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The Designing and Prototyping of Autonomous Underwater Vehicles

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Abstract

Through the overall design of the Autonomous Underwater Vehicles, the design of the thruster, the prototype production and the program debugging, the AUV prototype can complete the motion control of 6 degrees of freedom and meet the overall goal of the initial design.

Keywords

Autonomous Underwater Vehicles(AUV); Designing Prototyping.

1. Introduction

Unmanned underwater vehicles can be divided into remote-controlled underwater vehicles and autonomous underwater vehicles (AUV). Among them, AUV represents the future development direction of underwater vehicles.

In order to achieve true autonomy, the AUV needs to be able to perform planned tasks by controlling and monitoring the onboard system without any external input, and it needs to complete tasks under internal abnormal conditions, and at the same time have re-planning The path is used to avoid unknown obstacles. AUV is equipped with systems and subsystems that can provide power, motion control, navigation, obstacle detection, and collision avoidance. Therefore, it has the characteristics of large range of motion and strong flexibility. Moreover, with the development of computer processors, the intelligence of AUV will increase. Higher and higher, it can make its autonomous ability to perform tasks under water more perfect. There are various AUVs in the world, and different AUVs are used to perform different tasks. The uses of AUV generally include petroleum exploration, geological sampling, deep-sea exploration, environmental monitoring, chart drawing, underwater rescue, pipeline inspection, wreck recovery, and military missions.

As an important tool for exploring the ocean, AUV can perform underwater tasks autonomously. It has the advantages of low noise, high intelligence, high concealment, and small size. Therefore, AUVs are currently widely used in military, civilian and other fields, Demand and development prospects.

2. The Overall Design of the AUV

This submersible is mainly for short-range operations, has the ability to hover in the water and fine-tune its attitude, and has a certain wave resistance. Accordingly, the overall design requirements of the submarine are as follows:

a. Compact size and strong power.

b. The standard configuration of the high-performance detection system includes a variety of optional sensors.

c. Standard and beautiful modular design, accessories can be added at any time.

d. Easily detect and repair targets underwater.

The main performance indicators of AUV prototype navigation:

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a. Sailing speed in still water 2~3nm/h;

b. Diving speed 0.5~1nm/h;

c. Depth range of fixed depth: 0~150m;

d. Range of fixed height: 1~2m;

e. Orientation control range: 0~360°, continuous rotation.

The weight of the submersible is 8kg in the air, 0kg in the water, and the effective load weight is 3~4kg. Overall dimensions: length 350mm, maximum width 350mm, height 300mm (not including mission equipment).

3. Configuration of AUV

3.1. Thruster Research

The movement of the underwater robot depends on the propeller to complete. Most underwater robots use propeller propellers to achieve their movement, while the underwater robots that use propeller propellers are motor propellers, and others generally use oil motor propellers. Underwater robots have 6 degrees of freedom in underwater motion, namely three translational motions (forward and backward, floating up and down, horizontally moving) and three rotary motions (heading, pitching, and rolling). The number, arrangement and thrust of the propellers are important factors to consider when designing an underwater robot. Although there are many types of underwater robots at home and abroad, there are generally four ways to arrange their thrusters, namely, single-propeller arrangement, double-thruster parallel arrangement, double-thruster cross-arrangement and four-thruster circular arrangement. According to the funding situation, the arrangement of the thrusters for floating, diving and side thrusting of the submersible adopts a variety of thruster layouts. The robot mainly installs four propellers in the shape of a quadrangular prism in the front and rear of the hull. Two propellers are equipped in the middle of the hull to control the diving depth and pitch of the hull in the water. It can realize the motion control of 6 degrees of freedom.

The PLC control box of the underwater robot adopts PVC pipes and adopts a modular design concept. According to each functional module, the underwater robot is divided into a bow section, an energy section, a control navigation section and a stern section. Therefore, the connection form between the functional sections A standardized connection form must also be used. Each cabin section is sealed in the form of an O-shaped rubber sealing ring chamfered seal, and the functional sections are connected together by positioning pins and screw axial connections. Wedge-shaped rings are used to wrap the joints of the cabin sections to ensure the streamlined shape of the underwater robot's revolving body, so as to reduce navigation resistance and reduce energy consumption, thereby extending the running time of the underwater robot continuously working under water.

3.2. Robot Architecture

In this design, the structure is composed of a bottom plate, a top plate and two side plates, and the material is a PVC board with a certain thickness. To meet the requirements of strength, in terms of structural manufacturability, the corresponding area of the side plate is removed to form an approximate triangular structure to reduce the material, and at the same time achieve the effect of reducing the weight of the equipment and reducing the water flow resistance. While ensuring sufficient installation area on the bottom plate, the rest of the material is removed symmetrically so that the center of gravity of the entire frame is on the middle symmetry plane, and the top plate is cut with a large circular hole at the corresponding position to facilitate the installation of the vertical thruster. The manipulator and the plastic protective frame are connected with the main frame by bolts, convenient for disassembly, and the protective frame is easy to replace when it is damaged. As each device is assembled, it is

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necessary to constantly adjust the balance position of the AUV to maintain a horizontal posture at rest. At the same time, the thrust direction of the front and rear, left and right, and up and down thrusters should make the AUV move in the X, Y, and Z directions against fluid resistance in the water.

