Autonomous Underwater Vehicles for the RoboSub Competition

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***Abstract*—The Autonomous Underwater Vehicles is a kind of electromechanical equipment that controlled by remote or automatic control to make a comprehensive underwater operation .According to the specific rules ,our team designs this underwater machines .The vehicle will scuttle a ship, pass over an obstacle ,drop a marker ,fire torpedoes ,and retrieve an object, surface move the object autonomy. The design for this competition refers to many underwater robot high-end technology. Such as: Image, processing, autonomous recognition. The technology has many important applications in many ways, play an important role in the country's economic, military application, etc.**

I. INTRODUCTION

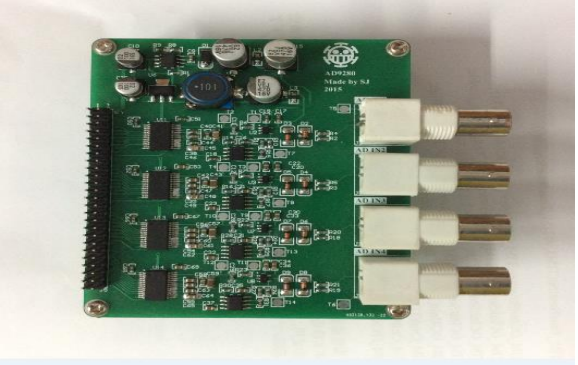
The Autonomous Underwater Vehicles is electromechanical integration products, and combine the knowledge of many subjects. The Autonomous Underwater Vehicles mainly contains the mechanical structure, electric control, power control, communication system. Our vehicle is made up of seven parts, structure, propulsion system, drive system, data processing system, motion control system, sensor system, power system, communication system.

II. THE NAVIGATION PART

The navigation system consists acoustic,inertia, vision navigation systems.

The acoustic navigation system's hydrophone signal processing system uses STM32F407 proces sor of ST's ARM Cortex-M4 ker-nel as the CPU, receiving the accoustic signal which measured by hydrophone through the serial bus, and then data processing, the source location information can be confirmed. Hydrophones placed in the 4 diagonal is mainly for positioning of underwater beacon through the correlation algorithm.The pinger location is used for some tasks.The robot always is navigated by the inertial navigation system, this INS combined FOG and DVL together to show the geodetic coordinate for control system. The vision system would provide the land mark for the control system.

And then control system integrate all the situation and data .the motion control commands would be issued, it makes the robot move to target location or fault-tolerant. The hardware platform of signal processing system of hydrophone are shown as follows.



III. THE SOFTWARE PART

A good program is not only structure and beautiful, gorgeous interface, more to have better efficiency. This year, we use the function block design pattern. The whole design didn't seem to be complex just like last year. The program design was writing by one person before. Due to program is huge, it is difficult for a person on some details, such as image processing. Now we are using block design pattern to focusing on the future. With the increase of software group, each person can be responsible for a module, it's good for details.

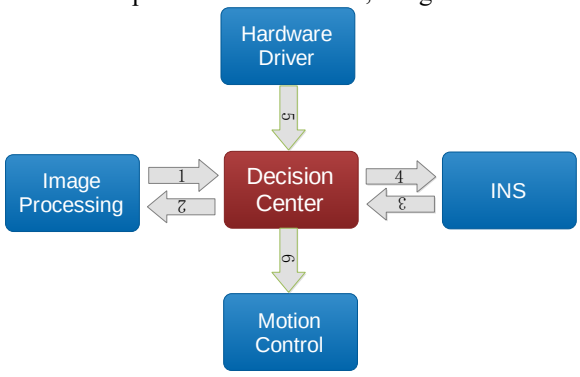


Fig1.Software architecture diagram

Now theapplication architecture is as shown above. Mainly divided into five parts: the Socket for communication, just like a person. Decision-making center is the brain, image processing is the eye, motion control is hands, hardware driver's nose. acoustic navigation is the ear, and the Socket communication is just like the nerve.

