Technical report of Eagle Ray

P.C.M.S.

Macau

Company:

P.C.M.S.

School:

Pui Ching Middle School, Macau

City:

Macau, China

Team members:

ROV:	Eagle Ray
CEO:	Garrick Chang Patrick Cheong
CFO:	Anthony Mak Tom Lee
Technology and Electronic:	Kevin Leong Patrick Cheong Kenny Ho
Structure and Waterproofing:	Anthony Mak Philip Cheng Simon Lo
Mechanical Engineering:	Kathy Cheang Kristy Wong Sally Loi

Instructors:

Thomas Lao	Design and Science teacher in Pui Ching Middle School, Macau
Bevis Leong, Chongman Leong	Computer Science student in University of Macau

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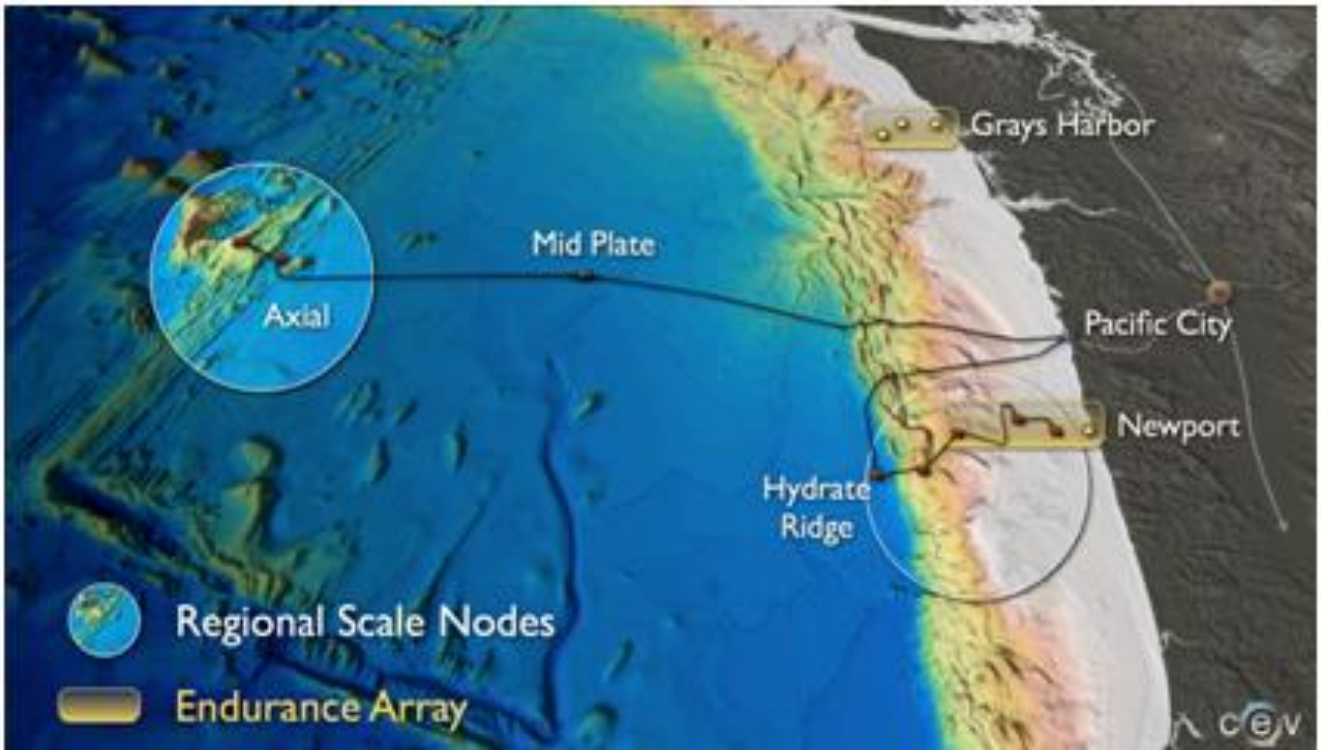
Abstract

PCMS, which is an academic activity team founded in 2012, which was a group of passionate teenagers who committed to marine ecosystems research and conservation.

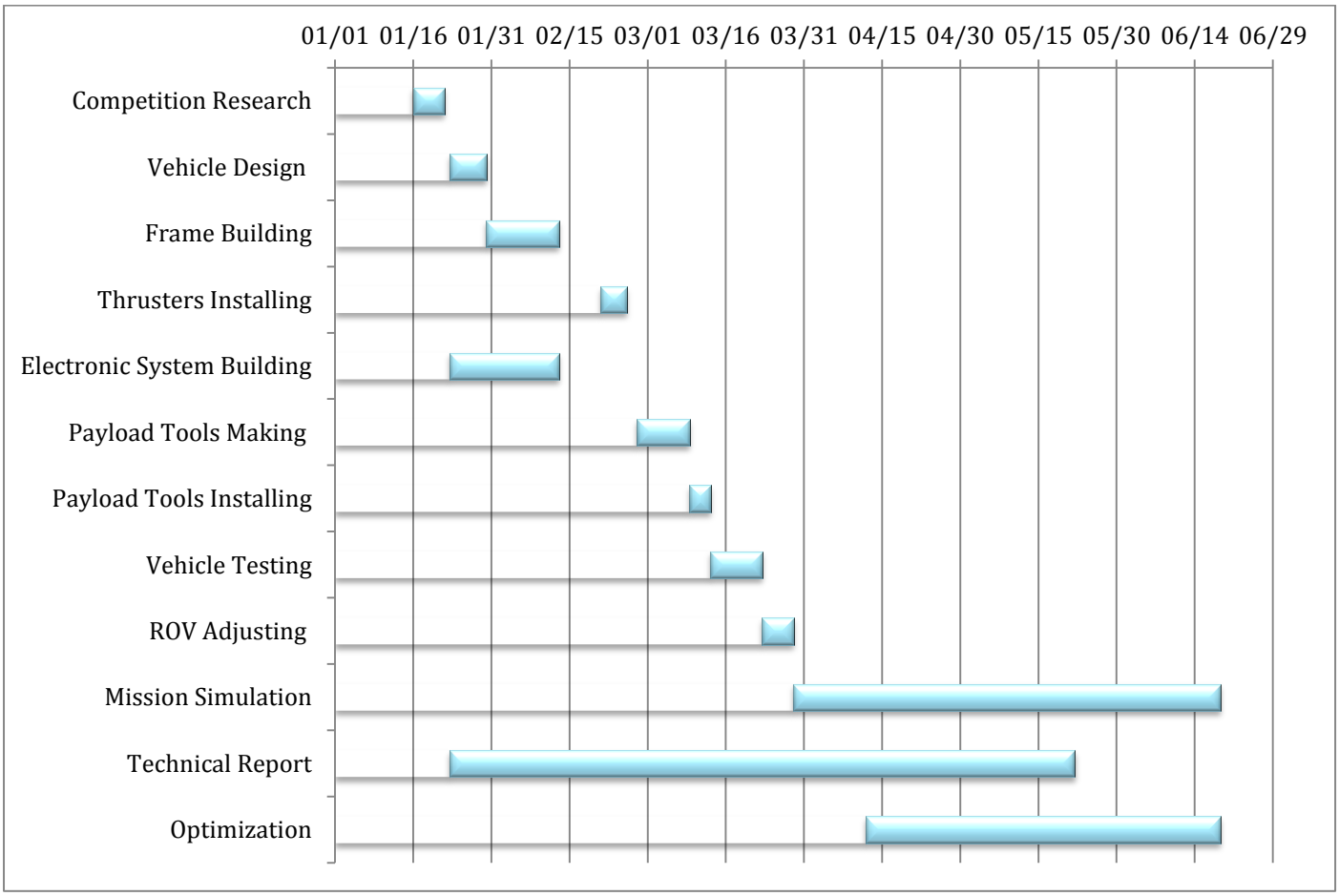
Understanding that the ocean is absolutely crucial to every part and aspect of the planet Earth, from marine ecosystem to global climate change, our main goal is to monitor and investigate this vast environmental body. To reach our goal, we designed and developed effective, multifunction and high adaptability Remotely Operated Vehicles (ROVs). Our ROV, Eagle Ray, features that it has two manipulators to adapt all kinds of missions, a self-made system that can manipulate the ROV to do a series of difficult movements such as panning and rotating underneath the water, also we can adjust the speed of the thrusters flexibly. On the other hand, we also want to promote the idea of protecting the marine ecosystem to the community. Nothing ventured nothing gain, although it may be a difficult and struggling path, but we will still use our optimistic and solidarity team spirit to overcome any challenges.

