support for the central hub(red) is connected and fastened to the bottom and upper board to ensure stability of hub during ROV operation. The overall shape of the structure originated from various images of industrial-grade ROVs on the Internet that we consulted.

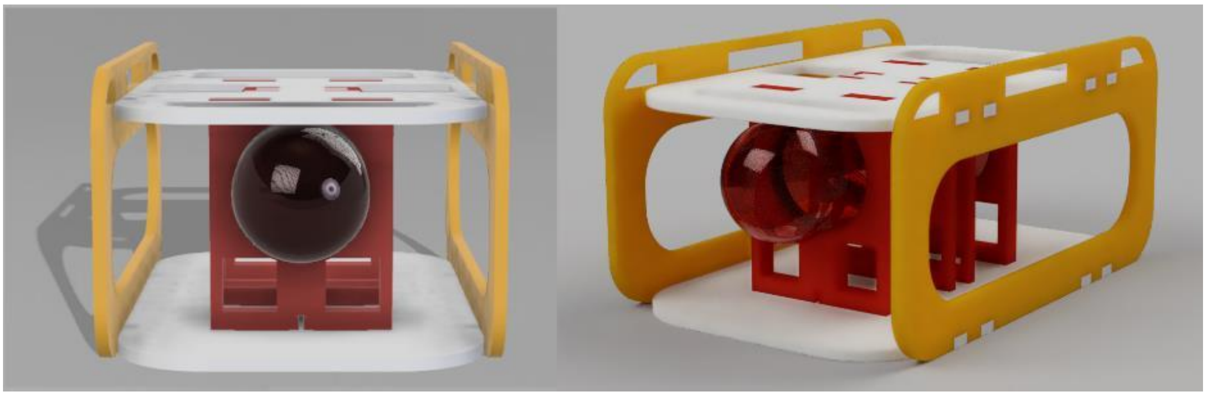


Figure 3.2.1: Rendering of frame with hub attached

The material chosen for the frame is acrylic board due to its ease of acquisition and machining. Other materials such as HDPE were considered but ultimately dropped due to costs and difficulty of acquisition. We also considered buying existing ROV frames from experienced makers, but ultimately decided against it due to high costs and the fact that their frames' dimensions were not compliant with MATE competition rules, so we built out own frame.

The boards are easily machined using our laboratory. For each board, two pieces of acrylic board with thickness 5 mm are superposed (board thickness 1cm) to ensure that overall structural rigidity will be enough for underwater operation as well as above-ground transportation. The same is done for the support structures.

As shown in Figure 3.2.2, the support boards, in particular the side boards, are hollowed out in areas that have minimal impact on the overall structural rigidity. The reasoning behind this design choice is to reduce resistance during underwater operation. With less board, the ROV Sentinel experience less drag underwater, thus increasing its velocity and maneuverability.

The boards are joined using a combination of prismatic joints and screws. Only screws would mean that during motion, the thread of the screw would exert a big force on the acrylic board, causing potential rift within the board and cracking it in the end. To avoid this scenario, we added prismatic joints to the boards. The boards are reused throughout the duration of testing because they have already been connected before, allowing for easier and more stable assembly. Hence, new boards aren't needed.

