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A SURVEY OF AUTONOMOUS VEHICLES IN SCIENTIFIC APPLICATIONS

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Abstract: *At a rough estimate 70% of the Earth's surface is covered by seawater in the form of lakes, rivers, seas or oceans. A study by the United States government concluded that all the water across the Earth would fit into a nearly 1,400-kilometer-long balloon. Water also exists in the air in form of water vapors, in lakes and debris, in polar caps and in glaciers and in living creatures.The quest for understanding what lies below the water bodies has motivated the development of autonomous underwater vehicles (AUVs).Nowadays, the Autonomous Underwater Vehicles (AUV`s) have an extensive palette of applications in marine geoscience, and day after day presents an important increase in the scientific, commercial, military, and policy sectors. The ability and the possibility to operate autonomously on board of vessel, makes them very usefully and suitable for exploration of extreme environments, beginning to the deepest small vents and finishing with polar ice sheets. The vehicle helps us to improve our ability to image the seafloor, ensuring a higher resolution of seafloor mapping data that can be obtained from surface vessel.*

Keywords: *applications, autonomous underwater vehicles*

Introduction

Marine robots divided into unmanned surface vehicles and unmanned underwater vehicles. The unmanned surface and underwater vehicle can support us to understand better the marine and other environmental prblemsand to protect the ocean resources of the earth from pollution, and efficiently utilize them for human welfare.

Taking a look at the current situation in AUV technology, until now are currently over 50 different types of AUVs in research and commercial operation, just a few of these systems are: Hydroid's REMUS (USA), Bluefin Robotics Corporation's Odyssey (USA), Kongsberg Simrad'sHugin 3000 (Norway), FAU's (USA), Boeing's, Woods Hole's ABE (USA), Oceaneering's and Fugro's Echo Ranger (USA), Sias-Patterson'sFetch (USA), University of Southampton's AUTOSUB (England), Alive and Swimmer (France), and Hafmynd'sGavia (Iceland).

Autonomous Underwater Vehicles are unmanned and self-propelled vehicles that are most of the time launched from a surface vessel. The vehicle can operate independently of the vessel for periods of a few hours to several days. Most of them are torpedo-shaped (e.g. the Mark 5; Fig.1), but some have a more complex configuration helping them to move slowly and safety across difficult places (e.g. Ciber-Fish – fig.2). AUVs are programmed to follow a preprogrammed curse and can be able to navigate using:

- Fig 1. Mark 5

- Arrays of acoustic beacons on the seafloor;
- GPS positioning, a combination of Ultra Short Base Line acoustic communication;

The submarine gliders are propelled using a buoyancy engine and have a undulatory trajectory. Unlike the submarine displacement, AUVs can maintain a direct and linear trajectory through the water and are used well done to geoscience applications, such as seabed mapping and sub bottom profiling.

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Fig.2. CiberFish

Remotely Operated Vehicles (ROVs) are tied to the vessel. This has some advantages: remained tethered to the vessel, help them to draw more power and communicate real-time data, but also some disadvantages: their mobility, speed and spatial range are very limited compared with an AUV. The uses of ROVs is currently limited to a few applications due to a very high operational costs with mother vessels and safety issues.

Various applications of marine robots include military, environmental systems, scientific missions and ocean mining and oil industry.

In the following tables are lists research organizations in marine robotics.

Table 1. Lists research organizations in marine robotics

Science	submarine environment research and mapping, early and rapid detection of oceanographic and geothermal events, geological sampling
Environment	monitoring over a long period of time, environmental remediation, inspection and observation of underwater structures, including dams, pipelines, tubing, etc.
Military	mine search and layout in shallow water, submarine off-board sensors
Ocean mining and oil industry	ocean survey and resource assessment, construction and maintenance of undersea structures
Other applications	ship hull inspection and ship tank internal inspection, nuclear power plant inspection, underwater communication between ships and submarines and power cables installation and inspection entertainment

Scientific application

The study of ocean currents and tides, ocean volcanoes eruptions, tsunami, aquatic earthquakes or other deep-sea biological phenomena, migration and changes in aquatic ecosystems are all examples of tasks in scientific applications of marine robots.

For example, HYDROID AUVs are used for monitoring and tracking the world's fish population, including determination the impact of over-fishing, habitat destruction of sea animals, pollution and toxin levels. Furthermore, the AUVs are used to determined how to increase the fish and other creatures' population. Beside overfishing, the changes of climate have led to a decline in fish stocks around the globe. Scientists are searching for a better understanding of fish habitats and their associated environmental characteristics.

Bluefin HAUV (Hovering Autonomous Underwater Vehicle) is an autonomous underwater vehicle used for ship hull inspection. The vehicle has designed two-man-portable hovering. Furthermore, the vehicle is equipped with a high-resolution imaging sonar. The resolution imaging sonar help us to surveys and inspect ship hulls and other structures with minimal prior knowledge.

The vehicle can be unpacked and checked out.and launched from a small boat. An intuitive mission planning tool enables dives to be planned in a few seconds, and data retrieval and reporting occur automatically.

