

Application Field and Development Trend of Small Autonomous Underwater Vehicle

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Abstract: In recent years, with the implementation and promotion of the national Marine strategy - "toward deep blue", it means that our exploration of the ocean is no longer limited to the offshore, and at the same time, countries around the world are also deeply exploring the ocean. Small autonomous underwater vehicle technology is not only playing an increasingly prominent role in Deep Blue's strategy, but also plays an important role in industries such as industry, agriculture, and services. This paper describes the application development and future prospect of small autonomous underwater vehicle in various fields.

Keywords: Small autonomous underwater vehicle, Autonomous underwater robot, AUV.

1. Introduction

Human exploration of Marine resources has never stopped since ancient times, and underwater vehicles are one of the more effective means of underwater exploration at present [1-2]. Autonomous underwater vehicles (AUVs) plays an important role in Marine environment observation [3-4], Marine resource exploration [5], seabed topography mapping [6] and other civilian aspects, and also plays an important role in underwater target detection [7-8], anti-mine warfare [9-10] and other military applications [11].

In recent years, small autonomous underwater vehicles around the world have changed rapidly, from being able to perform a single task at the beginning to perform a variety of tasks, from single robot work to cluster collaboration. In particular, small autonomous underwater robots have played a significant role in fisheries, seabed exploration, and deep-sea rescue, which can not only effectively overcome the problems of difficult tasks caused by complex underwater scenes in the past, but also promote the development of industrial levels and national strategies.

Because of its flexibility, long working time and wide working range, the small autonomous underwater vehicle has been studied and paid attention to all over the world. Foreign research on small autonomous underwater vehicles has entered the application stage of larger scale and wider fields, and the application research of small autonomous underwater vehicles in China is still in the initial stage.

This paper first introduces the significance and application value of underwater vehicles, then briefly enumerates the current research status and application fields of autonomous small underwater vehicles, and puts forward the prospect of its future development trend. Finally, the progress in the research and development of small autonomous underwater vehicles, the existing shortcomings and the necessity of continuing to develop high quality small autonomous underwater vehicles are summarized.

2. Application Field of Small Autonomous Underwater Vehicle

In recent years, the national multi-department joint support for the research and development of underwater robots, both

in theoretical research and technical practice have made significant progress, and some aspects of the research has ranked among the top in the world.

2.1. Military Field

Small autonomous underwater robots can be used as an important supplement to underwater unmanned weapon systems, supplement energy and maintenance with the mother ship as the base, enter the surrounding waters to complete the corresponding sea area detection, enemy search and other work, in order to strengthen the attack and defense capabilities of existing ships. Small autonomous underwater vehicles can also work together with land robots and combat UAVs to change the situation of traditional single-type robot combat into diversified and intelligent combat, which greatly strengthens the combat capability of single-type combat robots and expands the combat scenario [12].

2.2. Submarine relay

Nowadays, distributed underwater sensor networks of varying sizes based on the Internet of Things have been widely put into use. Sensor nodes distributed in the seabed and floating in the water sometimes decline the signal quality of communication with the base station due to the poor underwater environment and objects such as metal, which affects the real-time and network quality. As an important part of the underwater sensor network, the small autonomous underwater vehicle can monitor the communication quality in a specific sea area. When the node with weak communication quality is detected, it can drive itself into the appropriate position at any time, so as to amplify and forward its signal, so as to ensure the communication quality.

2.3. Fisheries monitoring and maintenance

In aquaculture and maritime transportation, aquaculture cages and ships are not only susceptible to seawater corrosion and the attachment of algae, but also easily adsorbed on the inner wall and ships by various impurities contained in the seabed, causing losses and threats to fisheries and maritime transportation [13]. Therefore, the small autonomous underwater cleaning robot can flexibly clean the inner wall of the aquaculture cage and the outer wall of the vessel by using its own sensor, negative pressure adsorption device, cleaning

device, attitude and motion device. Not only improve work efficiency, but also promote the overall development of underwater robots. In addition, the water quality and fish behavior in the aquaculture environment reflect the living environment and health of fish. Small autonomous underwater robots can replace human resources to monitor water quality and fish behavior, timely report abnormal water quality and fish with abnormal behavior, and ensure the healthy development of fisheries.

2.4. Scientific investigation

The collection of seabed data is conducive to the implementation of the strategy of maritime power. In the past, the method of manpower and ship cooperation was used to collect seabed data, which has the disadvantage of low efficiency. The traditional underwater scientific exploration method mainly uses the ship and underwater towed vehicle as the carrier, by carrying different sensors

Realize data acquisition and environmental sampling [14]. The small autonomous underwater vehicle has the advantages of large diving depth, strong flexibility, adaptability to the complex environment of the seabed, autonomous navigation, accurate navigation, excellent maneuverability, and can work away from the mother ship, and plays an important role in the seabed scientific investigation. In addition, thanks to the flexibility and strong environmental adaptability of the small autonomous underwater robot, it can be applied to underwater cultural relics investigation, Marine ecological environment monitoring, resource exploration and other tasks.