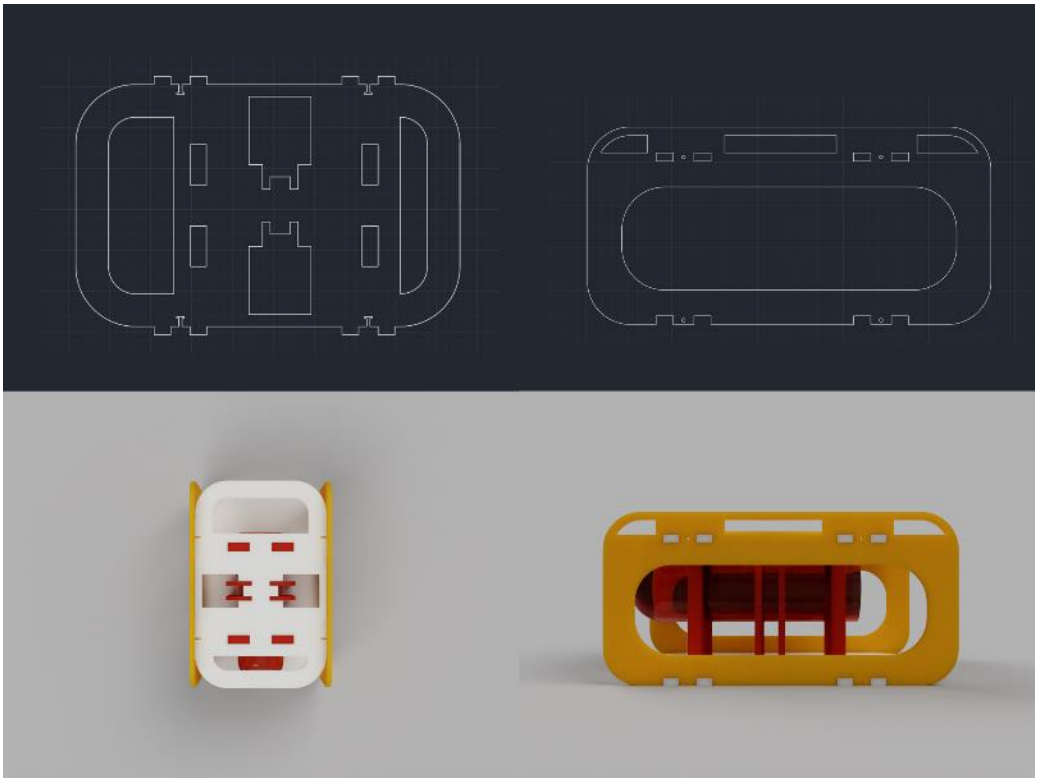


Figure 3.2.2: CAD design and 3D model for side(right) and upper board(left)

3.3 Propulsion

Sentinel employs four propellers that enables its movement underwater. Two propellers are situated on the bottom support board. They power the ROV Sentinel so that it can move forward and backward, as well as turning in the horizontal direction. The other two propellers are situated between the middle structural support and the upper board. They are arranged face-to-face at an angle of 45º to the horizontal plane (shown in Figure 3.3.1).

During the early stages of development, there was an alternative proposal that has the top two propellers solely powering vertical motion. This was rejected on the ground that such an arrangement would limit Sentinel's maneuverability underwater compared to the current layout. Data showed that the aforementioned proposal brought about negligible gains in diving/ascension speed while Sentinel exhibits a noticeable increase in both reluctance to turn and tilt while turning. Hence this proposal was scratched.

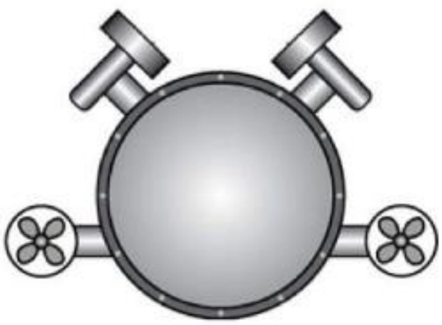


Figure 3.3.1: Arrangement of propellers on Sentinel

For ascension to surface, the net force produced by the upper two propellers is towards the top. This is because the vertical component of the force is upwards, while the horizontal component is canceled out due to propellers facing each other. This applies also to diving, with the net force pointing downwards (shown in Figure 3.3.2). This arrangement allows the upper two propellers to not only control diving and ascension to surface, but also horizontal movements to the left and right (by alternating propulsion directions of propellers).

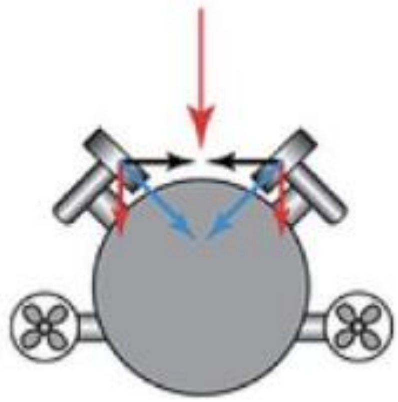


Figure 3.3.2: Illustration of the forces during diving

3.4 Mechanical Arm

The mechanical arm of Sentinel is strictly designed to fulfill the competition tasks. Due to the complexity of a mechanical arm with multiple degrees of freedom and the increased risk of failure that comes with it, our team has decided to employ a simple metal mechanical arm with some assistant parts.

Figure 3.4.1: PVC tube and motor attached to metal arm

In order to achieve rotation, a PVC tube is attached to the arm (Figure 3.4.1). A cable tie is used to connect this tube to a motor placed on the bottom board. While the motor is activated, it will pull the tube (and ultimately the arm) via the cable tie, thus achieving rotation.
For the grappling of the claw, a second motor is used. This motor is attached to a cable that protrudes from within the hollow metal arm (Figure 3.4.2). When the motor is activated, the force pulling on the cable will enable the claw to clench or relax depending on the direction.