Mission Theme

The Ocean Observatories Initiative (OOI) is a project funded by the U.S. National Science Foundation (NSF). A part from the OOI is cabled the Regional Scale Nodes (RSN) to observatory off the coast of Washington and Oregon. The system currently consists of seven scientific underwater terminals or "hubs" called primary nodes. Each node consists are composed with: the Backbone Interface Assembly (BIA) and the Science Interface Assembly (SIA). To connect the BIA and SIA, ROV is used to accomplish these series of task.



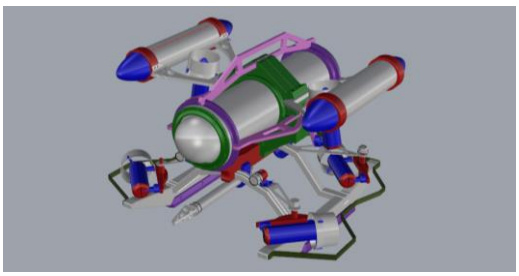
Schedule



Design rationale

Frame

This ROV's frame is made with aluminum. In addition to aluminum's features have excellent barrier, airtight, moisture and shading, it is a light metal. The weight of aluminum is triple lighter than iron and ductility of aluminum is better than other metal. When we need to machining, it would be more convenient. Aluminum is not easy to be rusted, no matter how many times that the ROV touch the water, the surface of the ROV is also glossy. When we joined the competition at April, we find that although we use aluminum to make the ROV's frame, it is too heavy and we are hard and inconvenient to move the ROV. After we back to Macau, we decided to hollow out the aluminum to make it lighter. And that we installed three thin, have little flexible aluminum, it can protect the body of the ROV From some of the impact of foreign objects.

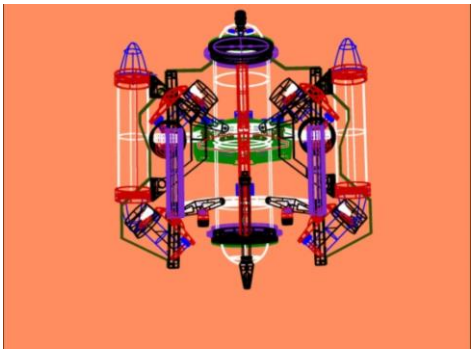


Because of the difficulty of the transportation, we have to install one aluminum bar on the top of the ROV for us to move it. Moreover we install the springs on the upper and lower parts of the connection position. It is because springs can Prevent the screws fall off from some vibration and shock to cause the upper

and lower parts of the connection position separate. In terms of design, we have design the ROV to streamline. It can reduce the mechanical the water resistance when the ROV moving in the water, so that the robot can move faster and more sensitive.

Propulsion system

We have six thrusters on our ROV. Four of the motors responsible for left right and front-back moving and the other two thrusters are responsible for the up-down moving. We put the motors, which are responsible for the translational and up-down movement in the same horizontal position. If we are not put in the same horizontal position, it would cause the thrusters' promote efforts are not average. And the reason of we use four thrusters to responsible left-right and front-back moving is it can make the ROV more stable and fast when it is moving.



We have tried to use two thrusters to responsible left-right and front-back moving; we find that it is unstable and slow when it is moving. The reason of we use two thrusters to responsible up-down moving is that they are enough to make the ROV up and down. If we use four thrusters to responsible up down moving, the ROV can 360 ° rotational movement. Apart from this competition don't need to do this action; we don't install four thrusters on the ROV. The brand of the six thrusters that we use is Seabotix. Seabotix thrusters' features are the thrusters' force is stronger and the motor is lighter. And the motor has a small hole; it is closed by a screw normally. When water entering the motor, we can remove the screw to let the water flow out. And then it has been designed for the thrusters of waterproofing and there have an annular protector to protect the propeller if it hit some objects or it may injury the creatures.

Buoyancy device

Since there are quite a lot tools we mounted on Eagle Ray, the gravity it receives cannot be saddled only by the motors. We decided to build two gas cabins, which was mounted on the both side of Eagle Ray.

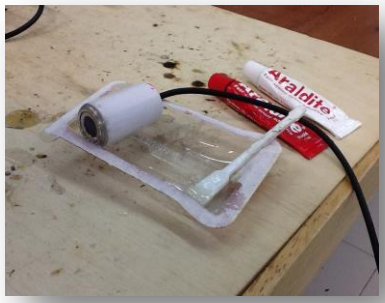
Housing

We use aluminum to make the frame and use acrylic sheets to make two gas tanks. At the rear side and the side of Eagle Ray, we install three pieces of aluminum to protect its noumenon and thrusters in order to avoid making it damage.