The frame of the underwater robot is unavoidable from errors in the design and manufacturing process. Therefore, all the equipment and the frame on the frame are fixed by bolts, and some of the openings are long round holes to facilitate the installation and adjustment of the thruster and the control and detection equipment.

According to the different forces at different positions, the frame is made of 304 stainless steel plates of different thicknesses, processed into the form of channel steel, and the connection between the channel steel adopts argon arc welding or bolts.

The AUV modular structure is forged with high-impact strength polypropylene synthetic material, does not require any special maintenance and is completely corrosion-resistant. Any part of the robot structure can be easily replaced, and the integrated equipment with the AUV can also be directly bolted to the structure. The pressure chamber is processed by corrosion-resistant aluminum alloy No. 6060.

The surface control unit is equipped with surface electronic control and AUV mainframe power supply, integrated in a 12U control box, equipped with a monitor and a video recorder.

Taking into account the structural strength, navigation performance and ease of arrangement and installation of equipment, as well as ease of processing and maintenance, the overall structure of the underwater robot is a frame structure with propellers, floating bodies, detection sonar, cameras, lights, and short baseline positioning placed on the frame. System transponder, GPS, control and circuit system, 4G communication module, adjustment counterweight, etc. As there are pipeline detection and operations in shallow water areas, a plastic protective frame designed to be easy to replace is installed on the frame to protect valuable equipment such as thrusters, detection sonars, lights, positioning transducers, and floating bodies from collisions. The floating body adopts modularization, which is convenient for mold making, installation and replacement, and can also reduce the influence of frame deformation on the floating body. In order to facilitate the storage and transportation of the robot, but also to transport the target to the disposal area by a transportation vehicle equipped with empty equipment after capturing the target, a hook is set on the upper part of the frame. The steel wire is connected to the bearing layer of the optical cable and hung on the frame to prevent the connector of the optical cable and the control box from being stressed and prevent damage. There are mounting holes in the four corners of the frame, which can be equipped with counterweights to adjust the position of the AUV's center of gravity and buoyancy, so that the underwater robot is in a horizontal state under water. Properly increase the center-stabilization distance to improve the self-stability performance during surges.

Set up a sealed control box to house the DC power supply, attitude sensor, lower computer control system, motor speed controller, etc. Only externally provide sealed sockets to connect with thrusters, mission equipment, cameras, lights, sonars, etc. The container itself also provides considerable buoyancy.

Equipped with high-definition cameras, small sonars, and underwater searchlights, these three devices assist each other to detect mission targets in pipelines or underwater. The camera is installed in the transparent cover on the front of the underwater robot to achieve the purpose of waterproofing and reducing costs. If the searchlight and sonar are installed in the waterproof cover, they will reflect light on the waterproof cover and affect the camera when the light is turned on. According to the observation, the sonar is not installed in the waterproof cover because the installation of the waterproof cover will affect the detection range and accuracy.

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4. The Composition of the Submarine AUV Test Prototype

4.1. The Composition of the AUV Prototype

The main structure of the prototype consists of a load-bearing main structure frame, six thrusters, a high-definition camera, two searchlights with strong lighting capabilities, a small sonar, a high-definition camera, a set of GPS positioning system plus a set for verification The multi-degree-of-freedom manipulator also has a set of release, recovery and energy devices.

4.2. Composition of AUV Control System

The control is mainly composed of a multi-channel remote control, a set of 4G communication modules, and a notebook computer that displays the robot's underwater navigation data, various hull information parameters, and video signals. The manipulator controls the three-dimensional posture of the underwater navigation of the robot and controls the speed and depth of the submersible to meet the operational requirements of the underwater robot; the laptop computer mainly displays the video signal of the submersible so that the submersible operator can perform video manipulation to achieve high precision The job meets the robot's job requirements, and the robot's posture information is also displayed on the laptop. Because the underwater environment is complex, it is not possible to rely solely on video signals to allow the operator to judge the relative specific posture of the submersible in the underwater environment and the relative specific posture relative to the mission target; assist in displaying the positioning information and water regime information of the underwater robot, of course It also includes submersible hull information. Because the shallow water environment is relatively complex and changeable, the hull may be damaged due to the complex and changeable environment. If it is not handled in time, it may cause permanent hardware damage, or cause greater positioning or The attitude information is wrong so that the hull cannot be recovered or the task items are lost for the second time, thus causing unnecessary losses to the user.

4.3. Test of the Prototype Control System

By placing the 4G communication module and battery together on the shore, the AUV control signal is sent out through the 4G communication module and the data collected by the AUV is collected, and the 4G communication module is connected to the 4G network through the network and transmitted to the shore-based control terminal through the network. The test operator controls in different places, and debugs the AUV's internal preset basic operating procedures to continuously improve and match the coordination of the control system and 4G communication.

5. Conclusion

In this paper, the overall design of the AUV, the design of the thruster scheme and the production of the prototype are carried out. Through the program debugging, the AUV test prototype can complete the motion control of 6 degrees of freedom and meet the overall goal of the initial design. The AUV finally realizes an autonomous navigation path, realizes remote data transmission and communication underwater, has the function of switching manual remote control, has a load capacity of 8kg, and has underwater self-stabilization technology, which can flexibly realize underwater movement with 6 degrees of freedom, and can be used for salvage tasks. Under the investigation, kelp harvesting, green algae exploration and other submarine operations services.

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