香港科技大學
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

SENG 工學院 SCHOOL OF ENGINEERING

HKUST ROBOTICS POSEIDON R.O.V. TEAM 2012

HONG KONG

TECHNICAL REPORT 2012

Boost Creativity

Innovate The Future

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HKUST Robotics A Young Talented Team HONG KONG

01 ABSTRACT

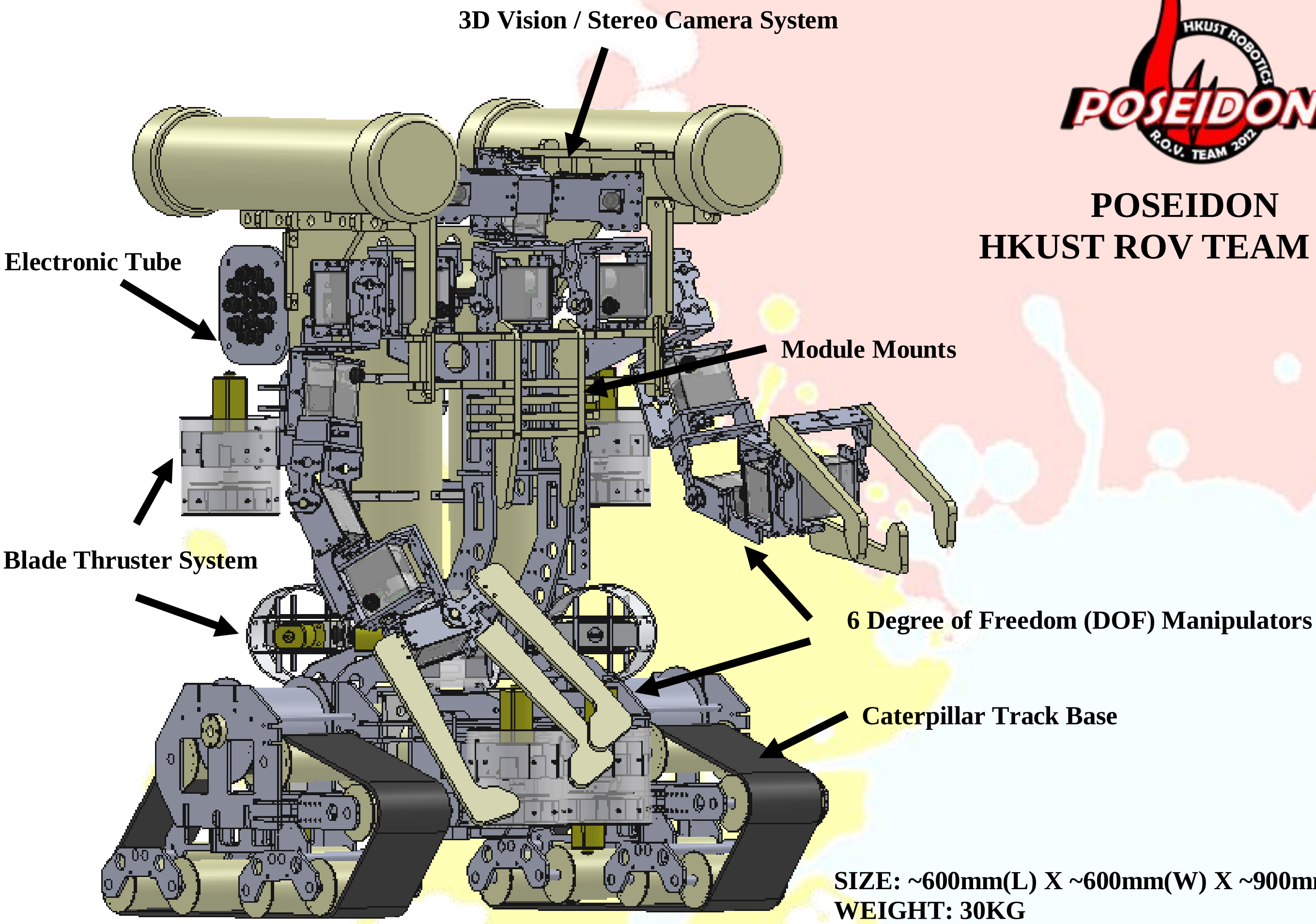
Turing imaginations into reality...

This year the MATE Center requires a Remotely Operated Vehicle (ROV) that would be capable of inspecting an oil tanker, the *SS Gardner*, which sank on December 25, 1942 off the coast of Florida with 5 million gallons of fuel. Poseidon Inc. has taken into consideration the specialized tasks required for this mission and we have come up with a truly remarkable solution. The Poseidon ROV is one of a kind humanoid ROV, equipped with two 6 degree of freedom (DOF) arms, stereo vision, 9 DOF ROV sensor tracking, caterpillar track wheels, customized electronics , powered by the Cortex-M4 processor.

From the experience of last year Modular-Based ROV, “GEAR”, the structure of the Poseidon is made from aluminum and plastic, ensuring durability underwater and highly modular-based. Poseidon is equipped with an ultrasonic thickness gauge, a neutron backscatter device, drills, sonar, a lift-bag, a sampling pump system, a metal detector and a magnetic patch, all specialized tools constructed for this specific mission. Featuring to provide “Avatar” style controlling, Poseidon coupled with our additional natural gestured based telemetry suit and 3D head mounted display with head tracking to mimic the operator’s motion.

Our twenty member team designed and built this ROV to complete the mission tasks specified by the MATE Center. We look forward to utilizing Poseidon for future missions, rendering our services and state-of-the-art ROV to potential clients.

POSEIDON
HKUST ROV TEAM 2012



SIZE: ~600mm(L) X ~600mm(W) X ~900mm(H)
WEIGHT: 30KG

Fig. 1 Solidworks 3D CAD Design of Poseidon

CONTENT

02 INTRODUCTION

This is the second year that the HKUST ROV team is taking part in the MATE ROV Competition. We built a wealth of experience from the competition last year where we won the Design Elegance Award at the MATE ROV Competition 2011. This year, our twenty member team at Poseidon has brought a refreshing new design into the field of ROVs. Our imaginative design hopes to merge the boundaries of creativity and technical skill, while functioning to perform the mission tasks.

This year we have created a humanoid ROV, complete with caterpillar tracks, offering traction as it moves along the seabed while also providing the option of amphibious usage. Poseidon also comes with a telemetry suit, 3D vision and head tracking, which help the ROV mimic the pilot's motion.

03 DESIGN RATIONALE

During last year's competition at NASA, we saw an atmospheric diving suit at the competition venue being put on display (Refer to Fig.2). We were inspired by this suit, and thought to ourselves,

"What if we could build something similar?"

However, instead of a human inside we would have a robot. The whole premise for having a robot instead of a human would be that it would eliminate the risk posed to deep sea divers and providing flexible ROV settings.

Having grown up seeing animated characters such as "Wall-E" and "Space Tank Gundam", our design for Poseidon was inspired by these characters. The caterpillar track system would allow the ROV to move along the pool floor and be allowed to be used amphibiously. The design philosophy for Poseidon is:

Fig. 2 Atmospheric diving suit seen at 10th International Mate ROV Competition at NASA, 2011

TO PROVIDE AN INTUITIVE CONTROL SYSTEM FOR THE DRIVER

AND

TO PROVIDE GREATER FLEXIBILITY IN MOTION FOR THE ROV, MIMICKING NATURAL HUMAN MOTION, THROUGH THE FUSION OF CREATIVITY AND TECHNICAL PROWESS.

Fig. 3 Wall E and Gun Tank in the Cartoon – Our inspiration for Poseidon

04 BUDGET / EXPENSE

At this session, the budget control of the Poseidon ROV Project would be discovered. The total cost of the Poseidon ROV including the spare parts is ~USD$8300.