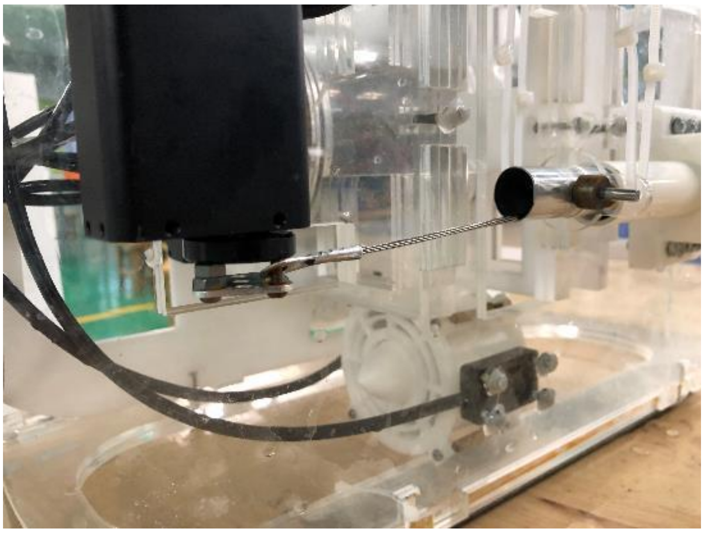


Figure 3.4.2: Motor connected to metal arm

As for the arm itself, a pair of 3D-printed claws (Figure 3.4.3) is manufactured to increase the overall grip that the claw exerts on objects, increasing the stability. The claw is also reused due to the lengthy time period it takes to manufacture one. Also, the claw also employs a hook that protrudes from its front end. It was specifically designed to handle U-shaped handlebars that will be present in the competition (Figure 3.4.4). It is designed specifically for missions like lifting the broken fence and the cannon.

Figure 3.4.3: Mechanical arm claw

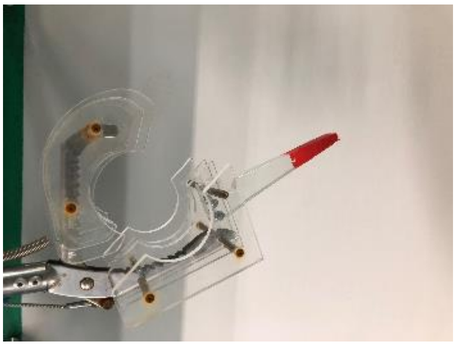


Figure 3.4.4: Mechanical arm claw and hook

4 Software design rationale

4.1 Software Philosophy & Overview

The software philosophy for ROV is to make an architecture that leverages the power of current technology to facilitate quick development, and ideal functionality. Generally, our robot takes the advantage of the concept of basic client-server architecture. This architecture allows the company to leverage many current web technologies that provide reliable data, such as video to transfer with long-term support benefits. Building on this model, there is a custom-designed intermediary proxy called QGroundControl. This separate piece of software runs on the client computer and connects to the ROV, managing data and video streams for the BattleStation to connect to manifest on the screen. The data stream passes control and states information from the Raspberry Pi server in the ROV to the BattleStation by UDP protocol. The video streams are sent from the Raspberry Pi (sever) to the PC (client), which is receiving images collected from the USB camera, leveraging the multiple cores of the Raspberry Pi, ROV runs functions in near-real time.

4.2 BattleStation

The BattleStation is Deep Dive BNDS's mission control software, providing pilot camera feeds and performances data, which allows them to control ROV Sentinel. This software translates the pilot's instructions in an Xbox-style controller of directions for the ROV. The driving display and communication with the ROV are achieved by implementing a web-based interface for the pilot. Because of the software (QGC) with detailed instructions, everything can run from one point of knowledge and requires very little prior knowledge.

This year Deep Dive BNDS utilizes the flight control unit to assist in the completion of submarine's tasks, as they provide critical information such as determining the direction of the motion by ROV's built-in compass; measuring the acceleration of the ROV to calculate the inclined angle of moving ROV in the water; using depth sensor and temperature sensor to gain the depth of the ROV and water temperature. After these data are collected, the ArduSub from flight control component will adjust the power supply for the motor and the angle that the steering gear drives in order to keep the balance of ROV to have steadier and quicker performances on the tasks.

A major focus of the BattleStation is the camera display. The BattleStation was given the ability to manifest the near-real time image within a very small time delay to ensure the consistency of the data. It can also run computer vision processes, which consume the raw video stream from the Raspberry Pi's cam and feed an UDP video stream back into the driver's visual with a computer vision (CV) overlay.