Payload tools

Camera

We use the AB glue to cover our camera as we put it
On the gap of the body of the camera. After it dried out, we put it into a shot cut of pipe and put some more AB glue in it. So it can afford the pressure of water in more than ten minutes.



Our group uses two different cameras, total of four. Two of them are bought from Taobao; they are immobile with AB glue and put on the front panel of the housing. One is responsible for observing the front; The other one is responsible for the observed robot. And

the other two are learned from the workshop. After that, we used some simple material to do it again. We waterproof them with AB glue.

They are placed at the bottom of the robot. One of responsible to observed on the left, and the other responsible to observed on the behind. They connected directly to the computer. And then, it will be fine as soon as we switch on the main switch, the cost is low and the image is also very clear. There are two camera are made by our crew, so we can recognize more the approach of camera. on it. The cameras are helped us to complete all tasks.

Manipulator

Manipulator played an important role in the entire mission. We use two Seabotix manipulators to complete every single task. We install one of the manipulator on the lower location of the ROV and the other is responsible for the above. If we have only one manipulator, we will waste lots of time in one mission. Knowing that we have not enough time to complete all the tasks, we use two manipulators so that we can do two tasks at the same time.

The manipulator on the top location will do mission while the other grabbing up some corals. It will be easier to pick the corals in case we put it below. It draws a maximum of 4 amps of current and works under 12 volts. The manipulator is three-pronged and the arm hasmaximally100 kg of gripping force. So it can hold objects more easily and stable. Manipulator is mainly used to finish missions such as gripping the coral and the lift bag.

Temperature Inductor

This is our temperature inductor. At first, it is ds18b20.We use stainless steel to cover the chipset and extend the pins. The red wire is the temperature inductor VDD, the black wire is the temperature inductor GND and the yellow wire is the temperature inductor DQ. We use this inductor to do Task 2.

Waterproofing works

Since not few circuit boards were mounted on ROV. If we put them into water, they damage. So, we need to waterproof the circuit boards or even some electric equipment. We choose Araldite(a mucilage used for waterproof and conglutinate) to protect the equipment that may not work as usual underwater, also, heat-shrink tubes were used to cover up on each wires joint, electrode, power switch, circuit board and somewhere that will have a short-circuit problem that caused by water.

Electronic system

The electrical system is divided into two parts, control panel and onboard control unit. Like the graphic upon, the system is worked under 12V. There is a fuse between the power source and the control panel. The Arduino of the control panel will read the data sent by the PS2 gamepad, and then it will transmit the data to the onboard through MAX485 and optical fiber.

After the Arduino Mega of the onboard control unit receives the signal, it will transmit the corresponding PWM signal to the Motor Driver Board to control the motors or different devices.

Electrical Schematic

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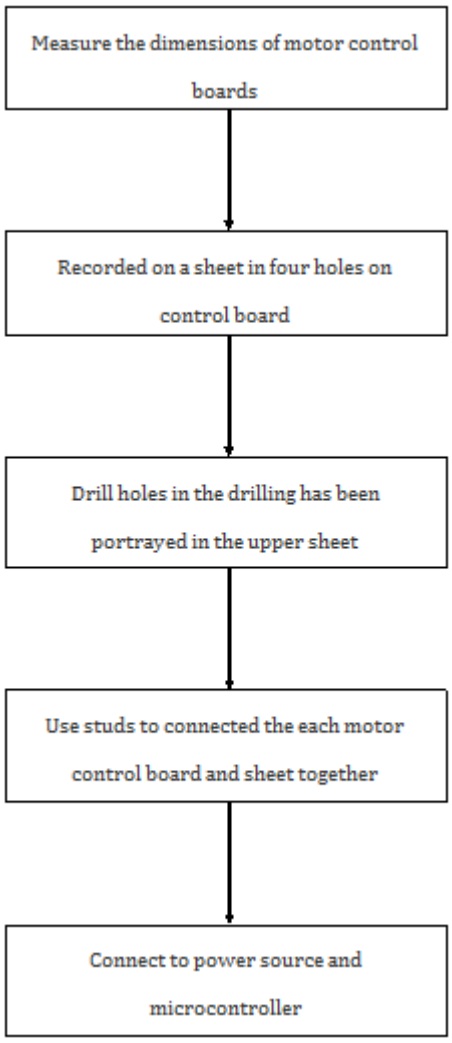
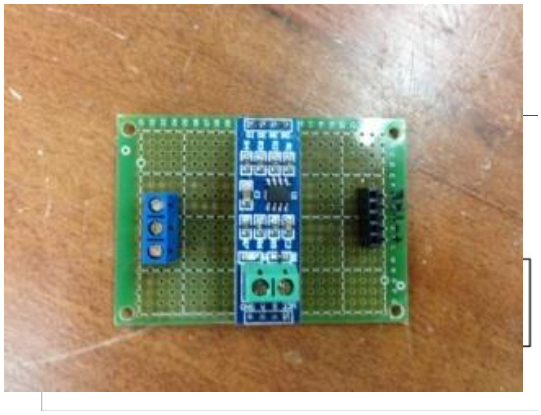
Onboard unit

Motor Control Board: The assembly process of motor control boards



We place them like this because it is easy to remove and distinguish. We can remove them when the system appears some problems, such as excessive current.



Communication with RS485

The control system we used is divided into two parts, a control panel and an onboard control unit. 2 microcontrollers (Arduino) is used for both control panel and onboard control

unit. And we used the built-in Serial protocol for communication. We deeply realize that if we want to transmit data from sheer to ROV in long distance stably, a robust long-distance communication technology is required to form a feed-back control system, thus, we use the IC RS485 which allows relatively long distance signal transmission up to 1000m. We use a pair of Arduino and MAX485 to communicate between sheer and ROV with long tether.

Not only stable long-distance communication is guaranteed, but also thinner and fewer cables are used in this case, thus, the cost and the weight of our ROV are significantly reduced. In addition, if you want to have some changes of the program or debug, you just need to download an amended program to the Microcontroller without any hardware modifications.