Item No.	Item Name	Quantity	Unit Price(RMB)	Unit Price(HKD)	Total Price(RMB)	Total Price(HKD)
1	HN38-60 12V 600pulse/min Encoder	2	68.00		136.00	
2	9 Axis IMU Sensor	2	155.00		310.00	
3	Saitek Cyborg V1/V.1 Flying Controller	3	150.00		450.00	
4	MD3003B1 Matel Detector	2	38.00		76.00	
5	9 Axis IMU Sensor	4	155.00		620.00	
6	MD-200 Metal Detector	1	53.00		53.00	
	ESH-10 Metal Detector	4	85.00		340.00	
7	Polyethylene terephthalate Cable Net 12mm diammeter	100	2.50		250.00	
8	10mm diammeter Air tube	1	25.00		25.00	
9	6.4mm diammeter sumitube	60	2.00		120.00	
	9.5mm diammeter sumitube	50	2.80		140.00	
	Polyethylene terephthalate Cable Net 6mm diammeter	100	1.45		145.00	
10	10mm diammeter Air tube	1	27.00		27.00	
11	9 Axis IMU Sensor	4	145.00		580.00	
12	Waterproof Header 3pin/7pin/9pin	140	10.00		1,400.00	
	Waterproof Connector 3pin/7pin/9pin	90	10.00		900.00	
13	9 Axis IMU Sensor	2	139.00		278.00	
14	Water Buoyancy Bat	6	16.50		99.00	
15	Cabling Connector 3pin/5pin/6pin/8pin	80	1.30		104.00	
16	0.5*3mm carbon fiber strip	15	2.50		37.50	
17	6m^2 diameter Cable notation tube	16	1.50		24.00	
18	Waterproof Header 3pin/7pin/9pin	143	10.00		1,430.00	
	Waterproof Connector 3pin/7pin/9pin	125	10.00		1,250.00	
19	SM S8166M 6V 33KG Servo Motor	20	125.00		2,500.00	
20	U1D	500	0.40		705.00	
21	STM32F407VG (MCU)	2	60.00		120.00	
	FR3710Z T0-252 (MOSFET)	300	3.00		900.00	
22	Logitech HD Webcam C270	11		180.00		1,980.00
23	HN38-60 12V 600pulse/min Encoder	10	70.00		700.00	
24	STM32F4 Discovery Board	2	135.00		270.00	
25	BUFFALO WCR-GN WIRELESS N150 ROUTER	2		139.00		278.00
26	HV MP800 MOUPAD x4	4				60.00
	Camera belt	1		138.00		138.00
27	HF-N-24/VC 36Wx61Dx25Hmm Plastic Case	9		45.00		45.00
	W1B 3X0.75qmm Power Cable(Black) 10pin	60		5.00		300.00
	2.54mm 20pin IDC connector	8		2.00		16.00
	SGE VR1-6 Power Cable Connector	20		2.40		24.00
28	CAT-5E Cable	80		7.00		560.00
29	STM32F407VGT6 PCB Board	10	23.00		230.00	
30	Air Pressure Connector(MECH.)	10		28.00		280.00
	USB2.0 Hubs	2		68.00		136.00
31	PWM Signal PCB Board V2	10	18.80		188.00	
32	PVC Pipe(Grey) (Mech.)	2		6.00		12.00
	Water Pump(Mech.)	1		280.00		280.00
	PVC Connector(White) (Mech.) (for making the ship)	1		46.00		46.00
33	10K Veriable resistor	50	2.20		160.00	
	Cable Tape	10		8.50		85.00
	Cable Tie	4		5.75		23.00
	PVC Pipe & Valve(Mech.)	20		13.50		270.00
34	Water Pipe(Mech.)	12		1.00		12.00
	Air Pump Connector(Mech.)	1		15.00		15.00
	1000uF/25V Cap	150	1.50		225.00	
	220uF/100V Cap	125	3.00		375.00	
35	9001A+B EPOXY RESIN+HARDENER(water proofinsul	3	70.00		210.00	
36	Electronic Tub O-Ring	4	50.00		200.00	
37	AB Glue	7		28.00		481.60
38	Power Cable	150		25.33		3,800.00
39	Servo Signal PCB Board(A)	10	20.00		1,040.00	
40	LM2576-HV	50	3		150	
	Aluminium Structure Cost					35,000.00
					16,887.50	43,842.60
	Total Cost in USD					8,240.00

Table. 1 Budget Spending Sheet of Poseidon ROV Project

05 DESIGN PROCESS

Gantt Chart and the design routine method has been adopted in order to provide on-schedule and creativity project management respectively. Good time management and co-operation within the multi-discipline team has been achieved .

5.1 Gantt Chart

We can see from the Gantt chart the design and development process for Poseidon. Initial brain-storming and designs were done in January. The designs were then finalized during the first week of February, after which construction of the ROV began. The time taken to build the various systems and the testing carried out on them is highlighted by the Gantt chart (refer Appendix).

5.2 Design Routine

A draft is firstly drawn by hands in order to illustrate the design concept. After evaluating feasibility and risk assessment including the safety issue., 3D CAD designs would be made and then manufactured.

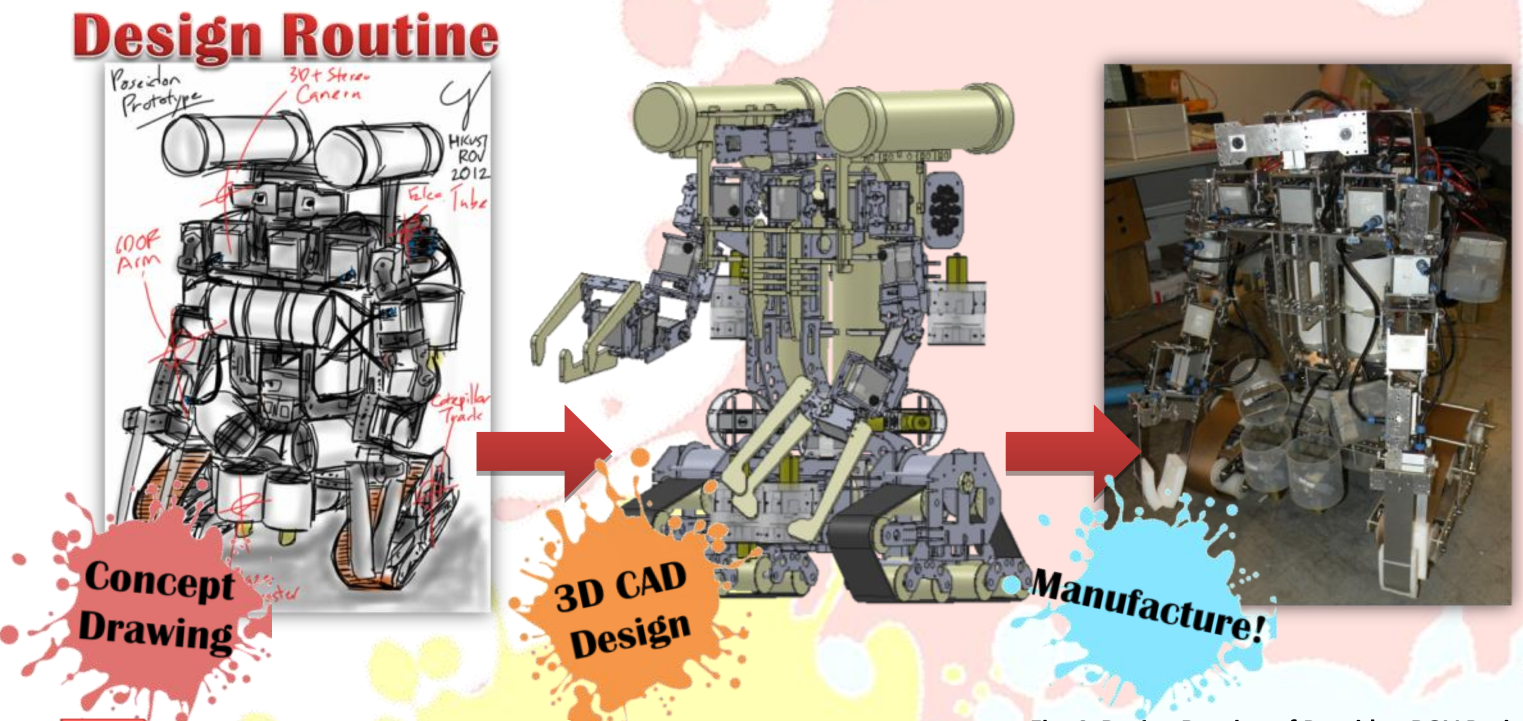


Fig. 4 Design Routine of Poseidon ROV Project

06 MISSION SPECIFIC ROV

The following sections will detail how the ROV was designed with respect to each of the mission tasks being taken into consideration.

6.1 TASK 1. Survey the wreck site

6.1.1 Measure the length of the wreck

At the brain-storming stage, we came up with three different ideas to measure the wreck of the ship. The following is a discussion of the various ideas and their merits.

Idea 1: Using Ultra-sonic Sensors
Idea 2: Using Measure Tape
Idea 3: Using Stereoscopic Camera

IDEA 1: Ultrasonic Sensor

This idea made use of two underwater ultrasonic sensors mounted on servo motors to measure the distance between the ROV and the ship’s bow and stern, along with the separation between the two sensors. This would allow for the formation of a triangle with the vertices located at the stern, bow, and the ROV, which can then be used to calculate the length of the shipwreck via trigonometry. However, the solution was considered unsuitable as the shipwreck was not a solid structure, hollow at most places. Attempting to focus the beams produced from the sensors to exactly coincide with the position of the PVC pipes would take the pilot a considerable amount of time.

Fig. 5 Ultrasonic Sensor in the market

IDEA 2: Measuring Tape

The second proposition was to attach a measuring tape to the manipulator of the ROV. The ROV would then be maneuvered to hook one end of the tape to the PVC pipe at the stern, and then move towards the bow where the measurement can be read off using the camera. The problem with this idea was it being very crude, unreliable because of the tension of the tape, and prone to parallax errors, potentially causing very inaccurate readings.