2.5. Intelligent pilotage

When sailing ships encounter extreme weather, pilots and lookouts often find it difficult to predict conditions such as seabed reefs, icebergs and wind waves, and even the line of sight is blocked. At this time, small autonomous underwater robots carrying weather radar and access to weather networks, and carrying sensors such as undersea detection sonar, can quickly open up a safe route for ships. The small autonomous underwater vehicle sends out conspicuous signal lights and quotation marks to conduct piloting on the sea surface. At the same time, the motion trajectory and pre-motion trajectory of the small autonomous underwater vehicle piloting can be displayed on the bridge screen of the ship to provide guidance and reference for the pilot.

2.6. Tourism Field

In Marine tourism, when divers dive in the sea, the traditional way of recording is to assign photographers to follow, resulting in labor cost consumption. By using a small autonomous underwater robot to track and shoot, divers only need to manipulate the remote control on the diving suit, and can choose to automatically track the video or take photos on demand. In addition, small autonomous underwater vehicles can take the place of humans to reach farther and deeper waters than they can personally visit, and observe more abundant Marine life and deep-sea scenery.

2.7. Inspection of submarine energy platforms

Some countries in the world have built oil exploration platforms, nuclear power plants and natural gas pipelines in territorial waters. These projects need regular maintenance, and in the past, ships and artificial diving methods were used to detect, and inspectors need to face the risk of changes in water pressure, low temperatures, oxygen deprivation, and

other factors limited by depth. The maneuverability and diving ability of the small autonomous underwater vehicle can be used to achieve the desired effect efficiently and avoid the risk of manual inspection.

3. Future Development Trend

3.1. Research and development of small autonomous underwater robots suitable for underwater rescue scenarios

Whether it is manned aircraft or manned navigators, when encountering danger in the deep sea, relying on manned rescue vessels to participate in the rescue, it can only rescue people falling into the water on the sea surface. In addition, if the aviation and navigation vehicles in danger are equipped with expensive equipment or data, they will face the situation that traditional rescue equipment is difficult to salvage, causing huge losses to individuals and even the country. Therefore, it is of great significance to develop a small autonomous underwater vehicle equipped with a robotic arm optimized for personnel and equipment rescue.

3.2. Strengthen the training on the operation of small autonomous underwater vehicles

At present, the field of aerospace, aviation, navigation, ground and other transportation in the world attaches great importance to the training, assessment and continuing education of pilots, and has a complete management plan. However, the training, assessment and assessment of underwater robot drivers need to be supplemented. With reference to more and more UAVs' infringement on civil aircraft and potential infringement on the operation of high-speed EMU, it is also necessary to strengthen the standardized use of UAVs if the routes of small autonomous underwater robots are not regulated. Due to the similarities between small autonomous underwater robots and drones, both adopt remote control, similar use scenarios, and the fuselage has a camera to observe navigation and the surrounding environment. Therefore, this paper puts forward an idea, in the early stage of regulating the relevant system of small autonomous underwater vehicles, it can refer to the training and examination mode of UAV pilot license.

3.3. Strengthen the research and development of amphibious small autonomous robots

Because the small autonomous underwater vehicle uses battery power supply, the battery capacity is limited by the factors of volume, mass, battery density and distribution equality. And there is no new breakthrough and obvious progress in the research of new battery technology led by graphene. The endurance of underwater vehicles is limited, and they often face the situation of insufficient power when performing complex tasks. It is suggested to adopt the design of carrying small autonomous underwater vehicles by a separable UAV. When executing a task, the UAV should be started first to bring the underwater vehicle to the vicinity of the operating area, and the operator will release the small autonomous underwater vehicle through remote control, and the small autonomous underwater vehicle will dive into the water. After the mission is completed, the small autonomous underwater vehicle floats up and is recovered by the drone.

3.4. Strengthen the research and development of wireless energy supply technology

Endurance is one of the weaknesses of small autonomous underwater vehicles. The traditional wired underwater vehicle uses the way of connecting the charging vessel to charge, which is relatively inefficient, and the task being performed may need to be interrupted. Therefore, wireless energy-carrying communication technology can enable the powered robot to reach the area near the underwater robot performing the task, and charge it without interfering with the operation of the small autonomous underwater robot performing the task.

3.5. Design small autonomous underwater robots with new materials

High quality new materials widely used in aerospace and aviation, with small mass, high hardness, small size, strong corrosion resistance and other advantages. If magnesium aluminum alloy and titanium alloy are used as the main materials of small autonomous underwater robots, the energy consumption of underwater robots can be effectively reduced, and the maneuverability can be improved. In addition, domestic and international cooperation should be strengthened to develop and design new materials.

