Research and Development in Underwater Robotics Technology in Malaysia

by Assoc. Prof. Dr Mohd. Rizal Arshad

1.0 BACKGROUND

The effort in developing new technologies to be applied in an underwater environment is becoming more important as we proceed to explore new frontiers in finding new resources and ensuring its sustainability. As much as we think that marine resources are crucial to the well-being of the human civilisation in the coming decades, more so is the development of the appropriate technology to make this goal realisable. Our marine resources are untapped resources, yet to be exploited to its optimum potential. For this to be done, we must ensure that the proper and appropriate technology be acquired.

The utilisation of an ingenious system and technology has become more pervasive due to the advancement of various support technologies which make up a complete operational module. The domains of applications also have become more varied and sophisticated. The advantages of using reliable underwater and technology systems are the minimisation of risk to human life and also the enhancement of functional capabilities. Each domain of applications provides a multitude of challenges and practical problems.

In Malaysia, we have many scientists who conduct basic and applied research related to the marine or underwater environments. We have, for example, groups of biologists, oceanographers and marine scientists conducting active research on our oceans. They are using a number of state-of-the-art sensors and equipment for their research. This is unavoidable in order to ensure that reliable data can be gathered and a justified conclusion can be made of any studies or investigations. Marine sensors and related equipment are, admittedly, very expensive.

The high cost of components puts a significant constraint on the type of R&D efforts that can be conducted. At the same time, we have many engineers and researchers who have the capabilities to develop our own locally-made sensors and systems. It is just a matter of linking these two groups together. With the first class facilities that we currently have in research institutes and universities in the country, there is no valid excuse for us not to venture into this endeavour.

The emergence of new technologies and solutions to address issues and problems encountered in our daily endeavours have often been greeted by caution and ill-informed presumptions. And the fate of these newly-found solutions may sometimes be grossly affected by the perceptions held by the masses. This is especially true at the initial stages of development. The true measure of technology viability is the first one or two years of its utilisation. Not all novel solutions are viable, and vice versa, not all viable technology is novel in itself.

The Earth is part of our source of problems and potential solutions. Development of newer and better technology for underwater applications are becoming very pertinent at this juncture. More research efforts are required to ensure that the problems of the proper exploitation of our oceans are addressed satisfactorily. Research collaborations across multi-facets of knowledge are important and fundamental. The sustainable themes revolving around the issues of measuring, monitoring and managing of the oceans are crucial to the wellbeing of the world as a whole.

R&D efforts into underwater system technology are becoming attractive because of the potential returns. As the commercial and industrial sectors' interest in the potential of underwater/oceans grows, so does the effort to produce better and cheaper enabling tools, i.e. underwater technologies. And, this trend is also visible in the defence sectors.

2.0 UNDERWATER ROBOTICS RESEARCH GROUP (URRG)

Research and development efforts into developing a fleet of underwater-related robotics platform have been ongoing for the past 10 years at Universiti Sains Malaysia (USM), at the School of Electrical and Electronic Engineering, Nibong Tebal, Pulau Pinang. The effort received its vital boost in 2007, after the National Oceanography Directorate (NOD), MOSTI, awarded a special development research fund to develop a locally-based intelligent hybrid underwater vehicle (IHUV), amounting to RM4.29 million. The research fund has enabled a fleet of underwater-related robotics platforms, as opposed to the single proposed IHUV, to be developed. This fleet of underwater robotics platforms consists of:

1. Intelligent Hybrid Underwater Vehicle (IHUV – Autonomous and Remotely-controlled mode
2. Underwater Glider Platform
3. Remotely-Operated Vehicle (ROV)
4. Robust Vertical Profiler
5. Autonomous Surface Vessel (ASV)
6. Drosobots (Micro-ASVs with multi-agent applications)
7. Towed Underwater Intelligent Surveillance System (TUISS)

In the past four years, the research and development efforts for all the underwater robotics platforms were conducted at the URRG lab in USM. A group of up to 20 postgraduate students and five academic staff were involved in the development of all the platforms. These students were doing their MSc. and Ph.D research efforts based on the platforms. The research challenges consisted of hardware, software and integration issues. The tasks of developing these platforms are in line with the government's effort for national capacity building, self-reliance, knowledge creation and also high potential wealth generation goals.

The development of these robotics platforms is crucial because of the strategic importance of the technologies involved. The applications are also varied. These underwater robotics platforms can be utilised in the oil and gas industry, for defence applications, scientific explorations and also for commercial use such as port security and also *in-situ* ship-hull inspection. More information on this research group is available at *http://urrg.eng.usm.my*.