Fig. 6 Measuring Tape

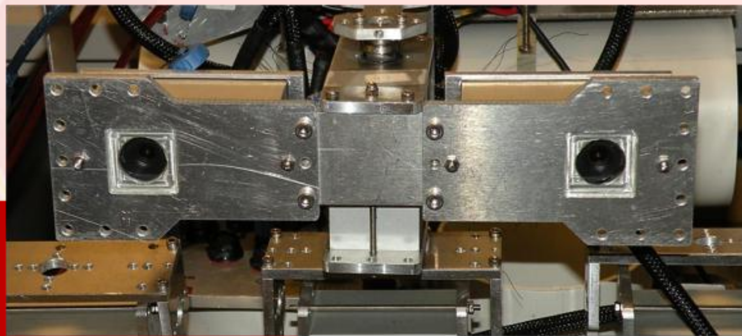


Fig. 7 Stereo Camera install on Poseidon

ADOPTED IDEA

IDEA 3: Stereoscopic Camera

The final proposition uses the image of the shipwreck captured by the two separate cameras installed on the ROV, building on the first idea of using trigonometry from detected sensor readings to assess the length of the ship. The image feed provided by the two separate cameras is used in the trigonometric calculations instead. Refer to the principle shown in figure 8, the computer will then process images feed from the stereo cameras and calculate the length of the wreck using trigonometric rules.

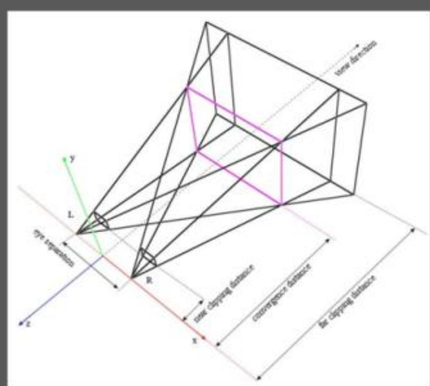


Fig. 8 Principle of measuring length by using stereoscopic vision

6.1.2 Determining the orientation of the ship on the sea floor

To determine the orientation of the ship on the seafloor, the procedure is to move the ROV towards the ship. Once the ROV is placed in position, in alignment with the orientation of the ship, the readings obtained from the 9DOF digital sensor, which is mounted on the ROV, are obtained. One of the readings, Yaw, provides the orientation of the ROV which is associated with the orientation of the ship. Besides, the ROV becomes more stable with feedback all readings to the main board controller. A measurable internal variable signal was feedback to compensate flow, so that the lading system tracked position system without delay. The measurable digital readings of the sensor are feedback to main board, so the tracked position of ROV is improved.

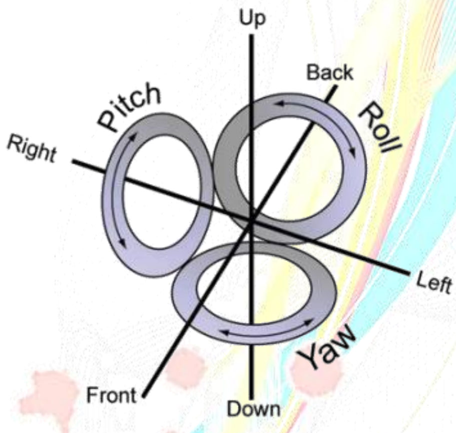


Fig. 9 Signal Readings of the 9DOF Sensor

	COMPASS	9DOF Sensor
Signal Information	One Plane	Three Planes
Cost	~USD $ 5	~USD $ 20
Advantage	Easy to install	Stabilized System

Table. 2 Comparison of compass and 9DOF

6.1.3 Creating a map of the wreck site

The information from the 9DOF digital sensor, the stereoscopic cameras and the other cameras installed on the machine for providing different angle views will all be used to create a map of the wreck site.

6.1.4 Determining if debris piles are metal or non-metal

To determine if objects are metal or non-metal a commercial handheld security clearance metal detector was modified and placed in a customized housing within the ROV. The circuitry inside the metal detector was then integrated with the existing circuitry of the ROV. Also, magnetic bars are also installed on the machine to act as a fail-safe device.

Fig. 10 Modified Metal Detector

6.1.5 Scanning the shipwreck with sonar

According to the MATE rules, we are required to shine a high intensity light onto three target areas. To accomplish this, the ROV is fitted with LED lights which can be switched on and off by the driver. The LED lights will be shined on the target areas and the video feed will be obtained using the stereo cameras.

6.2 TASK 2. Removing fuel oil from the shipwreck

6.2.1 Transporting and attaching a lift bag to a fallen mast

The lift bag will be transported and attached to the fallen mast using the 6 degree of freedom (DOF) arms. Details of the 6DOF arm will be described in the subsequent sections. A commercial lift bag has been adopted for stability and modulation.

Fig. 11 Commercial Lift Bag

6.2.2 Inflating the lift bag and removing the fallen mast from the worksite

A commercially available lift bag will be used by our ROV. Experiment has been conducted and the suitable size lift bag has been adopted. The lift bag will be inflated using an electric pump attached to the ROV. Once the lift bag, lifts the fallen mast, the ROV will move it from the worksite to the designated area using the 6DOF arms.

6.2.3 Removing endangered encrusting coral from the ship's hull

To remove the endangered encrusting coral from the ship's hull we designed two 6DOF arms, with 180 degree motion. These arms could be used for the other mission tasks and so would reduce redundant payload tools. The coral would be removed using the grabbers at the end of the arm. The grabbers are fitted with anti-slip grooves to enable them to firmly grip onto the coral.

Fig. 12 6DOF Water-Proof Servo Arm

6.2.4 Transplanting the coral

The coral will be transplanted using the 6DOF arms. The arms will hold onto the coral as the ROV moves itself to the designated area to place the coral.

6.2.5 Using two simulated sensors, determine if fuel oil remains inside the fuel tank

A rod designed according to the dimensions specified by the MATE Center in the mission document, is used as the two simulated sensors. The ROV will place the ultrasonic thickness gauge using the 6DOF arms so that it touches the black ABS sheet found on the hull. Once this is completed the ROV will then move onto the calibration tank. The neutron backscatter device is then placed so that it touches the calibration tank using the 6DOF arms. Using these two sensors the presence of fuel oil in the fuel tank will be determined.

6.2.6 Simulating drilling two holes into the hull and underlying fuel tank penetrating a layer of petroleum jelly

The layer of petroleum jelly will be penetrated by using an aluminum rod. The aluminum rod will be held by the ROV using its arms. The ROV will poke the petroleum jelly using this aluminum rod.

6.2.7 Removing fuel oil from within the tank and replacing it with simulated seawater

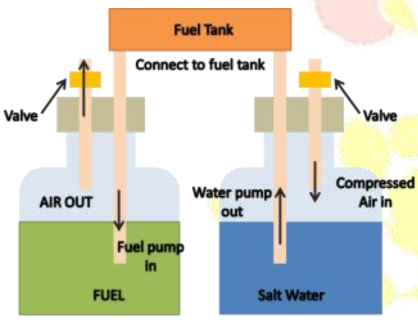


Fig. 13 Principle of fuel collector

In order to save the operating time, we aim to design the tool for removing the fuel and replacing the water simultaneously. The structure of the tools, which is shown in Fig. 13, consists of two collectors. The collectors are sealed together and control by the compressed air via the valve. PVC pipes will be fitted to the bottles, and the pipes will be connected using a valve. An air compressor would be fitted to one of the bottles via a valve, and the bottles will be filled with water. As the air compressor is switched on, the water will flow out and push the fuel simultaneously. The fuel will then flow into one of the out-flow pipes and then to the dump tank.

Another opinion would be installing the last year water sample collector on the machine. The water sample onboard has 1.3L volume and suitable for this mission.

6.2.8 Resealing the drill holes with a simulated magnetic patch

The design for the magnetic patch was inspired by magnetic door locks. The magnetic patch uses an electromagnet which is triggered using an electronic signal. This allows the patch to be precisely triggered. The magnetic patch will be placed onto the drill holes using the 6DOF arm.

07 FEATURING SYSTEM

In this session, the featuring unique system of Poseidon ROV will be introduced. This year, Poseidon have researched in different fields and brought to you the state-of-art technology.

7.1 Mechanical Frame

When East meet West
--Using Halved Joint with Aluminum Frame

The mechanical structure resembles a humanoid with arms, a head (stereoscopic cameras for eyes) and caterpillar tracks for ground propulsion. The ROV is constructed from PVC, aluminum, and plastic. The aluminum was machined and made into units for easy integration to form the final structure.

Fig. 14 Frame Concept Design

Halved joint is a woodworking joint in which the two members are joined by removing material from each at the point of intersection so that they overlap. The halved joint is differentiated from the lap joint in that the members are joined on edge, rather than on the

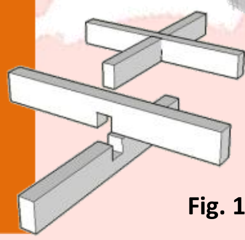


Fig. 15 Simple halved Joint

7.2 Blade Thruster System

New Generation
--Faster, Lighter and more Powerful

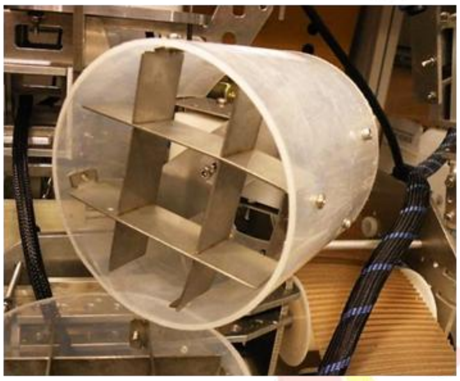


Fig. 16 New Generation Blade Thruster

This year we have decided to use the locally manufactured motors. We found them to be much more powerful and 30% lighter compared to the DME44BB thrusters used last year. Each unit provides about 0.7kg of thrust when operating at 5V and about 1.5kg of thrust at 12V, as opposed to the DME44BB model which only provided about 0.8kg of thrust at 12V.

