The Use Robotics for Underwater Research Complex Objects

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Abstract In the present article, the authors give an overview of the historical development of underwater technical vehicles and dwell on the modern representatives of this class of vehicles-autonomous (Unmanned) underwater vehicles (AUV). The authors touch upon the structure of this class of vehicles, problems to be decided, and perspective directions of their development, cover scientific materials basing mainly on the data about the benefits of the application of the vehicles in a number of tasks of narrow focus.

Keywords Autonomous · Robot · Underwater · Global positioning system

1 Introduction

In the scientific surroundings, the statements that Oceanographic researches are, in many aspects, more complex and challenging, even compared to space research are not rare. Now, in the middle of the second decade of the twenty-first century, there is no doubt that the study of the oceans has become an issue of global importance, covering economic, industrial, social, defense and many other activities and interests of the society in the modern world. We are seeing the necessity of expanding the boundaries of Oceanographic research, increasing the number of types and growth of quality of measurements in the water column as well as their

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systematization, increasing of the depths of research, which is caused by the growing necessity of sea bottom studies, etc.

Most projects of similar research are applied and become known mainly due to their commercial implementation. Undoubtedly, in the modern realities, it is more and more difficult to conduct scientific research regardless of the urgent production problems [1, 2]. Thus, cooperation of commercial structures, research institutions, military departments, etc. is required for the successful implementation of most projects. Certainly, the results of such projects can be effectively used by all the organizations listed above. For example, almost any innovation in the surveillance and search, under-ice and other studies in one form or another can be used for strategic or tactical military purposes.

2 Modern Technologies of AUV

The latest developments of AUV in Russia can present a small apparatus “MT-2012 (Fig. 1) and so-called solar AUV or SAUV [3, 4] (Fig. 2), designed by Far East branch of the Russian Academy of Sciences.

We can also mention the device “Bluefin-21” worked out by the company “Bluefin Robotics” and used to search the crash site of the plane MH370 of Malaysian airlines.

The peculiarities of modern AUV are as follows: lack of functional dependence on the support vessel, high speed of searching, large coverage, wide range of depths of immersion, accuracy of the target coordinate determination, accuracy of holding its own place in the area of deployment, underwater autonomy of the vehicle, stealth capability (physical fields), universality for performing a wide range of tasks, gathering data in close proximity to the object.

From the overview above you can see how the emergence of new ideas and tasks in constructing of the AUV has shifted the focus of current technological research.

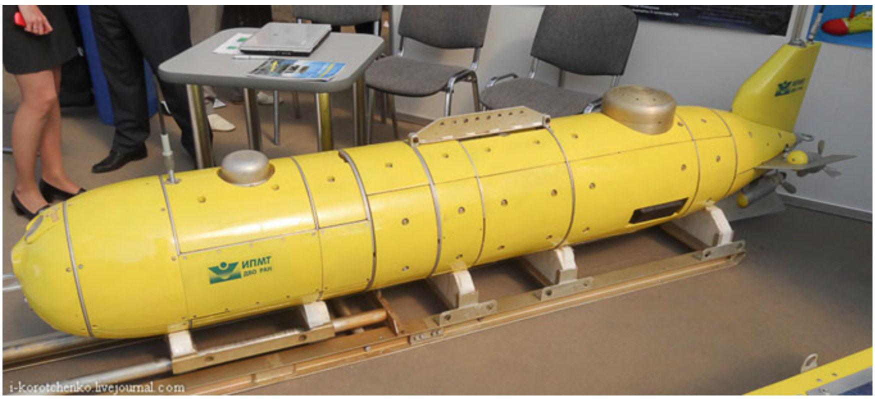

Fig. 1 Compact offline unmanned underwater vehicle MT-2012

Fig. 2 Solar Autonomous underwater vehicle (SAUV)

It is difficult to list the entire list of technologies used in the development of the AUV. The main directions of technological development manifested in recent decades are:

- autonomy;
- power supply;
- navigation;
- sensorics;
- communication.