Figure 4.2.1: BattleStation Display

4.3 Logic structure

The ROV's upper level machine is the PC client, which is QGroundControl application. The PC is connected with X-box game controller to control the motion of ROV. The ROV's lower level machine is the Raspberry Pi board as sever, connected with camera to collect the image and video to transfer to the Raspberry Pi. The Communication between PC and Raspberry Pi for transforming data is developed by the Internet by using Python (import socket and set the different addresses for each) with UDP protocol to give a mirror of the video. The communication between Raspberry Pi and flight control on ROV is that the ROV transferring necessary information from compass, acceleration of motion, and depth and temperature of the water to the Raspberry Pi for analyzing and processing tasks, then the Raspberry Pi feeds the proper instructions back into flight controller to adjust the condition of motors and steering machines to change ROV's movement with the help of ArduSub in the flight controller and compaction.

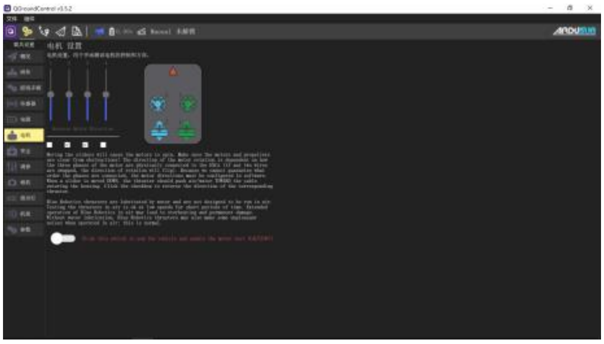


Figure 4.3.1: Setting motors' conditions

4.4 Computer vision

The image detection and analyzation are the cores of nearly all tasks. The BattleStation approximates the shape and color of the image in camera stream by using several CV algorithms. This works by firstly capturing the video collected from the camera, and then transferring the video to the computer by the link between the Raspberry Pi and PC, and then identifying and counting the shapes exist on the given images and also calculating the exact length of particular shape. The software uses algorithms like resizing, blurring to provide a higher quality image, and employs grayscale (color depth: 0-255) spectral data to isolate the color to extract the shape of distinct color depth value comparing with its surroundings. Finally, a shape contour algorithm is used to identify by calculating the angle for selection and eventually counting the shape of the identified colors for the polygonal approximation to run on. The results of the counted number for different shapes are returned to the pilot screen automatically for display. In addition, the magnitudes of the object can be measured as well by importing the module "imutils", "scipy" and so on. Its logic progress is firstly identifying the contour of the object, and then setting several positional points, and finally using formula provided by "numpy" module to get the length of the object. Furthermore, the name and the position of detected shape from the given image can also be manifested on the screen for display.

Figure 4.4.1: Shape detection program

Figure 4.4.2: Output message for detect_shape.py

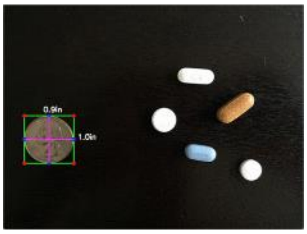


Figure 4.4.3: Magnitude measuring program

5 Team Management

5.1 Company Management

DeepDive BNDS is divided into four technical departments—mechanical, programming, electrical, and control system. Apart from the department leaders, two team members are assigned to each of the first two departments, and one to each of the latter. Every day, the team works at the level of each department, where members in the same department discuss possible plans, design structures, test models, troubleshoot, or corporate with other departments.

Both the Chief Executive Officer (CEO) and Chief Operating Officer (COO) are the head of all department leaders. Every week, CEO and COO organize a meeting on Sunday, with as many team members present as possible. During the meeting, each department reports the progress and the issues discovered in this week, so that every member of the team can notice the problem and brainstorm together. In addition, the CEO is a troubleshooter across all departments and an instructor of the competition procedure, while the COO spends the majority of time solving issues from the mechanical department and practicing piloting skills.

5.2 Project Management

Our project progress is divided into four stages—training, designing, constructing, and testing.

DeepDive BNDS started the preparation for MATE ROV from October last year. The mentors and returning team members provided the training to new members from September to January. The training includes the introduction of MATE ROV and necessary engineering skills for the competition, such as Python, Auto CAD, Fusion 360, etc.

After the training stage, our team entered the designing stage. We spent the holidays from January to February (Chinese Spring Festival) to brainstorm possible models of our ROV and discuss our ideas online. After we returned to school, we used the weekly schedule mentioned in 1 to specifically design each section of our ROV.
After most designing processes are accomplished, we entered the constructing stage, where each department develops its product and demonstrates it to everyone during the weekly meeting. Resource allocation is important at this stage, and to provide the most efficient access to materials for everyone, we used a warehouse for storage and several containers to distinguish different accessories (wires, tools, ROV body, etc.).
Lastly, our testing stage began at the end of April. During this stage, our COO piloted the ROV to see if it has any difficulties achieving any specific tasks. Then during the meeting, COO reflected the issues occurred during his piloting, and other team members troubleshot them before next testing.
For more details of our project management, please check the progress tracker in the appendix.