The thruster system consists of stainless steel propeller blades, designed and manufactured by our team members. The blades are housed in a plastic tube and have a protective grid on top for the propellers. The thrusters are powered by gold motors, which are not oxidized inside water, while providing a high acceleration and torque.

The thrusters are controlled using motor drivers manufactured by our team members. The motor drivers are small in size, which make it is easy to fit them inside the electronic tube. They are controlled using PWM signals, consist of fuses and are operational at up to 48V.

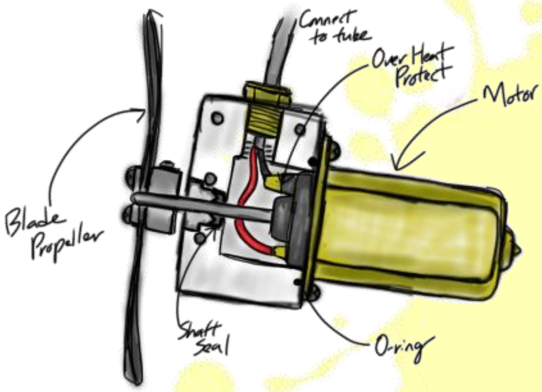


Fig. 17 Concept Art of the Blade Thruster

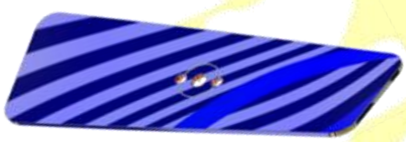


Fig. 18 Blade Propeller Simulation

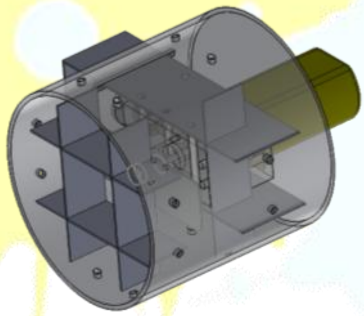


Fig. 19 3D CAD Design of the Thruster

Fig. 20 Self-developed Motor Drivers

7.3 Modular Water-proof Servo System

Modular Based
--Easy to assemble different manipulators

The servo system is a sub-block that was designed and manufactured by our members, so that we can easily link them up with screws and rapidly form and prototype a complete movable structure like 3DOF arm or 6DOF arm. The servo is housed in a waterproof casing and consists of connectors so that we can link the servos to other parts.

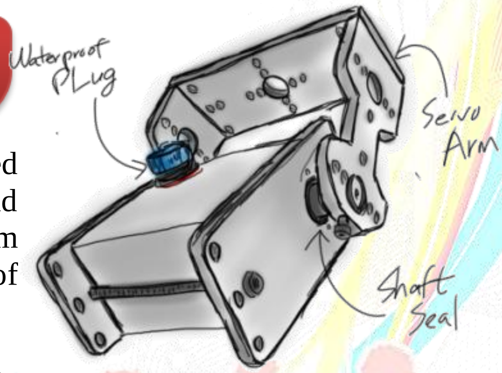


Fig. 21 Concept Art of the Servo Unit

For the servos we have used the SM-S8166M gear box, which provide torque at 30kg-cm and response time in 0.21 second .

4.8V		6V	
Response Time	TORQUE	Response Time	TORQUE
second	Kg-cm	second	Kg-cm
0.25	30.0	0.21	33.0

Table 3: Servo Unit Specification

Fig. 22 Manipulator assembled by the servo unit

7.4 Electronic Tube

Easy Installation
--Changes can be done in a short time

The electronic tube consists of a cylindrical plastic tube screwed in from the sides by two aluminum plates. The electronic tube is where all the electronic boards for the ROV are housed in. The plates are lined with O-rings and are clamped against the tube using screws, thereby providing waterproofing. Additional testing has been conducted by using the pressurized tube. In order to achieve high quality standard, all the equipments including the electronic tube has been put inside the pressurized tube to simulate the water pressure environment in 10 meters depth.

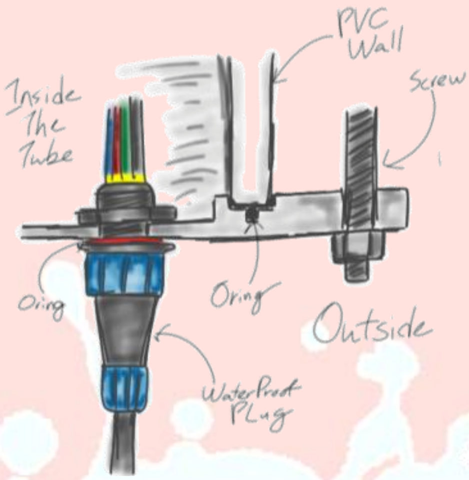


Fig. 23 Concept Art about the principle of the water proof tube

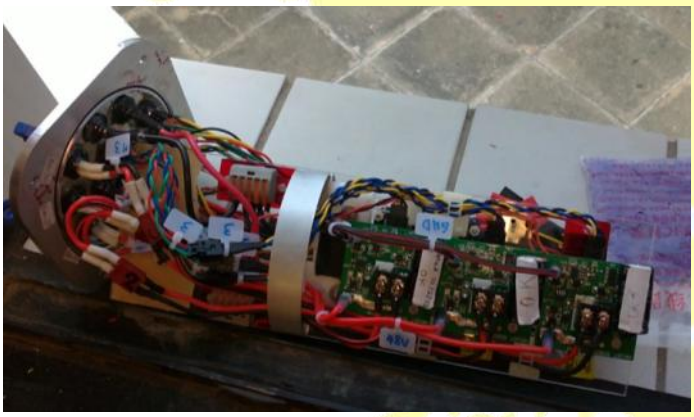


Fig. 24 Electronics installed and can be easily replaced

Fig. 25 3D CAD Design

7.5 Overall Electronic System

Modular Design
--Simple, Elegance, Multi-functional and Safe

In this session, the overall electronic system diagram will be introduced. Our system consists of multiple fuses and all electronic boards are designed and manufactured by our team members. Detailed schematic designs would be given in appendix.

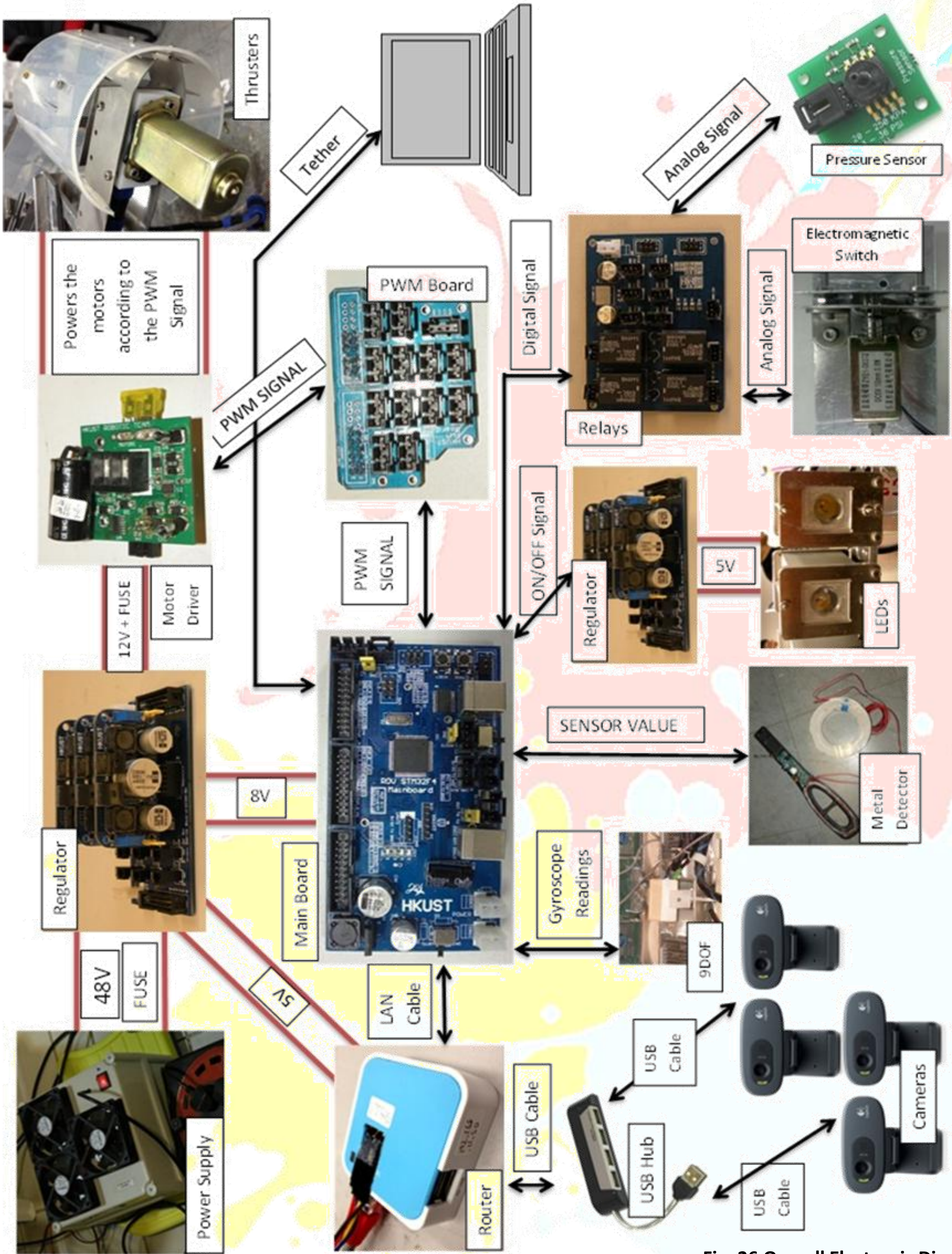


Fig. 26 Overall Electronic Diagram

7.6 Cortex-M4 Main Board

High Computational Power
--fast and reliable electronic system

The main board has been designed by our team members. We designed a new main board, because commercial main boards are not met our requirements. The new main board consumes less space, so that it can fit easily inside the electronic tube. The computational requirements of this year's ROV system made us choose the faster STM32F4 Cortex-M4 processor for the main board, over last year's ATMEGA UC3.