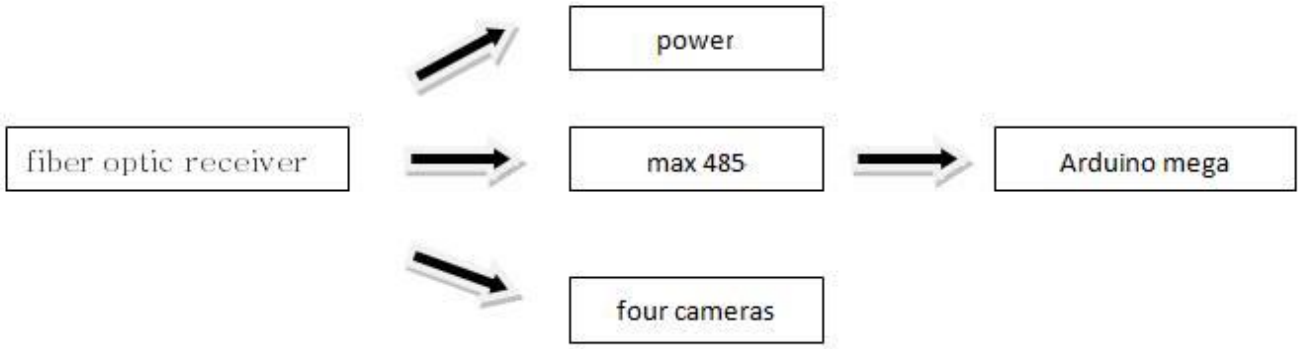
Optical fiber

We find that using cables to transmit data between the control panel and onboard panel will make the weight become very heavy.

Let us calculate, four video camera, four video cables, and Arduino, mega required between a cable to connect the Internet, coupled with the power cord, steel Jian; these are numerous weight add up to enough to make the ROV balancing more difficulty.

This time we chose the HD digital video optical fiber mux to integrate the four video signal and one data signal. This will greatly reduce the weight of communication line between two control units.

Now we only need to transmit data in one fiber. What a useful thing!

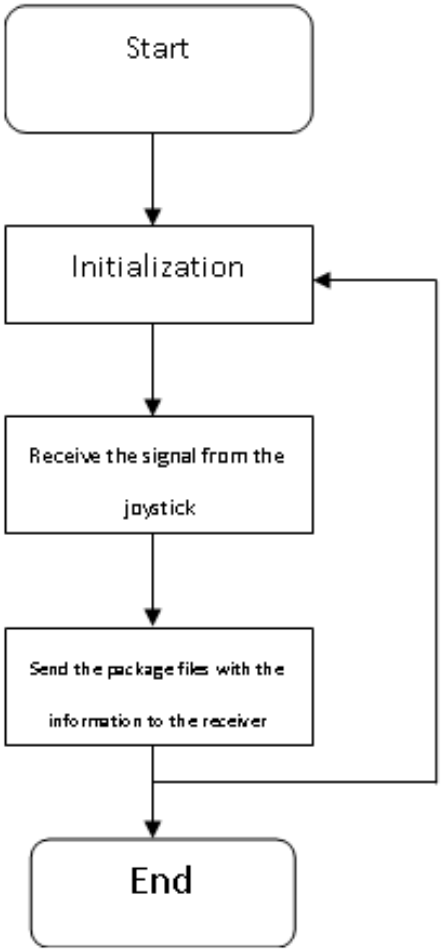


Motor Rated current

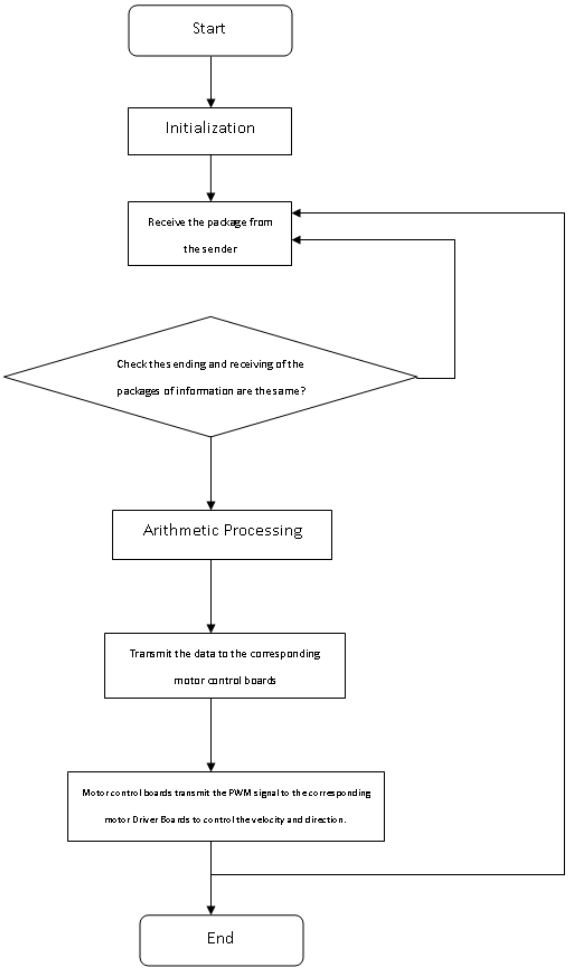
We chose AQMH2403ND driver module for motor drive, it has lightweight, small size, low heat, high output power (30W), high integration (2-way control) and the control signal, the driver outputs are optically coupled isolators, over-current protection Power reverse polarity protection as advantages. We use it to drive a motor, machine hand, is more than enough.