3.0 SYSTEM AND TECHNOLOGY DESIGN

Over the years, the focus on systems and technology development has changed as new ideas began to surface to address technology-related problems. Some of the problems have been solved while others remain and still await real solutions. Previously unknown problems have now come to the fore. The following list represents many of the technical issues that have been addressed over the past three decades.

- **Autonomy** *(What is the ability for the system to operate without human intervention?)*
- **Energy** *(What is the maximum duration of operation permissible?)*
- **Navigation** *(What is the ability to navigate a path with/ without obstacle avoidance?)*
- **Sensors** *(What kind of sensing parameters are required for particular applications?)*
- **Communications** *(What is the data size and transmission distance needed?)*

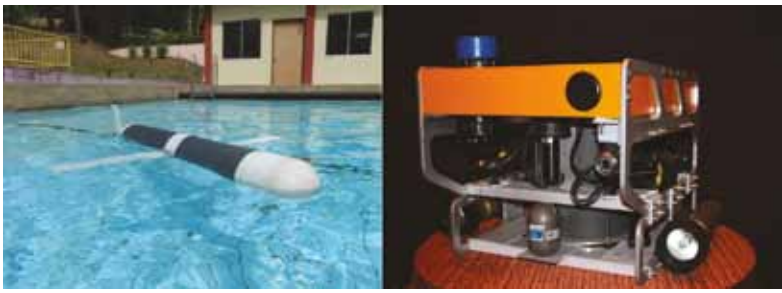

Figure 1: A sample of the AUV-Glider and ROV platforms developed by USM

The AUV's purpose is to carry payload (See Figures 1 and 2). The payload is determined by the mission of the vehicle. Unlike an ROV, an AUV carries its own energy source and is pre-programmed with a set of instructions that enables it to carry out an underwater mission without assistance from an operator on the surface. The interesting aspect of this list is that, although there have been advances in these technical areas, a number of these technologies still remain the technology *"long poles"* associated with AUV systems.

The limitation in these technologies affects the capability of AUV systems. Among the technology *"long poles"* are:

- Autonomy/Cooperation/Intelligent Systems and Technologies
- Energy Systems/Energy management
- Navigation and Tracking
- Sensor Systems and Processing
- 3D Imaging and mapping
- Communications – multi modal

Figure 2: The Intelligent Hybrid Underwater Vehicle (IHUV) by USM

Several important advances remain to be made such as in the area of autonomous manipulation. However, the emphasis of current activities is not along these lines. Other important design issues are:

- Guidance/Low Level Control
- Hydrodynamics and Control Systems
- Autonomous Manipulation/Work Systems
- User Interface/Development Tools/Emulation
- System Modelling

As AUV/UUV systems mature to a point where they are being commercialised, the importance of cost reliability and robustness are becoming increasingly important. Other important areas that must be considered in the future are:

- Software System Architecture/Distributed Control
- Hardware System Architecture/Standardisation
- Vehicle and Platform Design
- Cost/Reliability/Robustness

The key issues that will determine the characteristics of the AUV/UUV platform, and guide the system design are, among others:

- What sensors or other hardware must the AUV/UUV carry as payload?
- At what depth will the AUV/UUV operate?
- At what speed will the AUV/UUV operate?
- For how long will the AUV/UUV operate?

With the payload, depth, range and speed requirements defined; then only will there be enough information to produce a general configuration and layout of the vehicle. A second set of questions refines the size, weight and power requirements of the AUV.

4.0 SUMMARY

The use of underwater vehicle platforms (AUV/UUV/ROV) and other underwater robotics technology will be more pervasive as the oceans are given more priority in the future. This is especially true for deeper parts of the ocean. There are political and economical reasons for these increases. The integration of various underwater vehicle platforms will also be crucial in gaining a more holistic understanding of the measured conditions. Nevertheless, the robotics system used must not introduce unnecessary interference to the underwater environment. Certainly, many more intensive R&D efforts need to be done in the field of battery/power source technology, underwater sensing and communication, and new materials, to name a few.

The key to this enabling technology is the development of the optimum sensing and platform required, which are low cost, highly reliable, robust and environmentally friendly. It is hoped that the stakeholders, such as the marine industry community and relevant government agencies, will give more emphasis on the development of locally-based underwater system and technology. In Malaysia, the available research groups in institutes of higher learning and independent research institutes must welcome the move for more intensive research into this exciting domain of applications. We must work towards knowledge generation, which will lead us to wealth creation. ■

Note: The author is currently based in Underwater Robotics Research Group (URRG), Universiti Sains Malaysia, Engineering Campus and may be contacted at *rizal@eng.usm.my*

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