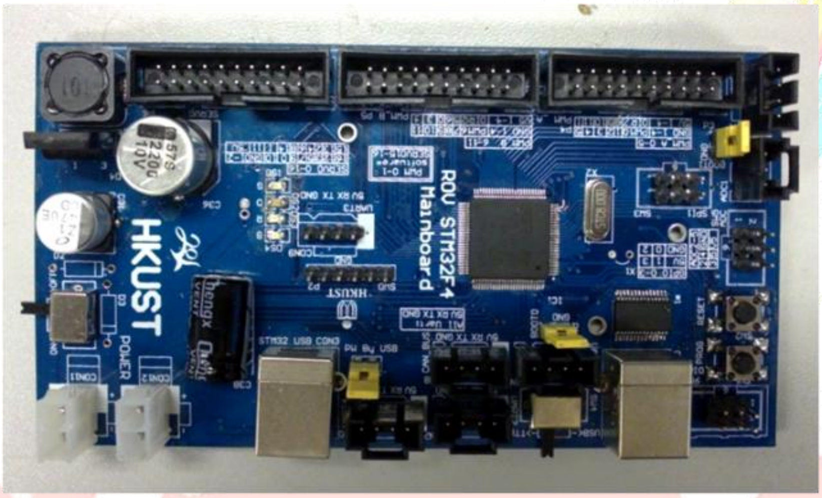


Fig. 27 Cortex-M4 Main board

7.7 Telemetry Suit

Mimic Human Hand Motion
--Creative Avatar Style Control System

The arms of Poseidon are used to grab and place items, such as coral or the magnetic patch. The arms mimic a human arm, providing greater flexibility and ease of control for the driver. The arm is made from servo units and has 6DOF. At the end of the arm grippers have been placed to enable it to grab items.

To control Poseidon we designed a telemetry suit for additional movement control. The ROV driver wears the suit and the ROV mimics the driver's hand motion. Joysticks are placed at the end of the telemetry suit so that the driver can control the grippers of the ROV arm. The telemetry suit is lined with encoders at the joints to take in readings of the driver's motion. The gathered signals are then passed onto the main board so that the ROV arms can mimic the operator's hand motion.

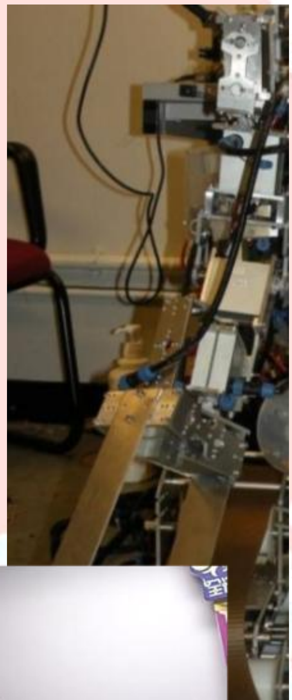


Fig. 28 6DOF ARM

Fig. 29 Concept Art of Telemetry Suit

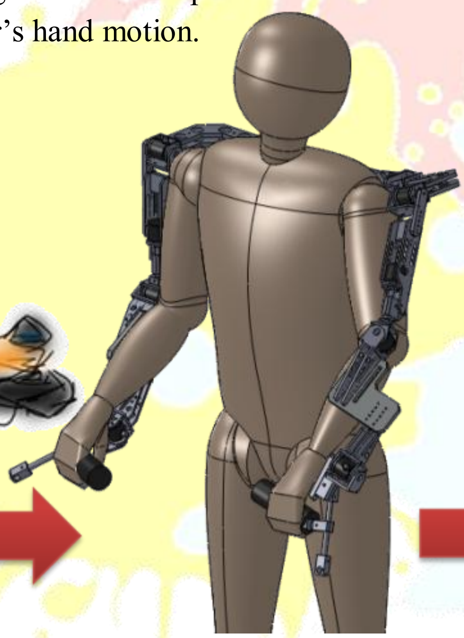


Fig. 30 3D CAD Design

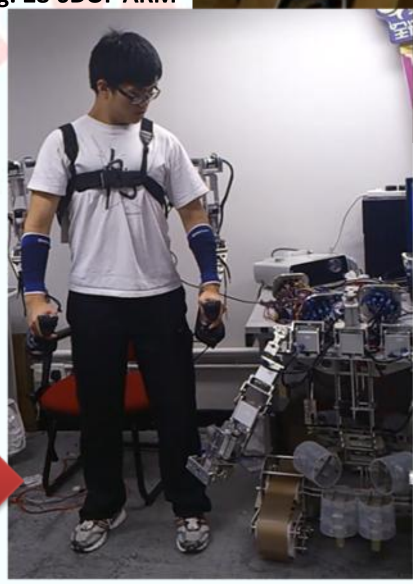


Fig. 31 Mimic Motion Tuning in the Lab

7.8 Caterpillar Track System

All Terrain Design
--Working underwater and also on LAND!

We want our ROV to be able to move to different locations swiftly. Since most of the missions require the ROV to be near the bottom of the pool, we thought of descending the ROV to the pool floor and then making it move to different mission locations. To enable this, we designed and implemented a caterpillar track system at the bottom of the ROV, so that it could move along the pool floor. The caterpillar track is made from rubber and allows the ROV to firmly grip the pool floor while navigating along it.

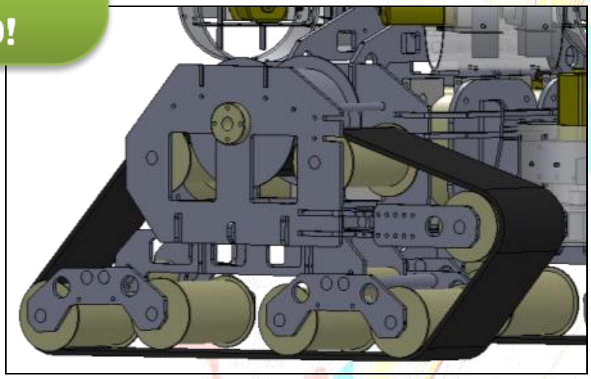


Fig. 32 3D CAD Design of Caterpillar Track System

7.9 TCP/IP to UART Conversion System

TCP/IP Protocol
--Long Range and Highly Reliable Transfer

For the computer to communicate with the ROV's main board we implemented a router system. This reduces the tether size, and enables long distance communication, with low signal attenuation. The router was programmed in OpenWRT and converts TCP/IP signals to and from the computer to UART signal to and from the main board.

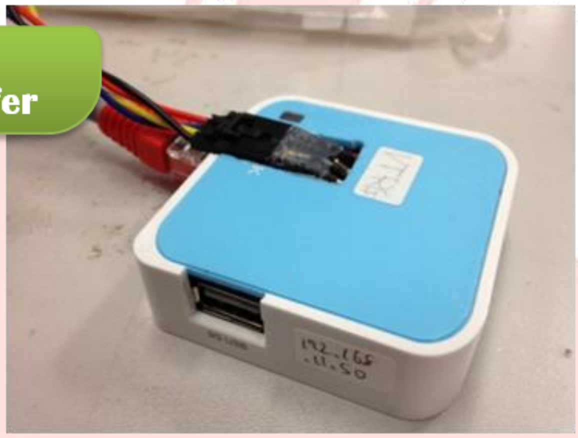


Fig. 33 TCP/IP to UART Conversion System

Fig. 34 Computer User Interface

7.10 Computer User Interface

Customizable Interface
--Easy tuning and adding new functions

The computer user interface consists of two screens. One screen displays the visual feed from the stereo cameras which is used for the 3D vision system. The other screen displays the visual feed from the four cameras, sensor and encoder readings, and displays the orientation of the ROV obtained from the 9DOF system.

7.11 9DOF (Degree of Freedom) System

Acceleration, Angle, Magnetic Field
--Get readings from different aspects

For the 9DOF system we placed a 9DOF sensor in the ROV. The 9DOF sensor takes 3 sets of sensor readings:

3 axis gyroscopic readings
3 axis accelerometer readings, from 3 accelerometers
3 axis magnetic sensor readings, from 3 magnetic sensors

The computer then obtains these readings from the 9DOF sensor via the router and main board. The readings are then displayed graphically on the user interface as yaw, pitch and roll.

