Development of a Remotely Operated Vehicle (ROV) for Underwater Inspection

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1.0 INTRODUCTION

There has been an increase of interest in underwater vehicles development since the 1990s. Commercial manufacturers have taken aggressive action each year to produce various underwater vehicles to support marine industries such as oil and gas, and underwater construction. From the academic perspective, either in universities or research institutes, academicians and researchers are just as keen to utilise underwater vehicles, such as a remotely operated vehicle (ROV), to explore the underwater environment.

Figure 1: USM's remotely operated vehicle

The cost to purchase a commercial underwater vehicle is quite expensive. One solution is for researchers to specifically design and develop their own underwater vehicle and system according to their research requirements and applications. The developed system must be able to perform the tasks required in a reliable manner. A basic unmanned underwater vehicle (UUV) system should be capable of undersea observation and carry out simple operations such as tele-operated sample collection.

In general, UUVs can be divided into either ROV or autonomous underwater vehicle (AUV). An ROV is a tethered underwater vehicle with an umbilical and is remotely tele-operated by a human operator. Meanwhile, an AUV is an automatic platform that has an onboard controller and is able to perform self-operated missions. The commands for an AUV system are usually pre-programmed before the mission or downloaded from the surface control station during the mission.

There are few limitations in using an ROV compared to an AUV; for example, operator fatigue, operational cost and safety issues. However, because an ROV's manoeuvrability is much more convenient, it can be deployed almost everywhere; sea, lake, river, well, pool, drainage or sewage system. Nowadays, ROV manufacturers are able to produce a wide range of ROVs that meet a customer's varied requirements.

In general, ROVs can be classified into several classes, namely, micro, mini, general, light work class and heavy work class. The last three classes, general, light work and heavy work may be required to operate down to a depth of 7000m. These kinds of ROVs are often used in ocean mining, offshore-oil industry and underwater constructions. There are several potential applications of underwater vehicles. The latter can be used for seafloor and geological sampling.

ROVs are often used for the inspection of underwater constructions such as pipelines and dams where a constraint in workspace is crucial. Heavy underwater constructions require heavy work class ROVs as, nowadays, there are quite a number of underwater cables for power grid and communication installed on ocean seabeds all over the world. Other applications that use ROVs include ship hull inspection, ship tank internal inspection, nuclear power plant inspection and underwater exploration.

2.0 DEVELOPMENT OF USM'S ROV

USM's ROV is an unmanned underwater vehicle developed by researchers from the Underwater Robotics Research Group (URRG) in USM's laboratory (See Figure 1). Several team members were heavily involved in catering to the various technical requirements in the ROV's design and development. This small class ROV was developed as a generic UUV platform to enable further researches in marine control system and modelling. The development of this ROV is funded under a research grant by the Ministry of Science, Technology and Innovation through its agency, the National Oceanography Directorate (NOD).

As a research platform, USM's ROV is equipped with standard equipment and payloads such as depth transducer, gyro compass, echo sounder, an optical camera and sonar. The propulsion system is provided by six brushed DC thrusters propeller with dedicated controller.

Table 1 shows the ROV's specifications. The ROV runs on 240v AC, 50Hz, supplied from a surface generator. A 100m umbilical supplies the electrical power and communication (i.e. for data and control signals transfer). AC voltage is used instead of DC voltage to reduce power loss from the 100m cable transmission. About 90% of the supplied power is consumed by the thrusters, while another 10% is consumed by other modules.

Table 1: USM ROV specifications

Dimension	665mm (L) x 550mm (W) x 500mm (H)
Gross weight	30kg
Rated depth	100 meter
Material	Aluminum alloy, PVC
Propulsion	Brushed DC motor propeller thruster
Controller	PC based controller, PIC micro controller
Power supply	240v AC, 50Hz
Equipments	AC-DC converter, Protection Circuit Module (PCM), ATX board, depth transducer, thruster controller, depth sensor, gyro-compass, echo sounder, collision avoidance sonar, optical camera, HID light, water ingress sensor

Four thrusters are mounted on the horizontal plane while another two thrusters are for vertical motion. The horizontal thrusters are fixed at an azimuth angle in X-shape configuration (Figure 1) to provide the surge, sway and yaw motions. The vertical thrusters are mounted in parallel to provide heave and pitch motions. The development of USM's ROV was done in two stages. The first stage was to develop a prototype system that is capable