Flow Chart

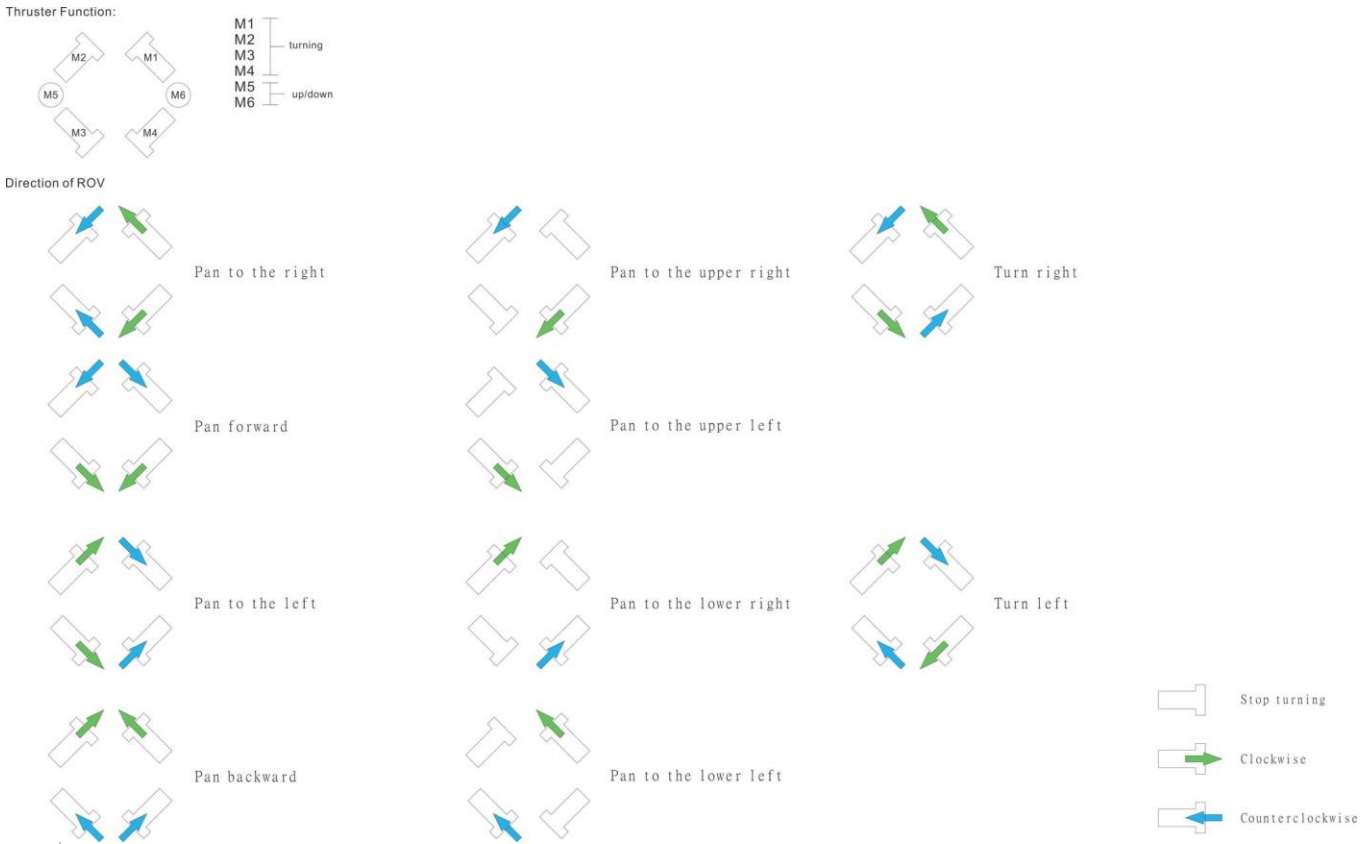
Sender Part Program



Receiver Part Program

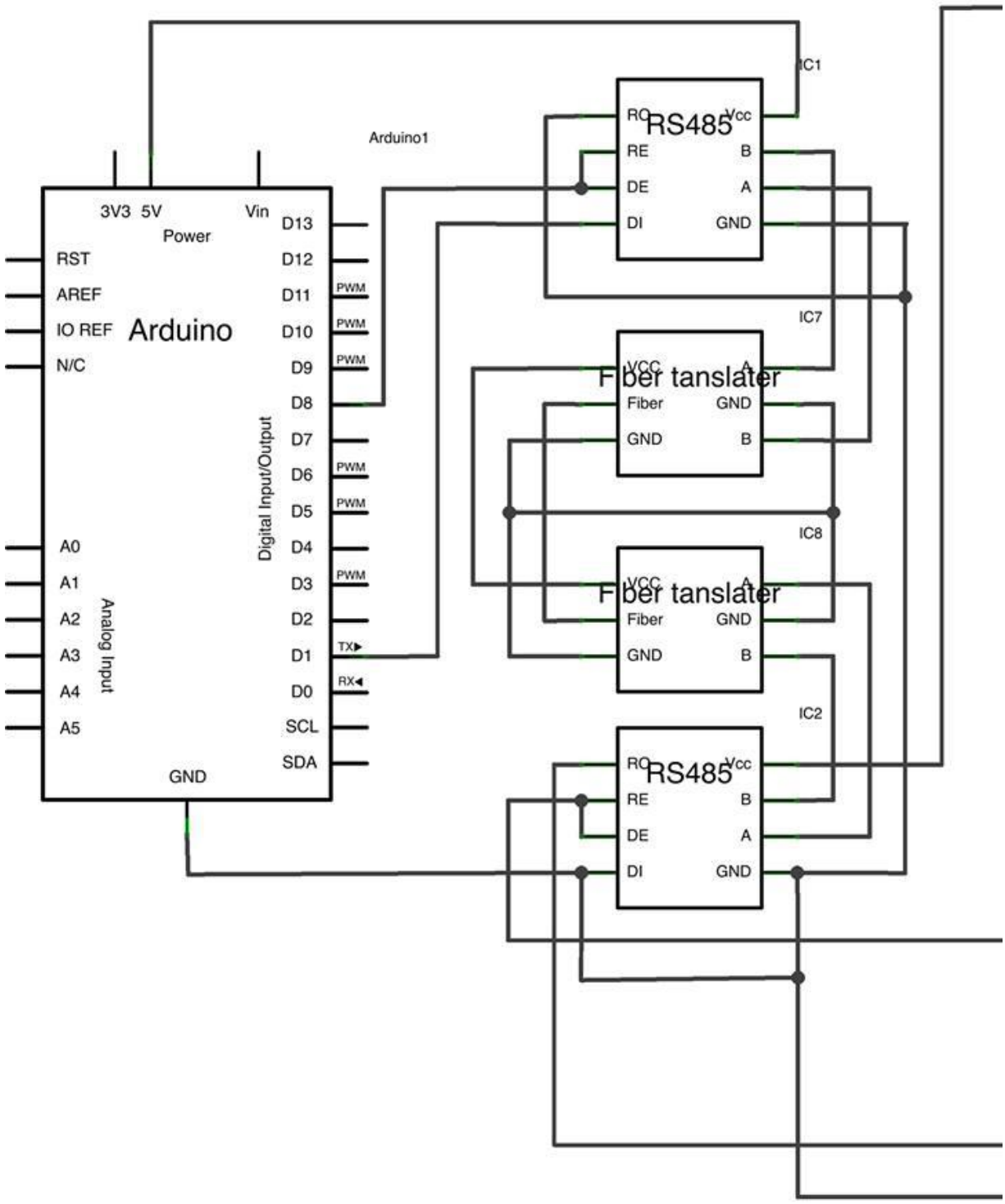


Thruster function

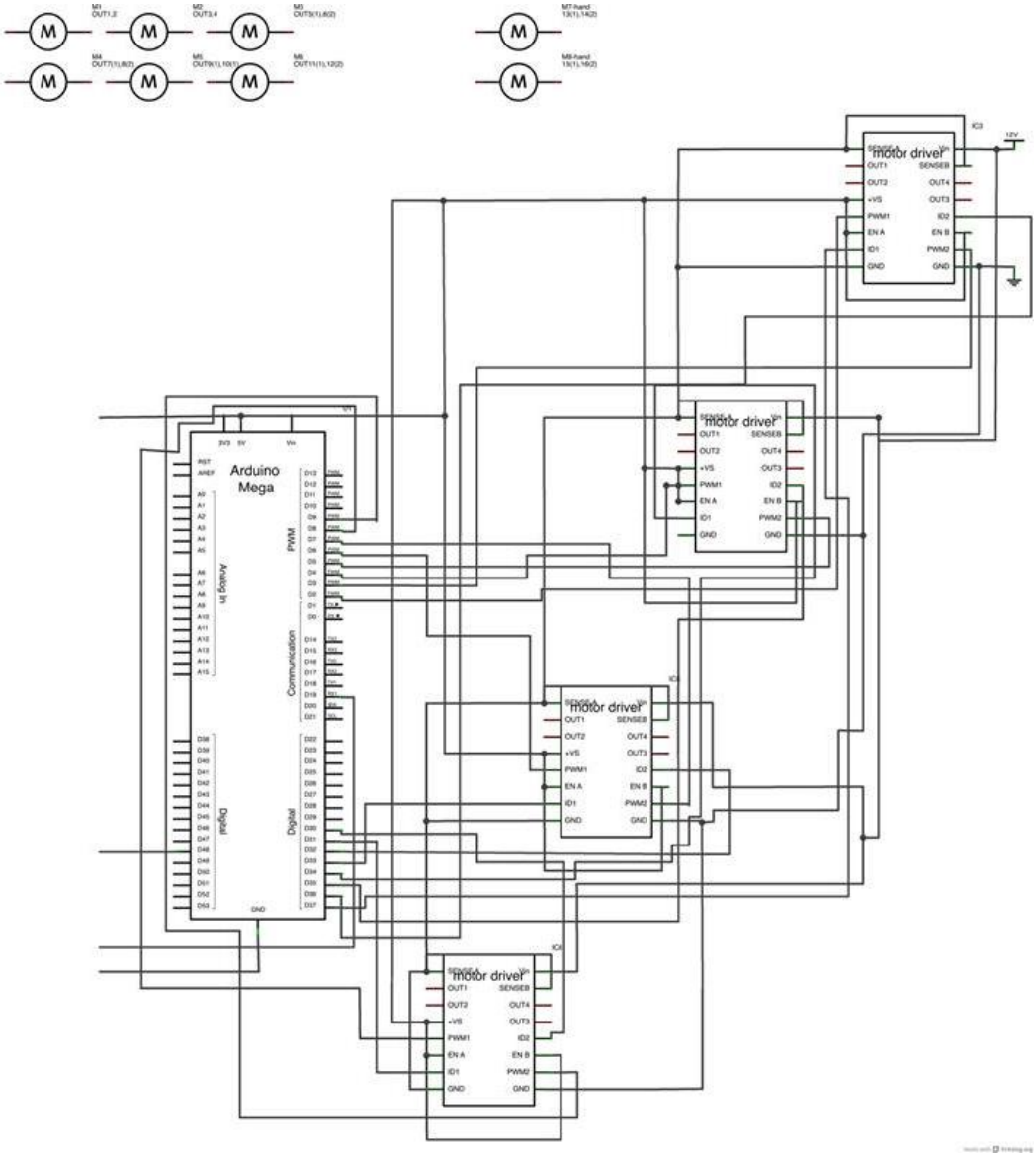


Circuit diagram

We use the software "Fritzing" to design the circuit diagram; this program can help us auto-routing circuit that can save our much time.



control thrusters system



on board control

Temperature testing device

Learning the experience from the seniors, the LM35 is a very great device to test the
The temperature LM35 receives the voltage change type of temperature sensor. Its voltage output is linear relationship between the Celsius temperature scales. Ashore Arduino board is to receive the temperature signal and Underwater Arduino is to send the temperature to the Control panel, finally, the temperature signal will appear on the screen.

Task Specific Design

In this description, we will use the following abbreviations that are quoted from MATE mission specification.

RSN: Regional Scale Node
BIA: Backbone Interface Assembly
SIA: Scientific Interface Assembly
CTA: Cable Termination Assembly
OBS: Ocean Bottom Seismometer
ADCP: Acoustic Doppler Current Profiler

Task1

In task1, we have to do the following actions.

First we transferring the SIA to the seafloor, install the SIA, remove the CTA from seafloor, and then insert the CTA into the bulkhead connector on BIA.

Secondly, we pull the pin to release the OBS, and remove the OBS from the elevator, deploying the OBS in the seafloor.

Last, we open the door of the BIA, remove the OBS connector and insert the OBS connector into the bulkhead connector in SIA.