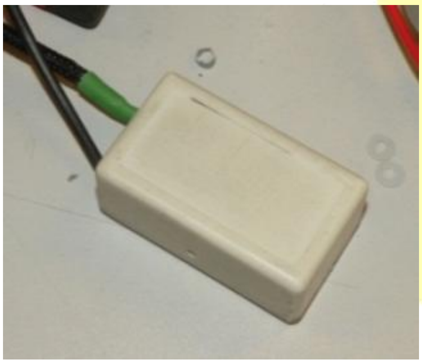


Fig. 34 Computer User Interface

7.12 Stereo Vision System

Two Cameras
--As same as the human eyes principle

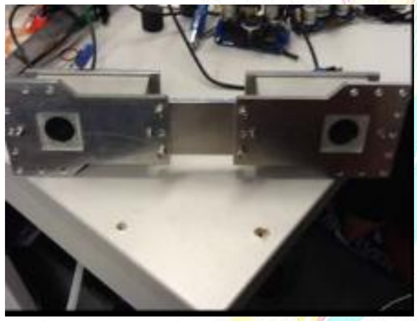


Fig. 35 Stereo Camera install on Poseidon

One of the additional features is providing the driver with the perception of depth when controlling the ROV via stereo vision system. This allows the driver to control the ROV more easily when performing the mission tasks, such as grabbing and placing items. The 3D vision system gets the video feed from the stereo cameras placed at the head of the ROV. For the stereo cameras we use two Logitech webcams placed side by side.

The camera feeds are sent over the router to the computer. The computer then converts these feeds into a 3D format which can be displayed on the head mounted display (HMD). For the HMD we use the Vuzix iWear VR920, which uses fame sequential stereoscopy.

Fig. 36 Vuzix iWear VR920

7.13 Tether

Thin Tether
--Flexible and multi-functional

The reduction in size of the tether is mainly due to the implementation of the Router System which uses only one signal cable (LAN cable) for the ROV. The other two cables are for the positive and negative power rails for the power supply. The total diameter of the tether is around 12mm.

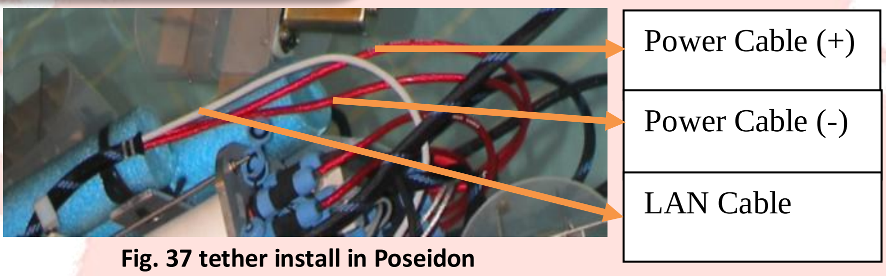


Fig. 37 tether install in Poseidon

7.14 Overall Software System

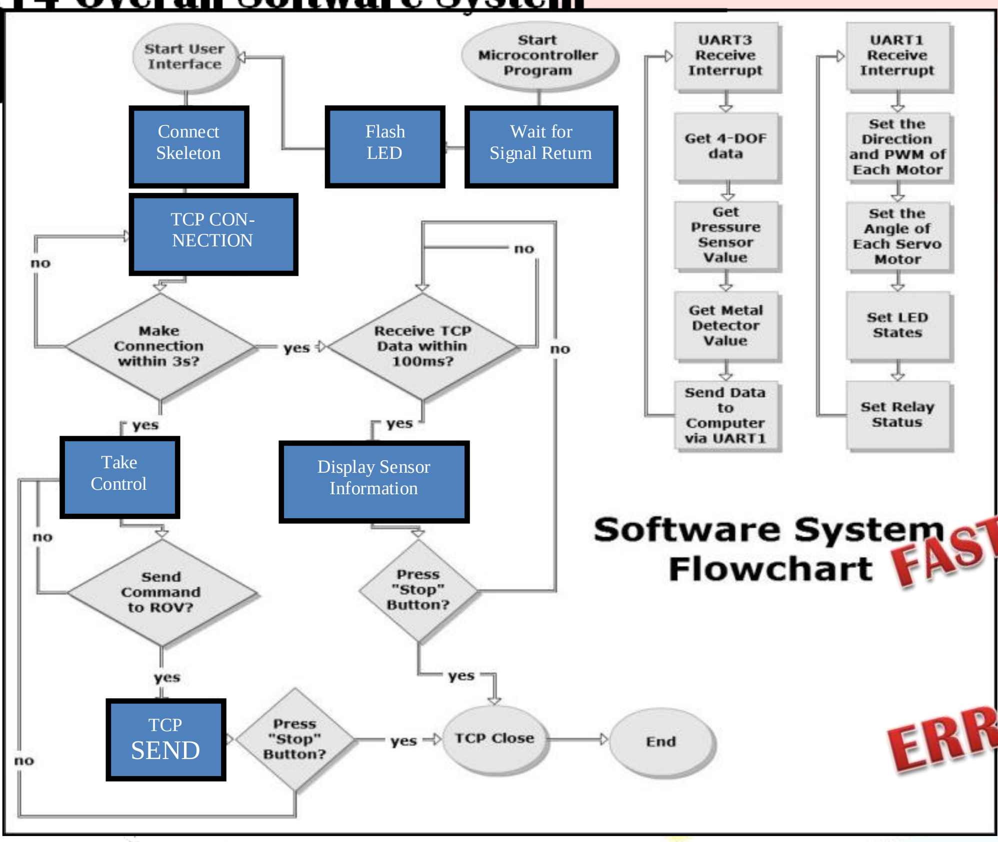


Fig. 38 Overall Software Flowchart

FAST RESPONSE TIME

ERROR HANDLING

08 SAFETY FEATURES

Out team took a great consideration when designing the safety features, as this is a very important aspect of any ROV design. Safety features were considered right from the design stage of the ROV.

Some of the safety features for Poseidon include fuses in every circuit board and labeling of wires and caution signs for dangerous zones in the ROV (high voltage wires and propellers). The propeller blades for the ROV have a protective grid to prevent objects from being sliced by the blades.

A set of protocols are observed whenever the ROV is activated. The power is first checked and then individual systems are checked for satisfactory operation and are then turned on, after which, upon positive feedback the whole system will be maneuvered. We took the **ISO 13482** *(ISO Standard for Robots and Robotic Devices-Safety Requirements for non-industrial Robots & non-medical personal care robot)* standard as a guideline while designing our ROV. Risk assessments have taken through the whole design process and user-oriented designs has adopted in order to provide safety and useful products.

09 CHALLENGES

9.1 System Integration and Quality Control

Some of the challenges we faced were making the system modularized and being able to integrate and fit all these components together into the final ROV. These problems were faced in both mechanical, software and hardware aspects. We were able to overcome these challenges through communication with each other and testing the systems during integration. Team members responsible for each of the integrated parts worked together to test the systems being integrated to troubleshoot and debug the problems. Quality Control is one of the important issues in the integration. As the system is highly modularized, every sub system have been tested in pressurized environment to ensure good quality. Also, documentations about the installation of different modules have been made.

Fig. 39 Using the self-made pressurized tube to test the modules

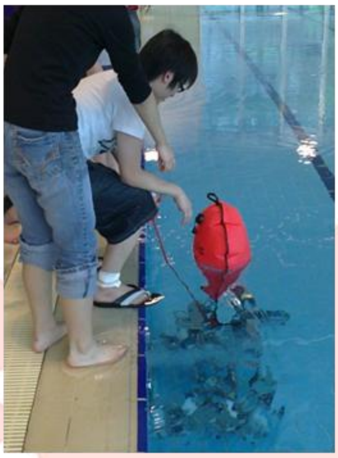
9.2 Technology and Experience Transfer

Since most of our team members are new to ROV, we need to set up training programs for training and technology transfer. We would like to give basic technically backgrounds and train up the skills for new members. Sub team presentations, ice-breaking events, exhibitions in the public are the tasks given to the new members. Through these events and trainings, our members can gain experience of the ROV technically skills, team members can also improve their presentation skills and describe how the robot works in laymen's term. We can also promote ROV information and ocean technology to the public.

Fig. 40 Exhibition in the public and presentation to the guests

10 TROUBLESHOOTING

Each component in the ROV was individually tested, and once the systems were integrated, the overall system was tested. For example when the ROV wasn't moving doing the initial tests, we were able to isolate the problem to the thruster system. First the electronics for each individual thruster, such as the motor driver boards, the main board and connecting cables were checked. After this the software for each of the thrusters was tested, making sure the correct signals was being sent to each of the thrusters. Once these were done, and we were able to ensure that all the thrusters were working, the whole ROV was placed into the swimming pool, and the ROV was then controlled by the pilot to make sure it could move properly.