6 Critial Analysis

6.1 Testing & Troubleshooting

In order to make our ROV function well and perform all the tasks, we adjusted many parameters and peripheral hardware in QGroundControl. For example, we initialized all buttons and assigned their corresponding functions for the joystick. We also adjusted the intervals and the mid-values of each buttons so that our control of ROV will be more precise. According to the direction the motors on our ROV are placed, we had to reverse the command. In addition, the designations of sensors, cameras and the servos for the mechanical arm were all in conflict, so we had to reset their values and calibrate by ourselves.

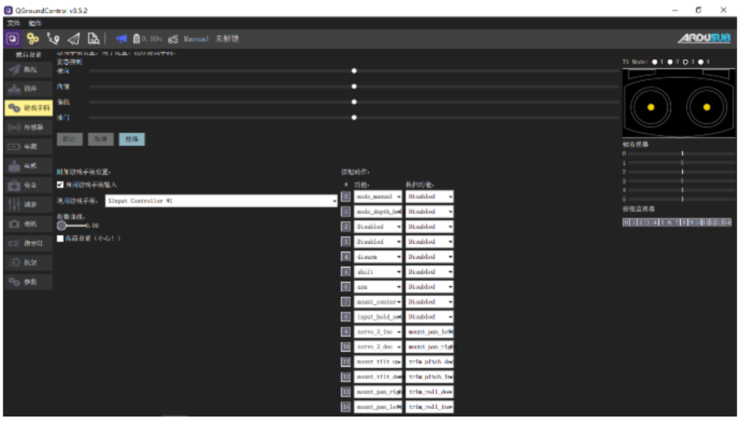


Figure 6.1.1: Joystick parameter calibration in QGroundControl

During testing of the prototype, we covered several areas: the power of the propellers, the coil-winding system of the micro ROV, the release mechanism for trout fry.

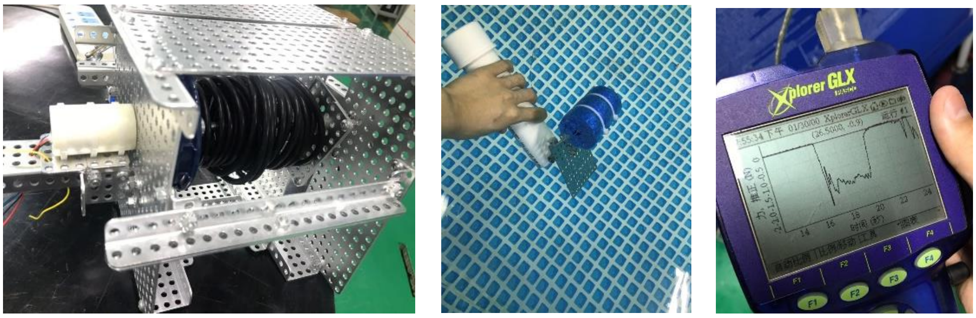


Figure 6.1.2: Coil-winding system, release of trout fry, and maximum pulling force measurement

6.2 Challenges

The biggest issue that came up was the material for the mechanical arm. The first version uses acrylic boards, but as the boards add up so does the water, resulting in an imbalance issue for Sentinel. This was scratched. The second version employs 3D-printed components, but there were air bubbles within them that makes them float underwater, causing imbalance issues again. It was not until we used copper columns to connect the acrylic boards did we solve the balancing issue. As a bonus, this also provided a greater area of grapple.

As many members are new to the competition this year, company management issues were burdensome. Members were confused about the various deadlines for different projects, resulting in everyone always working to catch up work.

6.3 Lesson Learned

On the technical side, the team learned to use two new tools. One is the principle and application of various signal and communication protocols, including I2C, CAN, SPI, PWM, USB, AHD, etc. The other is building and configuring a flight control system, which includes hardware connections and software tweaks. We obtained the valuable skill of learning and successfully controlling a new and complex system (flight control system in this case) without the aid of dependable reference materials and guidance. This competition provided an excellent chance for us to step out of our comfort zones and to learn something new.

Appendix

A. Safety Checklist for construction and operation

- **Pre-Run Checklist**
  - ☐ Check the electrical power connections.
  - ☐ Dry run to check that cameras are working properly.

- ☐ Check to ensure that all waterproof seals are secure.
- ☐ Check the thrusters to see if they are working and are clear of obstructions.
- ☐ Check the arm to see if properly functioning.