In these actions, we have to pull an object, move an object. So that we quickly thought that we can use a manipulator to complete this task. Through controlling the manipulator, we can hold an object, and move it or pull it by the movement of the ROV. So finally we placed a manipulator in our ROV to help us to finish the task1.

Task2

In this task, we have to detect the temperature. For detecting the temperature, we solved it by using some electronic equipment.

For the detection of the temperature, we used a one-wire temperature sensor “DS18B20”. We can receive the data and provide the power from Arduino UNO.

For installing the temperature sensor, we will design a round cover and put the waterproofed sensor inside the cover, so that we can put the sensor inside the tube and detect the temperature.

Task3

Same as task1, we have to disconnect / connect the power, remove / install ADCP, so that we used a manipulator to help us to finish this task.

Task4

In this task, we have to collect biofouling, so that we placed two manipulators in our ROV, so that we can collect the biofouling, no matter the position is high or low.

Safety features

Company Safety Philosophy

The ROV's safety is very important for us. We should make the ROV become safety so as not to nable us electric shocks and injuries. So we add a 13A fuse in the control box and some in the ROV. On our robot thrusters’ surface printed with the warning labels. It is tiresome but for the sake of safety. We have made every effort to make the robot. Spent a lot of time and effort on this thing. And we have an entire ROV and no people are threatened.