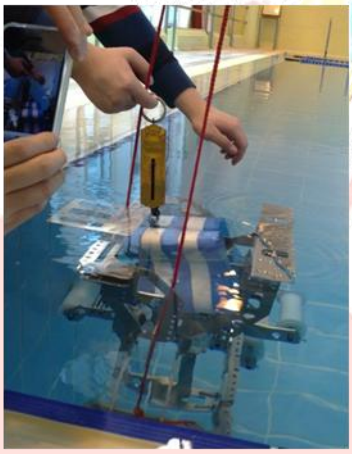


Fig. 41, 42 & 43 Testing in the swimming pool

11 FUTURE IMPROVEMENT

Future improvements for our ROV include adding a wider range of modules to the system so that it can perform a variety of tasks. In addition, we would like to have additional sensors on the ROV, so that the ROV could gather more data about it surroundings.

In addition, we plan to make our ROV operable over long distances. We have already implemented certain features for this system and hope to deploy and test this feature following the international competition. Therefore, for example, the pilot could be stationed in Tokyo, while manning the ROV located in a hazardous environment, miles away in another city.

We would also like to introduce "Indicator" into our electronic tube in our future plan. Indicators are set in different modules and electronic tubes. Indicator will be used to monitor the environment of the tube such as humidity, temperature and water proof condition. Instead of dissemble the modules to check for the errors from time to time, the indicators installed would let our maintenance team know when the modules need repair or change.

Fig. 44 Concept of Internet Control Design

12 LESSONS LEARNED

There were many lessons learned through the design and construction of the ROV. This was the first time our team member ever designed and implemented a humanoid-based ROV. We learned new techniques of human-computer interaction. We learnt about 9DOF digital sensor and 6DOF arm systems, the theory behind them, and how they could be used to control and manipulate objects.

In addition, our team member learned the importance of water-proofing techniques. Since we employed a new design with four electronic tubes, we have to take extra caution in performing the water-proofing for them. We included servos in our ROV therefore we needed to learn how to waterproof servos. Since our ROV uses numerous cameras, sensors, motors, and servos, we needed to pay particular attention to the power distribution within the ROV, in doing so our members learned and gained experience in designing voltage regulators and implementing them in the overall system. Due to the use of stereo cameras and the use of parallax to gauge the length of the shipwreck, our members learned about image processing, computer vision and stereoscopic imagery. They learned how to generated stereoscopic images, how to process them, to determine the length of objects in the image.

Furthermore, we learned valuable life skills through the process. We learned effective time management, working on the ROV, working towards deadlines, while managing our studies at the same time. We learned how to collaborate with team members from different disciplines, working together on integrating systems and subsystems to develop the complete ROV system. We used various online collaboration and communication tools, maintained a list of contacts and had regular meetings to discuss the progress of our work. This experience trained us to work together efficiently as a team to achieve something much greater than what each of us could have achieved individually.

13 REFLECTION

We were able to design and build a humanoid based ROV. This is definitely a first for the HKUST ROV team. We were able to turn our creative and imaginative ideas into reality. Through working on this project we were able to accomplish something amazing by working together as a team. Through the process, we were able to implement 3D vision systems, 9DOF digital sensor, 6DOF arm systems and a telemetry suit.

Through these achievements we learned about the theories of these systems while improving our soft skills, such as time management and teamwork.

We have an international team with members from Hong Kong, Indonesia, Malaysia and Sri Lanka. We had to overcome our language barriers and understand different cultures so that we could communicate better and have better teamwork. Since we have a large team, coordination among the team members is essential. We were able to overcome this challenge by having team meetings, using online collaboration and communication tools such as Dropbox, Facebook, Gmail and Google Docs, to share ideas and working tasks. Logbooks, Draft sketch books have been kept for review. We also made good friends with our team members and formed connections across cultures from different countries. We learnt about each other's cultures, traditions and languages giving our team members an international outlook.

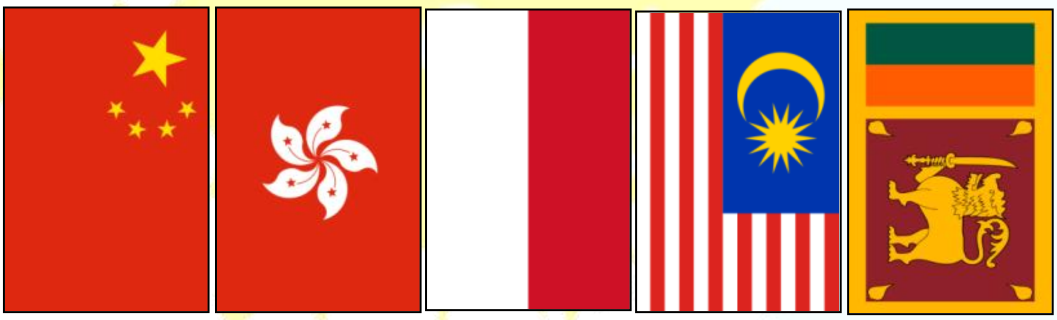


Fig. 45 Members are from different cities and countries

14 CONCLUSION

To conclude, we have achieved this year goal— " Turning Science Friction into Scientific Fact". We successful build a humanoid ROV Poseidon. We face a lot of challenges and difficulties in the manufacture process and we do solve it with a creative way. Through experiments and testing, we get new ideas and inspiration from the results and we look forward to improve and create higher quality and elegance machines.

Here is the list of improvements we have done this year:

1. **We have added more modules into our design library and upgraded all the modules we developed last year.**
2. **We have successful developed water proof servo module. Manipulators with different degree of freedoms can be easily assemble.**
3. **We have introduced 3D vision and stereo camera vision measurement into our ROV design library and control settings.**
4. **We have developed a additional control system—telemetry suit. Avatar style controlling can be achieved and we have different options to control the machine.**
5. **We have developed halved joints aluminum flame structure. This structure is strong, easy to assemble and do not need much repair works in daily operations.**
6. **We have reduced the size of the electronic tube. The tube has been reduced from 380mm (last year) to 110mm (this year) without removing any functions.**
7. **We have reduced the thickness of the tether. The tether has been reduced from 18mm (last year) to 12 mm (this year) without removing any functions.**
8. **We have set up a simple quality control and installation process control. All the modules installed on the machine must pass the pressurized environment test.**
9. **We have developed the new safety precautions rules in our team. We take ISO 13482 as a reference in design process and risk assessment.**
10. **We have promoted ROV technology and Ocean technology in Asia Regions. We have joined different exhibitions and presentations in Hong Kong, Mainland China and South East Asia Country.**

POSEIDON
HKUST ROV TEAM 2012

15 ACKNOWLEDGEMENTS

Poseidon would like to thank the following individuals, organizations and companies for their guidance and assistance in making the ROV a reality.

- **HKUST** – provides funds and laboratory spaces
- **HKUST DMSF** – provides technical support and suggestions
- **Prof. Tim Woo** – our mentor who guided us and advised us as we progressed through our project. We greatly appreciate his effort and support of our team in our endeavors.
- **Mentors** – Chap For LUI, Ming Shing WONG, and Chun Yin LEUNG, in guiding us, and providing us with technical advice, training and instruction during the development of the ROV.
- **Student Affairs Office** – provides the swimming pool for testing our ROV
- **MATE Center** – organizes the international competition and provides a platform to exchange ideas with other teams
- **Hong Kong Regional Competition Organizer and Helpers** – organizes the regional competition
- **RS Components** – provides in kind donation of electronic equipments required for the ROV.
- **DHL** – provides in kind donation of ROV transportation for the international competition.