Despite all the advances made in these areas, they remain priorities to this day. Any limitation of development of these technological areas are the direct limitations of using AUV.

3 Intellectualization

Working out every new project of AUV researchers have to solve the question of the necessary level of intellectualization of the AUV, developed for specific tasks, and ways of realization of this level. Such features of this area, as the architecture of intelligent systems, mission planning, situation recognition, and making decisions are difficult tasks. Some successful solutions of these tasks are embodied in hardware, in other cases, developers tend to insist that to reach the stated goals they do not need a high level of intellectualization and to provide a list of preprogrammed instructions is quite enough. This statement is rather controversial, in reality there are only few significant developments in the area and most developers prefer to focus on the issue of informational autonomy of AUV. But work in this direction is going on and it is not uncommon to meet a navigation system based on the artificial neural networks or similar systems among functioning models. Existing systems provide some recognition of emergencies, recognition of the real-time set of some simple geometric shapes or standard signals on the basis of data received from the vision systems. There are some successful solutions in the selection of the target images or signals in the presence of masking noise and false targets. A particular issue here is the need for processing in real time, as well as the difficulty of obtaining high-quality informative signal from the vision systems, as underwater conditions for fulfilling these tasks are particularly difficult. Similar challenges can be seen in providing AUV with intelligent control.

Another direction of research is creation of simulators and models for training and testing of intelligent systems of developed AUV. This is not a trivial task and successful implementation of it will allow researchers to design more effective AUV and explore their behavior, debugging algorithms, architecture, and systems prior to costly field tests.

4 Informational Autonomy

The number of successes in this area, obtained for other Autonomous vehicles, do not affect the AUV. There are only few programs aimed at solving the problems of autonomy of the AUV. However, with the observed increase of missions performed by the AUV, the necessity of such programs is obvious. Some researchers believe that the problems of autonomy must be addressed in conjunction with the development of intellectualization of control systems for AUV. This would allow AUV to adapt to the environment to the best of their resources. It is worth mentioning that the vast majority of modern AUV require a vessel or vessels of technical support to be near their place of their work. Moreover, these vessels must carry special equipment, both electronic and constructive. All this seriously increases the cost of AUV using and thus reduces the economic attractiveness of their using.

As it was noted in the historical overview, the use of the mode of cooperative operation of several AUV was first proposed in the 80s of the last century. Some work has been done in this direction but even a half of potential of this direction has not been implemented. In recent years, the number of tasks where the use of the mode of cooperation of AUV is recognized as perspective grows. The greatest success was achieved in using this mode for the search and clearance of mines. However, this is only a small part and there are still a lot of unresolved problems left.

5 The Autonomy of Energy

This figure in the history of the evolution of AUV has grown from several hours to tens of hours of Autonomous run. Some samples are able to work for days and few samples are able to work for years. However, this increase in autonomy has become possible due to reducing of sensitivity of the onboard systems, as well as the speed of movement of these devices. The researchers try to increase this indicator by means of lots of measures, which include the development of new energy sources: batteries or alternative sources; reduction of consumption of electric power by control systems and power units of AUV. The latter, in particular, include measures to reduce losses of electric power spent on the hull and its parts resistance to water.

Currently, the batteries that operate on the basis of fuel cell like aluminum-oxygen, hydrogen-oxygen, and lithium batteries have the highest capacity. They provide, respectively, a battery life of AUV from 36 to 60 h.

In some applications, the solution may be in the use of solar energy, as it was done in the domestic SAUV (Fig. 2). The devices of this class require the provision of phases of charge with rising to surface and phases of work. However, this approach is not universal. For example, it is unsuitable for under-ice studies. So, in AUV of the ALTEX project, designed to study currents in under-ice space, the researchers use batteries on the aluminum and oxygen elements.

Another solution is the use of Glider type AUV (Fig. 3) that uses, as a rule, the energy of heating to change the buoyancy of AUV so that it slides on a parabolic or sinusoidal trajectory in the water column. The potential autonomy of these devices is measured in years.