Specific Safety Features

Robotic safety is very important for us. Our ROV had a number of specific features designed and some danger things. Once the system malfunctions, we can switch off the system with the emergency switch manually. There have safety guards used to the thrusters because the propeller might hurt us. And there’s cover warning labels. The fuses are used to control the current. If we don’t use the fuses, it may melt the wires that make us get an electric shock. So we can able to do the safety measures.

fuse & emergency switch

Safety Precautions and Checklists

In order to ensure that our robot is safe, we have a safety checklist. Many safety measures are in the safety checklist.

Safety Check List

Mechanical

No circular connectors are mixed up. _____ ☐

All the cables are fastened._____ ☐

Make sure all the cables' connection is good. _____ ☐

All the screws must be tightened. _____ ☐

No junks are involved in the thrusters. _____ ☐

All thrusters must be covered by a mesh casing._____ ☐

Sharp edges on the ROV have been filed down. _____ ☐

Hazardous areas of the ROV have warning labels. _____ ☐

All parts of the ROV are securely are attached to the chassis. _____ ☐

Installed some aluminum bar to protect the ROV. _____ ☐

Electrical

No metal parts of cables expose. _____ ☐

No cables are damaged. _____ ☐

Installed 13A fuse in control box. _____ ☐

Only one attachment to main power source. _____ ☐

Make sure no wires may cause shorts._____ ☐

Make sure no loose wires._____ ☐

Any soldering joints in the tether are covered in heat shrink. _____ ☐

Waterproofing

Any soldering joints in the tether are covered in epoxy adhesive. _____ ☐

Make sure the O-ring is installed suitable._____ ☐

Make sure the main cabin is sealed._____ ☐

All the circular connectors have been tightened. _____ ☐

Trouble shooting

Waterproofing

At the waterproofing part, we use the glue to make the float tight in cause the water infiltrates through the float. We also use the epoxy adhesive and O-rings to stick the circular connectors to ensure that the water cannot infiltrate in it.

Appearance of the teammates

Because most of our teammates participate in many afterschool activities, so some of them cannot attend for some lessons of the ROV club, and slow down the schedule of making the ROV. At last, our teammates found a balance between the ROV club and other activities, and we finally catch up the schedule gradually.

ROV testing

We also tested our ROV with the small pool of our school. The depth of water is just 95cm. Although we cannot make the whole wreck of the mission because of the depth of the pool, we try to use the PVC pipes to make the parts of the wreck. We have test the device installed such as manipulator, measuring tape. After testing the device, we can know how many time we spend in each task, then we write a schedule about what should we do during the 15 minutes mission time.

Budget sheet

No.	Category	name	USE	price US	quantity	total	Donated	Donor/Source
1	Parts	Thruster	movement	625	4	2,500	bought	N/A
2	Parts	Light	light	6.25	2	13	donated	Seve Studio
3	Parts	Screws, Screw nut	fastener	25	1batch	25	bought	N/A
4	Parts	Circular connector	communication	3.75	12	45.0	bought	N/A
5	Parts	Manipulator	mission	25	2	50.0	bought	N/A
6	Parts	Waterproof lens	mission	10	2	20.0	DIY	N/A
7	Parts	Floating cabin	floating	1.25	2	2.5	bought	N/A
8	Parts	Fuselage cable	communication	67.375	20m	67.4	bought	N/A
9	Parts	Aluminum for frame	chassis	2500	1	2,500.0	donated	Seve Studio
10	Parts	Straps (nylon cable tie)	fastener	0.125	15packet	1.9	bought	N/A
11	Parts	Polyoxymethylene(POD)	fasten	0.375	13	4.9	bought	N/A
12	Parts	Buoys	floating	2.5	1box	2.5	bought	N/A
13	Parts	Wire mesh pockets	cluster	0.625	20m	12.5	bought	N/A
14	Parts	Lens	mission	6.25	2	12.5	DIY	N/A
15	External	Box	contain	3.75	1	3.8	bought	N/A
16	Internal	motor control board	control	6.25	4	25.0	bought	N/A
17	Electronics	Arduino Mega connected to an expansion board with Arduino Mega	control	60	1	60.0	bought	N/A
18	Electronics	The Max 485 CRS485 the communication module	communication	2.5	1	2.5	bought	N/A
19	Electronics	Fiber Converter	communication	18.75	3	56.3	bought	N/A
20	Electronics	Arduino Uno	control	22.375	1	22.4	bought	N/A
21	Electronics	The voltage comparator communication CRS485	communication	6.25	1	6.3	bought	N/A
22	Electronics	PS2 control	control	4	1	4.0	bought	N/A
23	Electronics	Fuse 13A	safety	0.0625	1	0.1	bought	N/A
24	Electronics	Main switch	safety	0.125	1	0.1	bought	N/A
25	other	Soldering paste	tool	2.5	5	12.5	bought	N/A
26	other	Epoxy adhesive	tool	1.875	3	5.6	bought	N/A
27	other	Threaded rod	tool	6.25	1	6.3	bought	N/A
28	other	Compass	mission training	1.875	1	1.9	bought	N/A
29	other	Pipes and tasks Road	mission training	3.75	4	15.0	bought	N/A
30	other	Thermometer	mission	6.25	1	6.3	DIY	N/A
					Total:	**54,116.5**		

p.s.: expect the DIYs and donations, all fees were paid by our school.

Learning

We have learned many meaningful lessons during this activity. We all agreed that the most important skill gained is the ability of working smoothly with the teammates. During the process of making a ROV, we have ever quarreled just because of the a little decision. But after we cooperate for longer time, we start to learn how to help each other to get out of dilemma. We work just like a big family.

To build our ROV, we go to find the suitable component whose name we don't know. Then we go to the shops and ask. If the shop we ask doesn't have the product, we need to ask for more information such as where to buy. Finding suitable parts is also an adventure to us, which makes us become braver and learn how to communicate with others.

We try to use many technologies to build our ROV, just like we use the PVC pipe to waterproof our circuit boards. During work on waterproofing of t PVC pipe, we know more about the materials and structures of different o-rings. We found that using the softer one is easier to waterproof. And we found that even the plugs we use in electronic housing are not safe enough to avoid leaking. So we glue the bottom of the plugs to prevent leaking.

Also, we learned how to develop an onboard control unit better for our ROV. The one we make is more systemized. With that, ROV's tether becomes much thinner. We found that thinner tether not only give us the ease of transporting Eagle Ray, but also makes it move more smoothly underwater.