IV. THE MECHANICAL PART

A. Introduction

The structure of robot is just like a submarine, but not a round one. It is more like a fat fish. There are 5 propellers, we made a new kind of propeller, which is smaller and more powerful. Among the 5 thrusters, there are 2 fixed beside the vehicle to control the speed and heading of the vehicle and 2 fixed vertically to control up and down. There is also 1 horizontal thruster to control the robot to move forward and backward. This kind of arrangement can ensure our vehicle move freely and then accomplish missions easier. This time, we optimize the use of space, pressure hull and batteries are all positioned inside the non-pressure hull.

There is an embedded PC -GM45 with P7350 CPU in our vehicle to do image processing work and navigation. There is a STM32 control board in our vehicle to control the motors. All the data of sensors are processed by STC12C5A60S2. A DSP board is used to process sonar information.

For improving the function we use the FOG(Fiber optic gyro) and Doppler equipment to navigate, by using integrated navigation, the vehicle can move and make missions accurately.

Our team is make up of many students of different majors, they donated their own specialty to do robot competitions. They also learned so much and obtained many from this competition..

B. General design

The shape of the robot is roughly like a submarine, the cross section is not circular nor oval, it is a circle elongated from the diameter.

The whole scheme design of the robot consists three parts: propeller arrangement is located at head and tail and the pressure hull, battery, DVL and grabber is at the middle part of robot.

The solidworks 2012 and autocad 2008 are used for the three-dimension design. The carbon fiber reinforced composite was used because of characteristics of lighter and stronger, than the glass fiber reinforced plastics used last year.

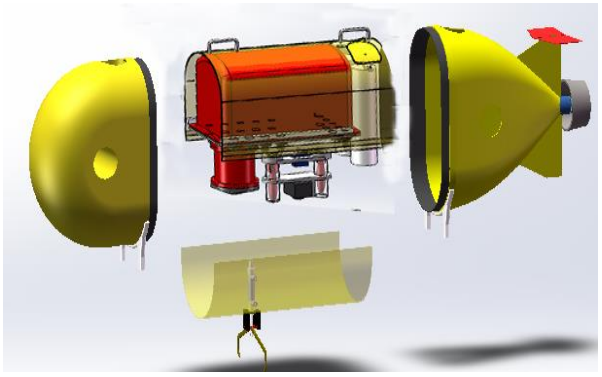


Fig 2. Robot mechanical structure diagram

C. Propeller

All the thrusters are made by ourselves. The shell is aluminum and o-ring sealed. We use the brushless DC motor and planetary gear box. All the 5 propellers are driven by STM32 motor control board.

New propulsion has a smaller volume, but the power density is greater.

D. Marker dropper

The marker dropper arrangement is located at the middle and lower of robot. Markers drop on gravity, and it can make the movement direction of the vertical downward automatically by the gravity and buoyancy adjustment. Before the launch, Markers stay in the robot by magnetic adsorption. The release mechanism was controlled by a servo motor. There is a camera in the middle of tubes which is used to storage markers.

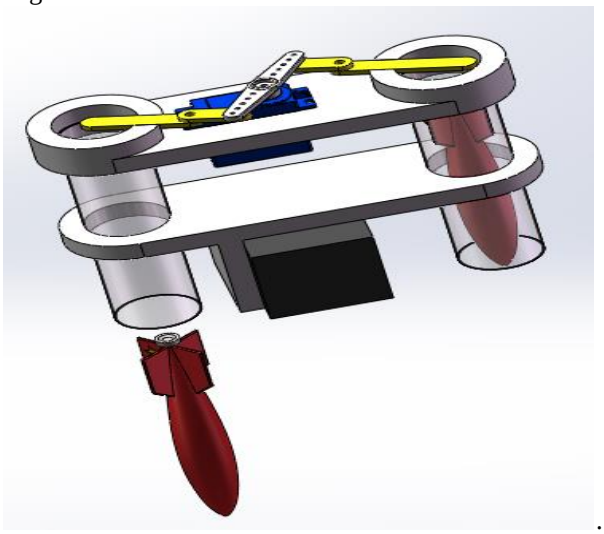


Fig 3.Marker Delivery device structure diagram

E. Grabber

The grabber is located beside the dropper. There are two servo motors to control a pair of jaws for the stronger power. Two motors are synchronous, to drive the jaws to be open or closed.