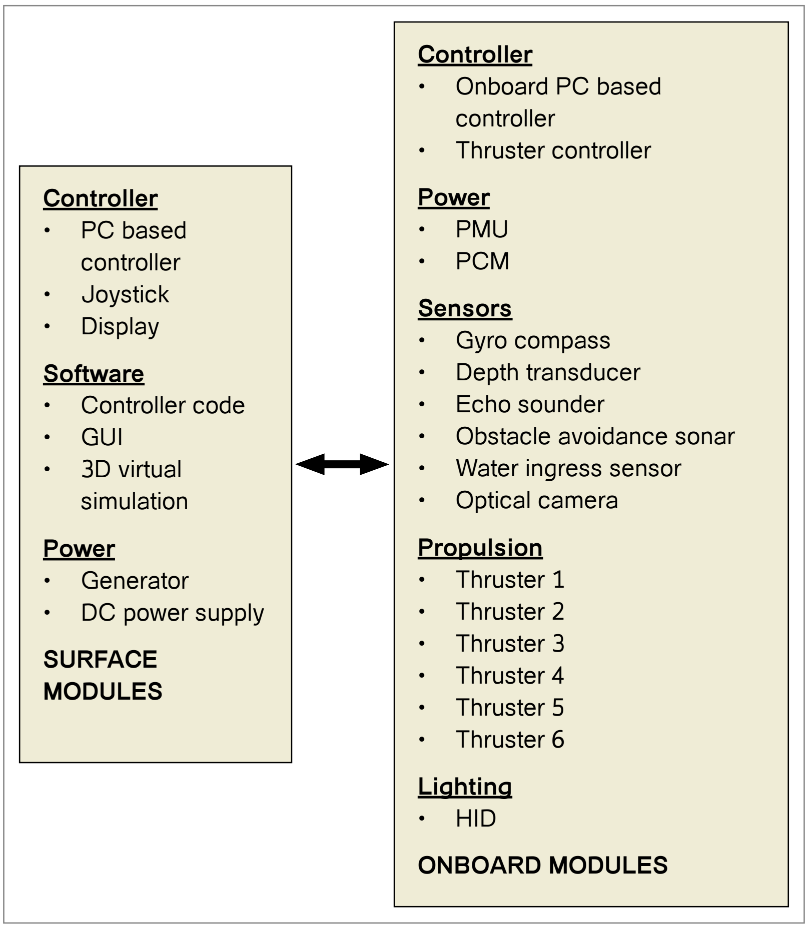

Figure 2: Hardware and modules

of performing the standard manoeuvring of an ROV and simple tasks such as underwater monitoring.

The system assemblies and parts were based on modular integration. Each subsystem was either purchased or fabricated. Each module was tested individually before being assembled and integrated as a complete ROV system (See Figure 2). A series of laboratory tests were conducted before the system was completed.

USM's ROV system was tested in a fresh water testing pool before being tested in open seawater condition. The subsequent stage was to improve the control system with an intelligent system that enhances the overall system. This ROV system was also equipped with an echo sounder and collision avoidance sonar. With such equipment, the ROV can perform more efficiently in practical applications. The most current research on the ROV is on the development of the fault tolerance control of the propulsion system.

3.0 FIELD TEST

USM's ROV has been tested in both fresh water and seawater. During the fresh water experiments, two aspects were tested, namely, its manoeuvrability and the vision system. The X-shape configuration of the horizontal thrusters provides agility and smooth navigation. Figure 3 shows the freshwater testing in a swimming pool.

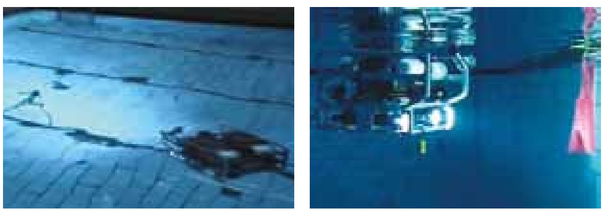

Figure 3: Freshwater test

USM's ROV has also undergone its first seawater test (See Figure 4) in a coastal area near Bidan Island, Kedah. This island, located in the northern part of Peninsular Malaysia, is part of the coastal area of the Straits of Malacca. Again, two aspects were tested, namely, the navigation and vision system.

Figure 4: Seawater test

4.0 CURRENT DEVELOPMENT

USM's ROV is currently being upgraded in terms of its specifications and capabilities. A forward looking sonar is being added to provide collision avoidance ability and undersea scanning abilities. Several units of echo sounders are also being added to provide attitude measurement and ranging. The most current research being carried out on the ROV is the development of a fault tolerant control for the propulsion system. This research is motivated by difficulties in tolerating the malfunction of the propulsion system. The fault tolerant technique was originally used in safety-critical systems such as an aircraft or nuclear power plant. The approach is being specifically designed and modelled to suit the ROV's system.

5.0 CONCLUSION

USM's ROV is a prototype ROV developed as a research platform. Although it is designed as such, it still serves the basic functions of a standard ROV system such as for monitoring and inspection purposes. The advantage of developing its own ROV system is that the researchers are able to access the system freely without any restrictions that are usually imposed by a commercial ROV manufacturer. By developing its own Malaysian-made ROV, the cost can be reduced and researchers can have a tailored ROV system that suits their needs and applications. This is a starting point for a fully submersible research vessel. ■

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