Reflections

Garrick Chang

As a CEO of the team, there are many things I have to concern and care about, such as keeping the team in the correct schedule, making sure that my teammates have nothing trouble. During this time of making ROV, I find out that managing a team is really a tough job, sometimes I may made some irresponsible manners and not doing the work well, but I am determined to correct my rather poor attitude. Although our team may have some tough time, but I believe that we can overcome all the challenges standing in our way.

Philip Cheng

Since this is the first time to join this competition, so that I lack of experience in machinery, waterproofing and electronic. When I joined the competition at April, I had learned how to be careful to do everything. And I needed to spend some times to find the pronunciation of the vocablary; it is because I have seldom to speak English in Macau.

Anthony Mak

This is my first time to join this competition and I learned a lot of ROV during making our robot, Eagle Ray. My job in our team is the waterproofing part and the structure part. The most difficult part of my job is to use the epoxy adhesive to make our circular connectors tight to our robot's cable. It is my pleasure to join this competition.

Kevin Leong

First I want to thank my teachers, they let me know that technological world is very big, I find that my knowledge is actually not enough, motivated me to read more books about physical, chemistry, and biography and computer science to increase my knowledge.

Kristy Wong

I am responsible for the manipulator. It is quite a hard work for me to work with it because I have no idea about machineries and this is the first time take part in this workshop. I am not really good at it. Thanks for the helping of my teachers, finally I completed the manipulator, and I know more about how it work through with the gear set.

Kathy Cheang
I think this is a rare opportunity to go to Seattle for the International ROV Competition since this is only the first year I study on ROV. Every one of us charges of different parts of the work. Although I am not the most important one, I will try to do my best. I am glad that can be exposed to ROV. It gives me a lot such as how to communicate with others in English, and do everything with heart and soul, just like in the ROV.

Simon Lo
This is my first year to join the ROV team. This is quite difficult for me because I haven't many chances to join this event before I join the ROV. This workshop let me learn a lot of tools and the relevant knowledge. My main job is to use the epoxy adhesive to stick the plug. Although the epoxy adhesive has stuck my hands, it is a good experience for me. I am very grateful to our teacher.

Kenny Ho
I am very happy to join the ROV.I has learned welding, how to use the CorelDraw and the electronic structure of the internal robot. I thing the weld is the most difficult because it is easier to Welding something wrong am never know the electronic before I join the ROV. This speed me long time to learn.

Daniel Lau
This is the first year that I join the ROV team; I am the electronic engineer in our group. It is a new challenge for me to work with a group of people for a long time. I felt exciting at the first time, we can use ROV to explore the mysterious ocean, but I did not finish so much work, and then I found that we should be hard working and serious all the time.

We went to a ROV workshop in Hong Kong; I learned a lot of things there. I learned how to use a drill, hammer, screwdriver, heat gun, and hacksaw. We made our first pipe ROV at there, It is a useful lesson. At last, we made aluminum ROV for our first competition at Hong Kong, the result was not very good, but we can do it better in the next competition.
I would like to thank you Mr. Lau, he teaches us a lot of things and let us join the ROV team, it is great to make a robot which can go under water and do some difficult mission!

Patrick Cheong
This is the first year that I joined the ROV group. Before this, I have no idea about ROV. After operating. with my group mates and instructors, I know more and more about ROV. I learned something which is involved programming design, Electronic Engineering, waterproofing. I also learned how to well-organized my work. After joining ROV group, I felt it enrich my life and let me know more knowledge. It made my life better.

Sally Loi
I join in this class because I think it would be very interesting. I am attracted by the topics of this class. I would expose to this class because our school opened a new subject this year. I am responsible for the camera, logo and T-shirt. This is not a very difficult task for me because I am very interested in design. I learned that we should do anything with patience and perseverance. We should also do anything seriously. After this year, I know that this class can training our manipulative ability、learning ability and leadership capacity.

Tom Lee
Through this activity, I have to learn a lot of useful knowledge, such as: How do the financial statements in Microsoft Excel, how to find the price of the things. But I still find some questions in that such as, use Microsoft Excel, the different objects classified and labeled uses and sorting, and the most difficult is the search for some terms, such as POM, etc.

Future improvement

In next year, we want to have these changes in our ROV:

- Increase three-axis gyro shift.
- Increase automatically regulates the body's balance.
- Improve weight problems.
- Try to reduce the volume of the ROV
- Hope that we can make a manipulator by our own, but not buying one

Acknowledgements

Marine Advanced Technology Education (MATE) Center

Thanks for holding the competition and gathering the ROV builders from different places.

Macau Pui Ching Middle School

Thanks for donating us the money of building material, supplying us the venue of testing our ROV and the supply of the tools.

Seve Studio

Thanks for donating us the rov of building material.

Macau foundation & DSEJ of Macau

They sponsor our travelling fee.

HKUST Robotics Team

Provided the advanced rov workshop.

Robin Bradbeer

Help us to join the ROV competition..

Thomas Lao and his lovely family

Thanks for giving us opinions, the support from the spirit and giving up his time after school

Bevis Leong &Chongman Leong

We are grateful for your instruction and the time you two spent to teach us.

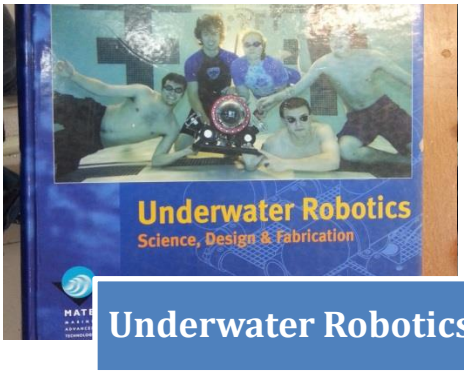
Our families

Thanks for the support from the spirit.

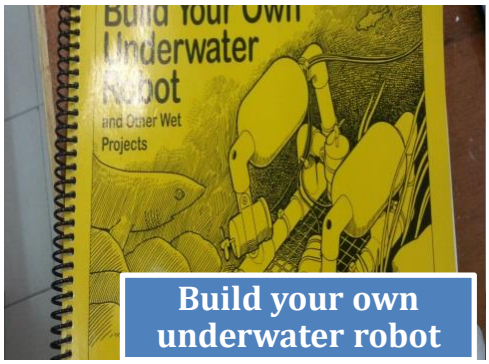
References

Build your own underwater robot

Underwater Robotics



Underwater Robotics



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http://zh.wikipedia.org/zh-hk/

http://en.wikipedia.org/wiki/Main_Page

http://www.marinetech.org/rov_competition/report_examples.php

http://www.iciba.com/

http://www.kejiyingyu.com/

http://keith.martin.home.att.net/Kilauea.html