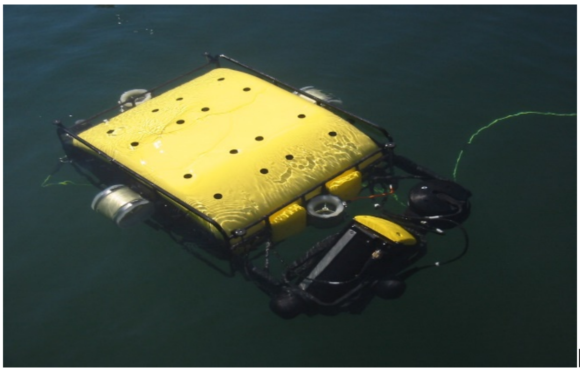

Fig. 3. Bluefin HAUV

Since 1998, The Japan Agency for Marine-Earth Science and Technology

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(JAMSTEC) has developed a very sophisticated deep-sea vehicle for study and exploration the ocean resources. The vehicle URASHIMA is powered by full cell technology. The URA Laboratory, University of Tokyo, has also developed a series of underwater vehicles, such as Tri-Dog AUV that are used in ocean research, and have also been used in environmental monitoring experiments in fresh water environments (Lake Biwa Research Institute).

The AUV *URASHIMA* is adeep-sea cruising autonomous underwater vehicle. The vehicle operated since 1998 by JAMSTEC for deep-sea exploration. An advantage is represented the fact that the vehicle can be pre-programmed to travel autonomously, using its onboard computer. Getting closer to the seabed during exploration than a research vessel, AUV *URASHIMA* offer extremely high-resolution seafloor topographic data and mapping and sub-bottom profiler data. The vehicle could achieve sufficient data to form a detailed bathymetric map of a 5 km²-wide area per dive by travelling about 100 meters above the seabed.

Fig.4. AUV URASHIMA –Offer a large space is available for payloads. (*URASHIMA*did not carries humans, only instruments when diving.)

Another remotely operated vehicle is *HYPER-DOLPHIN* completed by Canada in 1999, which has the possibility to conduct surveys at a maximum depth of 3,000m. Equipped with an ultra-high-sensitivity high-definition TV camera, the vehicle has facilitated visual and filmed surveys in the deep sea. Samples on the ocean floor can also be collected by the two manipulators (mechanical arms) on the vehicle.

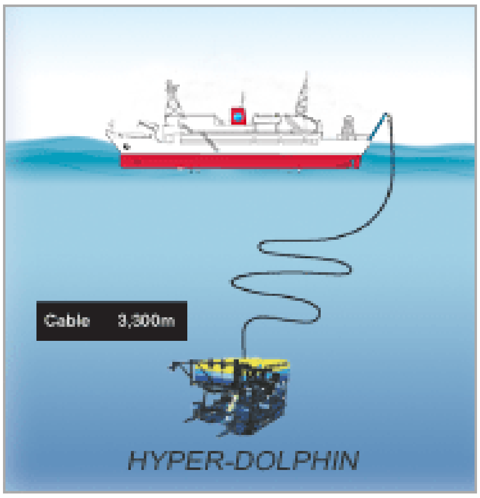

Fig. 5. HYPER DOLPHIN

Environmental monitoring systems

Marine robotic systems are currently used as notifications of systems with environmental implications. For example: The Autonomous Oceanographic Sensor Network (AOSN) and River Net. The Autonomous Ocean Sampling Network (AOSN) project brings together sophisticated new robotic vehicles with advanced ocean models to improve the ability to predict and observe the ocean. The operational system includes data collection by smart and adaptive platforms and sensors that relay information to a shore in near real-time (hours) where it is assimilated into numerical models, that create four dimensional fields and predict future conditions.

The River Net Project is for development of distributed sensor networks integrating mobile autonomous underwater robotic vehicles applied to problems of environmental monitoring with special emphasis on the Hudson River and Estuary.

The SAUV II is a solar-powered autonomous vehicle capable of operating on the surface or underwater to the depths up to 500 meters.

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Fig. 6. The SAUV II

Other type of marine robotic vehicles

There are other types of marine robotic vehicles

, such as gliders and biomimetic systems.

An underwater glider is a type of autonomous underwater vehicle (AUV) whichglide slowly up and down in the oceans using small changes in its buoyancycontrol system tracing a saw-tooth profile, observing data such as temperature and conductivity versus depth. In contrast with a float, a glider uses wings to convert that vertical motion to horizontal.On the moment when the vehicle is at the surface, positioning is obtained via GPS.The communication between the vehicle and the home base is made via satellite. The most recent glider development activity is currently underway at the Office of Naval Research (ONR). The Liberdade prototype, the X-Ray glider AUV, is the world's largest underwater glider. Size is an advantage in terms of hydrodynamic efficiency and space for energy storage and payload. The glider is designed to track quiet diesel electric submarines operating in shallow-water environments.

Fig.7. Spray(Photos courtesy of Bluefin, Applied Physics Laboratory, University of Washington and Webb Research Corporation)

CONCLUSION

Marine robotic vehicles represent besides a very active research area also a promising industry as the demand of more advanced marine robotic vehicles increase for various applications. In the last decades, been made significant progress on these types of autonomous vehicles. Even with these advances, remain a total of research issues.

Autonomy,navigation, endurance, sensors/sensor processing, underwater robotic manipulationandexcavation,andcommunicationsremainas theenablingtechnologiesforthesesystems.Althoughalevel ofcapabilitydoescurrentlyexist,user requirementscontinue to push the required capability beyond current technology.

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