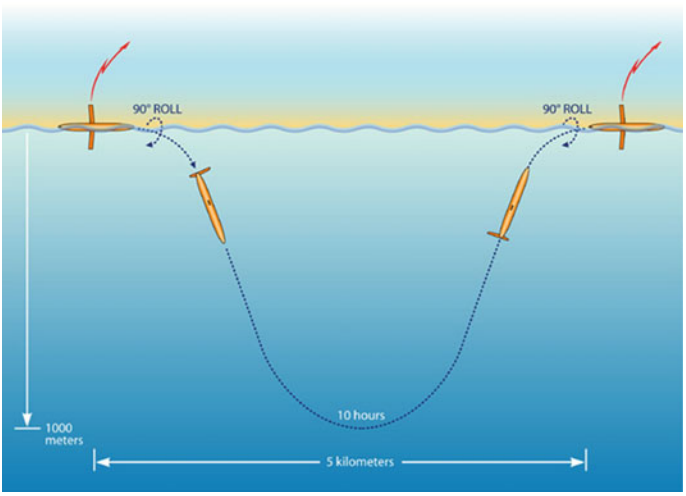

Fig. 3 Glider type AUV

6 Navigation Systems

Navigation systems continue to improve in terms of increasing of the accuracy of positioning. In recent years, even relatively cheap AUV received the global positioning system (GPS). However, for positioning such apparatus must periodically rise to the water surface, which is acceptable not for all tasks of AUV. So now, the research continues in the field of navigation systems that use the environment "habitat" of AUV. Usually such studies are based on the use of gravimetric or similar near-bottom characteristics.

Sensor systems, data processing, and surround vision. Most researches in this area are devoted to increase of the resolution capability of systems of visual and acoustic vision of AUV. The development of microprocessor technology allows researchers to obtain high-resolution images from increasingly long distances. This is evidenced by, for example, a successful project LENS of acoustic vision of high-resolution based on a movable acoustic lenses [4, 5]. But such developments become impractical and unclaimed due to the lack of appropriate systems of processing, analysis, recognition of images in offline mode for decision-making on maneuvering and control of AUV. For example, the above-mentioned project AUSS that possesses the energy autonomy of approximately 10 h of work, required up to 10 h on automatic processing and recognition of pictures obtained in the process. And in the end, the final decision on the results of processing had to be made by a human operator. Another part of development in this direction is the use of modes of cooperation between groups of AUV touch for large-scale studies and collaborative information processing. These simple examples show how close the interconnections of priority technical directions of the development of modern AUV mentioned above are.

7 Conclusion

There are a number of new promising developments in communication technologies. The use of laser communication at short distances and the use high-frequency fields (radiofrequency) for relatively noise-free communication over long distances are among them. But the greatest progress has been made in the field of acoustic underwater communication, which at the present stage of its development allows communicating at a distance, measured in kilometers, while speed of information exchange is several kilobits per second, and probability of error is relatively low. Another promising area of development in the field of communications of AUV is the prospect of realization of communication between groups of ANPA via network infrastructure. Such network AUV can communicate with the vessel of technical support by a buoy or other object on the surface that is able to communicate with ground networks like the Internet. The problem here is not only in the organization of the communication between AUV, but also in ensuring of its efficacy.

From technical point of view, the most demanded progress in the development of AUV is the progress in the field of increase of their autonomy, particularly energy autonomy. And although the rest mentioned above problems are also a priority, it is obvious that the possibilities of ANPA are primarily limited by their low autonomy.

High modularity of modern AUV and path of their development toward multipurpose use, leading developers to use the analogue of the standard “Plug and Play” in AUV, requires a corresponding powerful software for AUV. As for the relevance in accordance with their intended purposes, we are now seeing a rapid formation and development of the oil and gas industry at sea, and of sea communications made by means of the underwater optical fiber cable lines. The development of these areas requires regular surveys of underwater communications, lying, as a rule, at large and medium depths. Some success in this field can be presented in the form of a few layouts of devices with mixed (remote and Autonomous) control that have passed the shallow water test.

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