➢ **Tether Protocol - Set up**

- ☐ Unroll the tether.
- ☐ Safely plug the tether into the control box.
- ☐ Prevent other employees or workers from stepping on the tether by ensuring they're aware of it.
- ☐ Connect tether to ROV.
- ☐ Connect strain relief to ROV.
- ☐ If all steps above are done successfully, launch the ROV.

➢ **Tether Protocol - Disconnect**

- ☐ Safely unplug and disconnect the tether from the control box and from the ROV.
- ☐ Roll up the tether.

➢ **Post-Run Checklist**

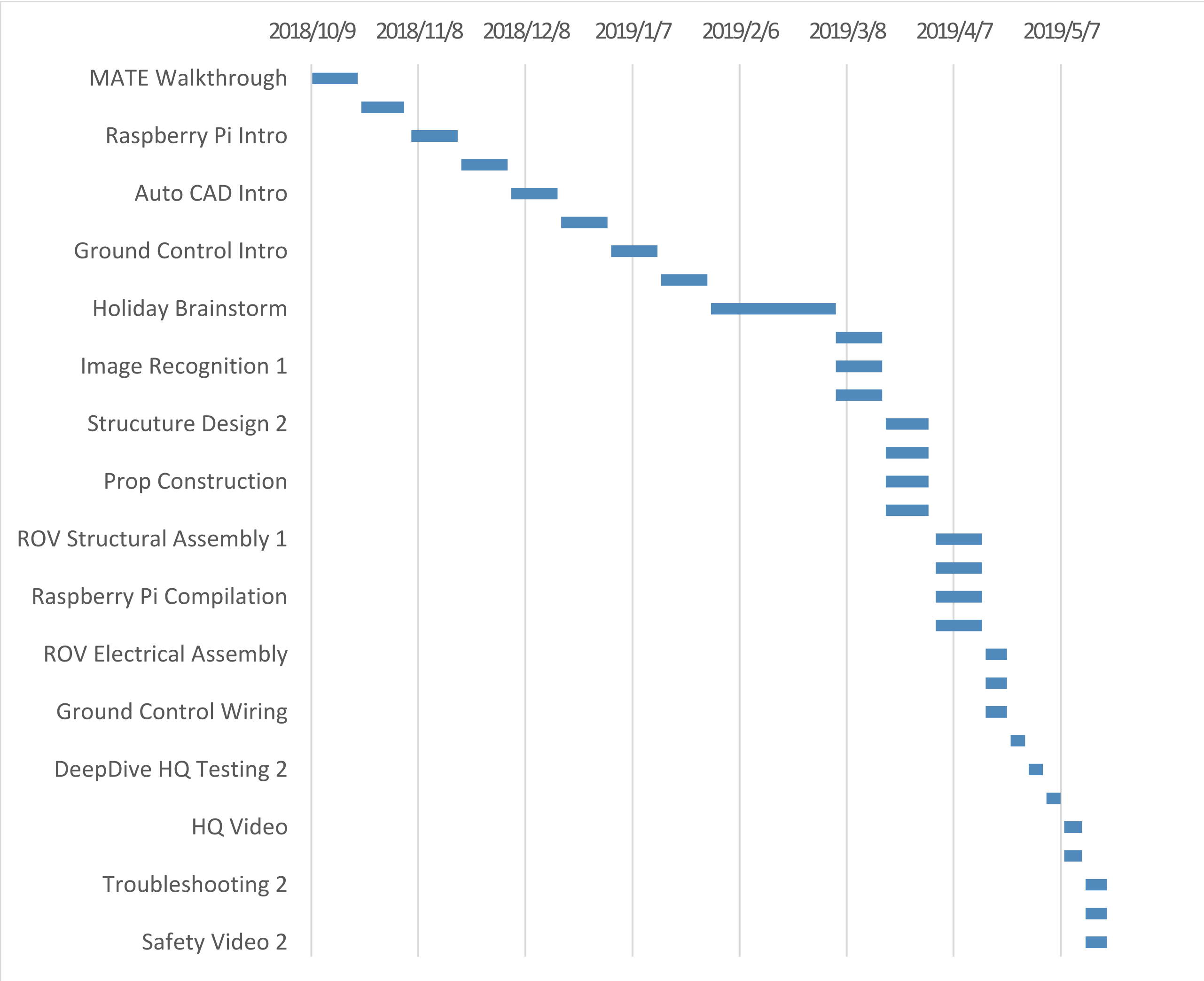
- ☐ Turn off power, first turn off main power, then Arduino power, then ROV power.
- ☐ Follow the tether protocol.
- ☐ Disconnect all electronic connections.
- ☐ Dry the ROV and set it safely on the cart.
- ☐ Clean up work area of all materials, props, supplies, and trash.