3.6. Research on a small autonomous underwater vehicle equipped with 3D reconstruction technology

In the investigation and rescue of submarine vessels and the scientific investigation of submarine caves, operators can not know the internal structure in advance, and by the seabed light, impurities and other interference, even if the underwater robot into the workplace, it is difficult to clearly understand the internal structure of the workplace, so as to develop a reasonable operation plan. By using autoregressive Transformer method combined with neural network algorithm and deep learning model training, a single scene image and camera motion track can be input to make each frame of the generated picture correspond to the position of the motion track one by one, thus synthesizing a long-distance long lens effect [15]. In this way, the onshore operation team sends a small autonomous underwater robot to the outside of the work site in advance to take pictures, and then enters the inside to generate a distance track. The AI will do 3D reconstruction of the inside of the work site, and the operators can understand the internal structure in advance, and can more accurately analyze and reasonably formulate rescue and scientific research operation plans.

3.7. Executing Tasks with Unmanned Intelligence

Drawing on and integrating computer vision technology, machine learning technology and sensor technology, this paper studies the unmanned intelligent execution task of small autonomous underwater robot. Small autonomous underwater vehicles are trained to perform tasks in various complex scenarios, such as crack detection of cross-sea Bridges. First, robots can be manually manipulated to perform specific tasks, such as inspection work along a bridge. In this process, the robot can record and collect a large number of tracks, images and other related data. These data are processed and analyzed using relevant algorithms to build intelligent models. Machine learning techniques can use this data to train models

that enable robots to automatically recognize and understand different scenarios and make decisions based on the environment and task requirements. For example, robots can automatically identify and locate cracks on Bridges through computer vision technology, so that data and analysis reports are transmitted back, without the need for traditional manual methods to actually reach the area to be detected. Then through the continuous updating and optimization of the model, the small autonomous underwater vehicle can gradually realize the ability of unmanned process intervention, intelligence and automation to perform corresponding tasks. It can work in a variety of complex environmental conditions, such as deep sea or extreme climate conditions, without the need for human intervention. This will greatly improve the efficiency and safety of task execution.

3.8. Research and development of bionic robotic fish

The bionic robotic fish has the advantages of environmental protection, high efficiency and strong mobility. In the driving mode, learn from the idea of fish swimming, with good resistance performance, can maintain stable operation in the case of more energy saving. However, robot fish belongs to an interdisciplinary discipline, which involves the fields of bionics, control, sensors, artificial intelligence, materials, etc., and the corresponding disciplines should be set up in the future to focus on the integration of technologies in these fields, in order to design better robot fish performance.

The purpose of this paper is to solve and improve the shortcomings of the existing economic fish species identification methods. The existing methods can not make full use of the key information in fish images, and do not have good adaptability to the changes of light conditions and fish pose, as well as low detection accuracy, robustness and real-time. This paper presents a new method of YOLO V8s economic fish species recognition based on GAM attention. The main innovation of this method is the use of YOLO V8s object detection algorithm incorporating GAM attention mechanism to achieve the focus and enhancement of important areas in fish images. Specifically, the YOLO V8 algorithm is the latest and superior version of the YOLO target detection algorithm family, and the detection accuracy and speed are significantly better than the current typical target detection algorithms. The GAM module can automatically learn the key information in fish images and improve the accuracy of fish species identification by weighted processing. The main work of this paper is to improve the performance of economic fish species recognition, so that it can adapt to the diversity of fish species, attitude changes and light instability. Through the improvement and experimental verification of the existing methods, this paper aims to provide an effective method for the identification of economic fish species, and provide a practical method for related scientific research and fishery practice.

4. Peroration

In this paper, the application field and future trend of small autonomous underwater vehicle are discussed comprehensively. It has certain significance for understanding the application potential of small autonomous underwater robots in Deep Blue exploration, industry, agriculture and service fields, as well as the importance of

promoting Marine economy and protecting Marine ecology. Through in-depth understanding of the application and future development of small autonomous underwater robot technology, it can promote the research and application practice in related fields, and further promote the development of Marine industry and the rational utilization of Marine resources.

After years of practice and exploration by scholars, the types of small autonomous underwater vehicles have become complete and their operating fields have covered a wide range. Universities and research institutes have reached the level of independently designing underwater vehicles according to different needs [16]. However, there are still some problems such as insufficient battery life and difficult recovery.

In the future, we should continue to strengthen the research and development of small autonomous underwater robots, in order to improve the application level of underwater robot technology, in-depth analysis of national strategic needs, based on the national Marine strategic needs, in order to improve the level of equipment, and make more contributions to China's Marine strategy.

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