POSEIDON
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16 APPENDICES

16.1 Schematic Design of the Main Board

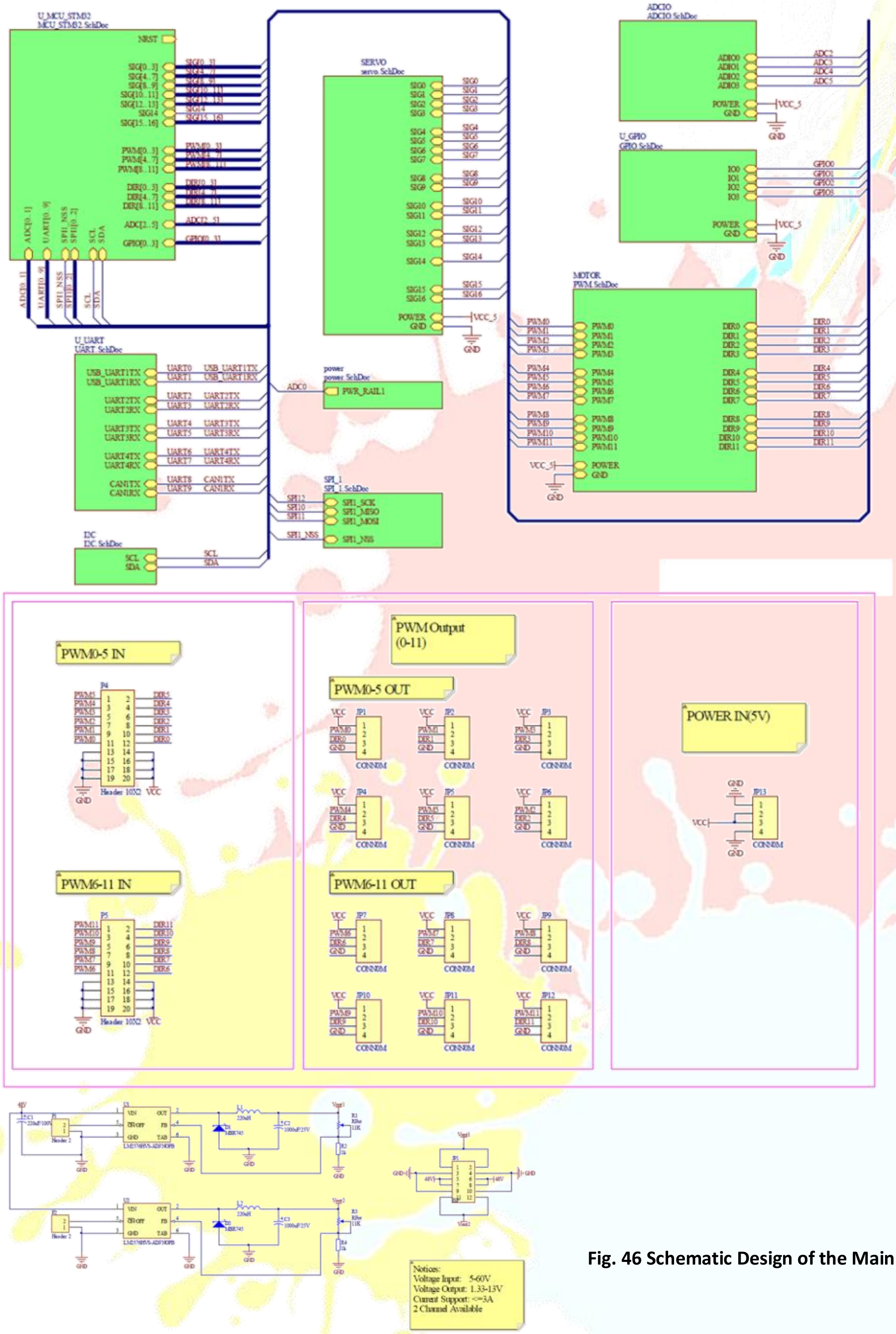

Fig. 46 Schematic Design of the Main Board

16.2 Hardware Block Diagram

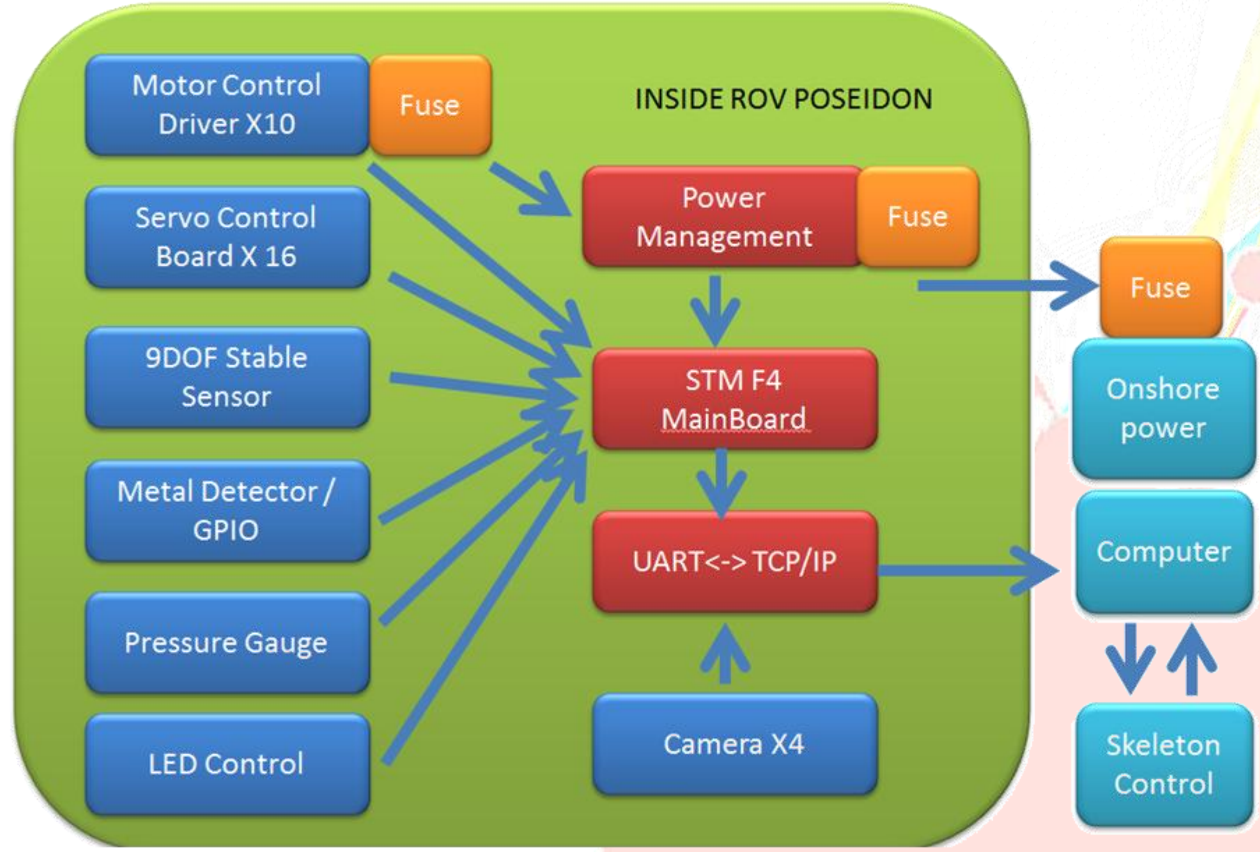

Fig. 47 Hardware Block Diagram

16.3 Gantt Chart

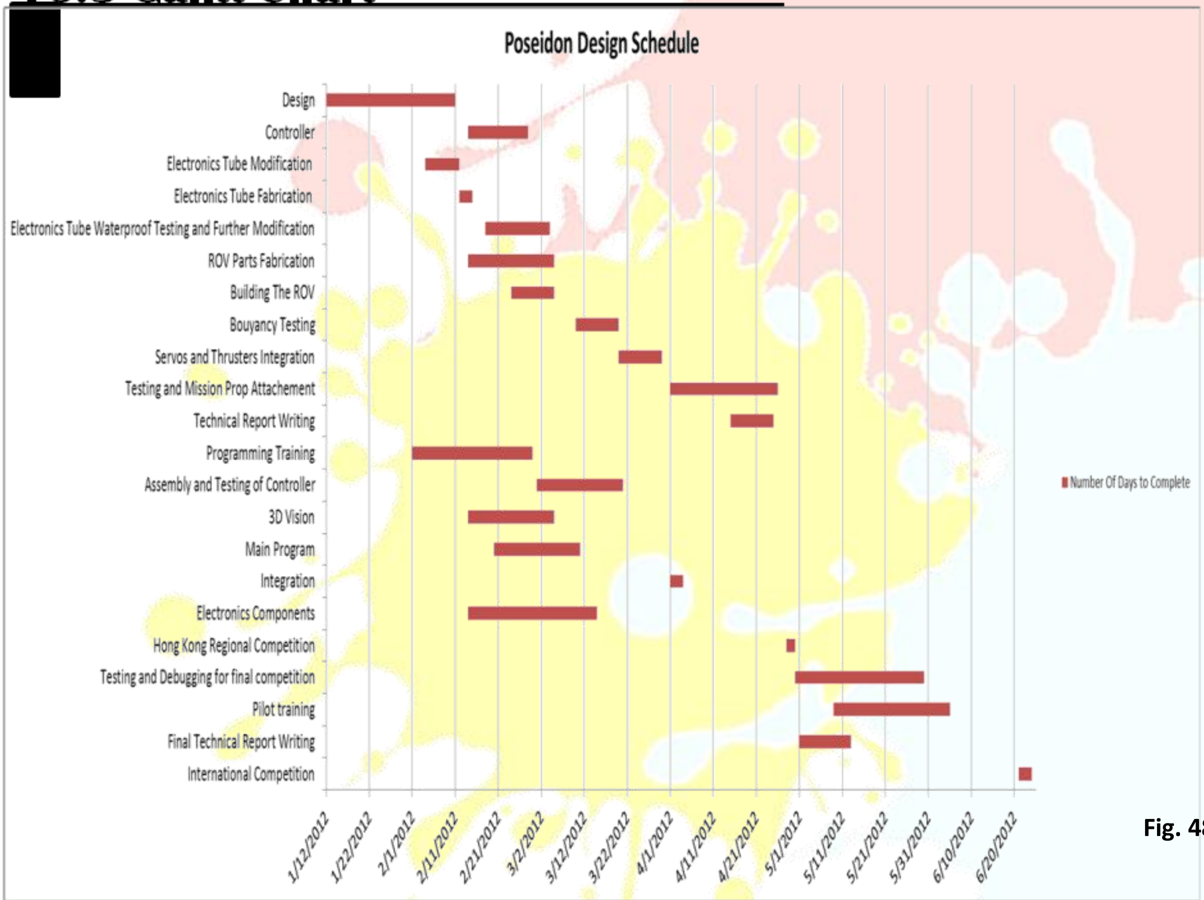

Fig. 48 Gantt Chart