B. Budget of ROV Sentinel

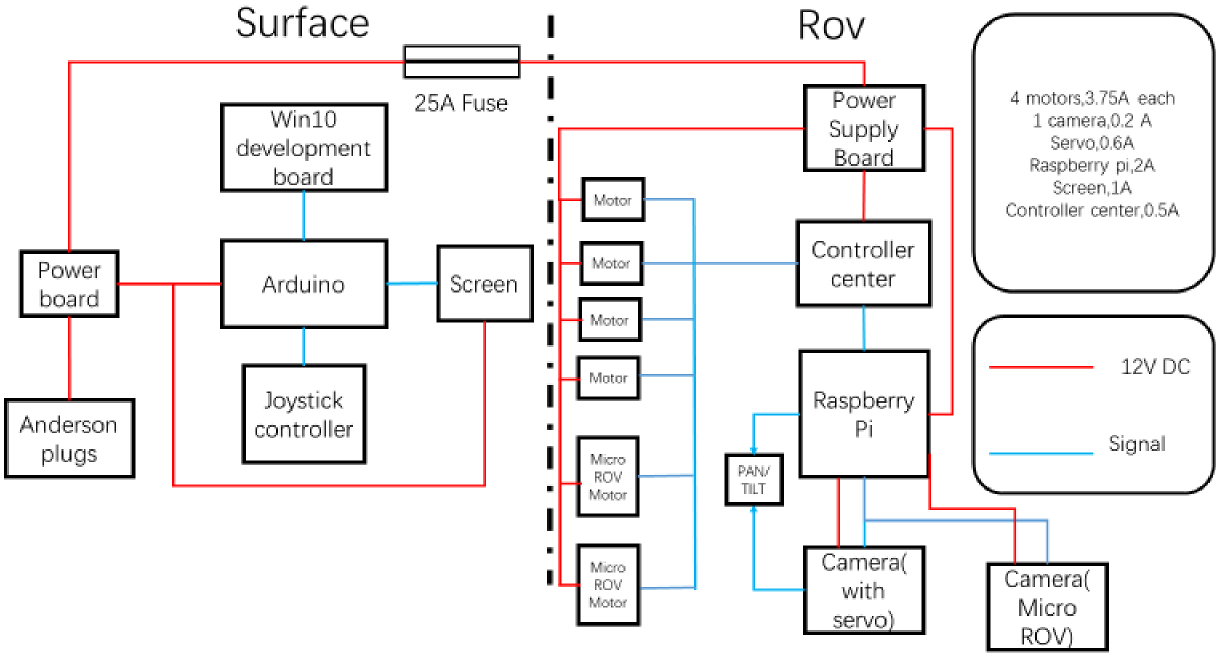
Date	Category	Expense	Description	Sources/Notes	Quantity	Unit Price	Total Price
1	**Electronics**				**Total**	**¥7,163.00**	
2018.12	Electronics	Raspberry pi camera	ROV		2	¥48.00	¥96.00
2018.12	Electronics	Raspberry pi 3b	ROV	RS-3b	1	¥236.00	¥236.00
2018.12	Electronics	Raspberry pi zero	Non-ROV	zero w BadUSB+shell	1	¥125.00	¥125.00
2019.04	Electronics	Underwater servo	ROV		2	¥412.00	¥824.00
2019.04	Electronics	Propeller	ROV	Positive paddle/Anti paddle,2 for each type	4	¥559.00	¥2,236.00
2019.03	Electronics	Power managemen	ROV		1	¥265.00	¥265.00
2019.03	Electronics	ArduSub Control	ROV		1	¥499.00	¥499.00
2019.03	Electronics	Xbox handle	Control Box	black	2	¥349.00	¥698.00
2018.09	Electronics	Micro computer	Control Box		1	¥859.00	¥859.00
2018.09	Electronics	Waterproof motor	Non-ROV	Positive paddle/Anti paddle,1 for each type	2	¥58.00	¥116.00
2018.09	Electronics	HD endoscope	Non-ROV		1	¥72.00	¥72.00
2018.11	Electronics	Monitor	Control Box		2	¥50.00	¥100.00
2019.04	Electronics	USB expansion			1	¥146.00	¥292.00
2019.04	Electronics	power transformer	Control Box		1	¥569.00	¥569.00
2019.04	Electronics	Button	Control Box		9	¥19.60	¥176.00
2	**Hardware**				**Total**	**¥5,804.25**	
2018.12	Hardware	Acrylic sheet	ROV	4*400*600/5*400*600, 5 for each type	5	¥45.00	¥225.00
2018.12	Hardware	Network cable	Cable	20m,black	1	¥18.90	¥18.90
2018.12	Hardware	Audio cable	Cable	200 core	25	¥2.35	¥58.75
2018.12	Hardware	Anderson connector	Control Box		50	¥0.80	¥40.00
2019.04	Hardware	Anderson fuse	Control Box		5	¥5.00	¥25.00
2019.04	Hardware	Underwater switch	ROV		1	¥99.00	¥99.00
2019.04	Hardware	Depth sensor	ROV		1	¥380.00	¥380.00
2019.04	Hardware	Waterproof connector	ROV	m10/m8,10 for each type	20	¥20.00	¥400.00
2019.04	Hardware	Pan-Tilt	ROV		1	¥620.00	¥620.00
2019.03	Hardware	Electronic cabin	ROV		1	¥125.00	¥125.00
2019.03	Hardware	Acrylic tube	ROV	Length 250mm,outer diameter 110mm	1	¥50.00	¥50.00
2019.03	Hardware	Acrylic dome cover	ROV	outer diameter 110mm	1	¥265.00	¥265.00
2019.03	Hardware	Acrylic hatch	ROV	9 holes	1	¥50.00	¥50.00