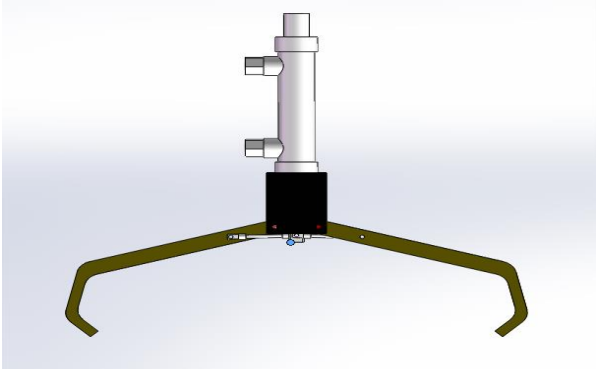


Fig 4 Pneumatic manipulator structure diagram

F. The electrical part

This Appendix is optional and also does not count against the page limit. Recall that a foundational purpose of RoboSub is to strengthen and enhance the community. Therefore, teams are encouraged to briefly summarize their educational outreach activities. The Appendix may also be used to include a team photo The industrial computer is placed

upon the FOG(Fiber optic gyro). The industrial cameras are connected on the GM45 board. The Doppler equipment is connected to the PC by UART port.
There are parts of the electrical subsystem. They are STM32 MPU, DSP board, power management and sensors board and FOG(Fiber optic gyro). All the modules is connect with each other by serial port. This structure is a parallel model, this model makes it easer to install and uninstall the new attachment equipment.

The embedded PC model is GM45 with P7350 CPU. That's a industrial PC running under windows XP OS. GM45 is the 3.5 inch mini board, Intel 945GM(E) and ICH7-M chipset, integrated GM45 graphics, DDR3 memory, Realtek AC97 Audio, Serial ATA and one Intel 82573L Gigabit LAN. The power input is 12V DC. It is equipped with a P7350 processor running at 2.0GHz and 2 GB of RAM and for vision, mission, and control processing. The PC communicates with the sensors, motor driver, servo driver, STM32 board and FOG(Fiber optic gyro) and Doppler equipment. though UART and USB-UART converter. An intel 32GB SSD is used for onboard data storage. It is fully equipped with 4 USB2.0, 4 UART ports. There are 2 cameras connected with the computer by USB. Ethernet LAN is connected to the aluminum board, there is a special debug connector and cable for robot debugging so that we can login the computer remotely. The most convenient thing is that we can use this PC to debug STM32 and DSP board because all the debug cable is connected to this PC. We don't have to open the hull to debug them..

G. Power Supply

There are 2 channels of power input from two independent batteries. Input voltage is between 12.8V and 14.2V. The maximum current can reach 10A. The battery pack is stored on the button floor of the main frame. These batteries are Ni-MH batteries with 4950mAh, it allows the vehicle to continue with its mission for at least 40 minutes at full power, longer than that during normal mission conditions. One group of cells is for control system and another group is for thrusters and mission execution unit. The battery pack is stored on the button floor of the main frame.

This unit has a power converter, it is designed for power control, it can convert the power to 3 standard voltage .They are 5V, 8V and 12V, and directly output to embedded PC. 5V is for the miniARM2440 and DSP board, and the controller on the motor driver board. The current and volt sensor will supervise the power situation.

H. Depth Sensor

The depth sensor is able to measure 0 to 2 bar and shown in Fig.12. An output of the depth sensor is analog current between 0~40mA potential to real depth and transmitted to the DSP board.