2019.03	Hardware	Flange	ROV	outer diameter 110mm	1	¥150.00	¥150.00
2019.03	Hardware	fastener	ROV	outer diameter 110mm	1	¥40.00	¥40.00
2019.03	Hardware	Screw set		m4*25,m3*25,m5*25	6	¥13.50	¥81.00
2018.09	Hardware	PVC tube (straight)	Task props	Outer diameter 25mm	20	¥3.25	¥65.00
2018.09	Hardware	PVC tube(3 passes)	Task props	Inner diameter 25mm	20	¥1.29	¥25.80
2018.09	Hardware	PVC tube(3 plane	Task props	Inner diameter 25mm	20	¥1.10	¥22.00
2018.09	Hardware	PVC tube(4 passes)	Task props	Inner diameter 25mm	20	¥1.30	¥26.00
2018.09	Hardware	PVC tube(angle	Task props	Inner diameter 25mm	20	¥0.99	¥19.80
2018.09	Hardware	PVC tube(4 plane	Task props	Inner diameter 25mm	20	¥0.90	¥18.00
2019.03	Hardware	Matrix accessories	Non-ROV		30	¥100.00	¥3,000.00
3	**Consumables**				**Total**	**¥510.20**	
2019.03	consumables	Cable tie		4*250, black/white, 2 for each color	4	¥23.90	¥95.60
2019.04	consumables	Potting kit	ROV-waterproof		1	¥21.00	¥21.00
2019.04	consumables	Vulcanized rubber set	ROV-waterproof		1	¥135.00	¥135.00
2019.04	consumables	Copper column		m3,m4	1	¥31.00	¥31.00
2019.04	consumables	heat shrinkable			1	¥32.00	¥32.00
2019.04	consumables	hot melt adhesive			3	¥7.20	¥21.60
2019.04	consumables	solder wire		55g*0.8mm	3	¥22.00	¥66.00
2019.04	consumables	buoyant rod		150cm*6cm	10	¥1.80	¥18.00
2018.06	consumables	PLA		35kg, for 3D print	6	¥10.00	¥60.00
2019.03	consumables	gaffer tape		0.03kg	10	¥3.00	¥30.00
4	**Tool**				**Total**	**¥606.20**	
2018.12	Tool	Wire stripper			1	¥27.20	¥27.20
2019.04	Tool	Glue gun	ROV-waterproof		1	¥57.00	¥57.00
2018.06	Tool	hot melt glue gun			5	¥19.80	¥99.00
2018.06	Tool	heat sealing gun			1	¥99.90	¥100.00
2018.06	Tool	soldering iron			3	¥39.90	¥120.00
2018.06	Tool	tyre pump			1	¥34.00	¥34.00
2018.06	Tool	hammer			5	¥14.00	¥70.00
2018.06	Tool	pliers			5	¥19.80	¥99.00
						Total	¥14,083.65

C. Project Management Schedule



D. SID


Surface
Rov
25A Fuse
Win10 development board
Power board
Arduino
Screen
Joystick controller
Anderson plugs
Power Supply Board
Motor
Motor
Motor
Motor
Controller center
Raspberry Pi
PAN/ TILT
Micro ROV Motor
Micro ROV Motor
Camera(with servo)
Camera(Micro ROV)
4 motors,3.75A each
1 camera,0.2 A
Servo,0.6A
Raspberry pi,2A
Screen,1A
Controller center,0.5A
12V DC
Signal