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Remotely Operated Vehicle for Surveilance Applications On and Under Water Surface

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***Abstract*— This paper presents the low cost hardware prototype of a Remotely Operated Vehicle (ROV) for surveilance applications. The vehicle is designed to make maneuvers under water and on surface of water, where its movement is guided remotely via a GHz-scale wireless communication system. The main electronic control unit (ECU) of the vehicle is an 8-bit microcontroller, which is used to control 6 motor actuators. Two motors are embedded in a ballast tank used for pumping and draining in and out of the ballast tank. While, the other four motors are used for vehicle movements on water surface. One wireless transceiver is embedded in a joystick and the other is separately placed in the waterproof box mounted on the vehicle. The performance tests present that, in general, the ROV can be controlled well with limited performance. The total weight of the vehicle is 10.35kg with weight density of 0.89kg/ltr.** *(Abstract)*

***Index Terms*— Remotely Operating Vehicle (ROV), Control Systems, Microcontroller, Surveilance.**

I. Introduction

Remotely Operating Vehicles (ROVs) are a kind of vehicles that can be operated remotely by wire or by wireless media using a specific wireless communication systems. The ROVs are usually used for surveilance/obsevation, exploration, discovery or for monitoring of areas, which are not easy to access, such as under sea level. In general, ROVs, operated remotely underwater, play a significant role to support offshore petroleum production facilities [1]. The ROV can also be used for monitoring of hazardous or high risk areas such as fired forest, chemically contaminated areas, hydrothermal exploration [2], etc. Although ROV can be operated not only under water, but also on-ground or on-water surface, ROV is always associated with vehicles that are operated under water.

Since the ROV are normally used for surveilance or observation or monitoring application, then it is usually equipped with embedded camera. The prime movers of the ROV are motors. The ROV certainly should be able to be controlled remotely via a specific data communication system, by cable or by wireless. Electronic control unit is accordingly required to coordinate the guiding signals sent from operators to the ROVs, and the observation data from the ROV's camera to the display system at operator host.

Several modern ROVs have been developed by company and by research institute in developed countries [7]. The design cost for that ROVs is usually expensive. For educational purpose, this could be a problem especially in developing countries. Therefore, ROVs for educational purpose or lab-scale experiments are interesting to design [3], [4]. Our paper will present a low cost ROV that can extended for further or real surveilance or observation applications. The ROV's material is obtained locally and built with minimum cost. A simple ballast tank system is used for under water surface movements, and a minimum number of motor actuators is used for maneuvering under water and on surface of water.

II. Problem Definition

The vehicle is designed for on-water-surface under-water surveilance applications. Therefore, the ROV should be able to move not only on water surface but also under water surface. The weight density of the ROV is designed higher than water. Hence, it can move easily on water surface. How it can move down under water surface? The hypotetical answer is to make the weigth density of the ROV lower than water. Therefore, the objective of the ROV design concept is to find a suitable mechanisme to ease the ROV maneuvering on water surface and under water.

III. Proposed Concept and Model

The ROV is designed such that it can be operated on water surface and below the water surface. In order to answer the problem defined in the previous section, then we propose to use a ballast tank to enable vertical movement below water surface and vice versa. Figure 1 presents the 3D model of the ROV. Six motors are used to design the ROV, four of them are used for ROV's maneuvre in and on water, while the rest two motors are embedded in the ballast tank for pumping water into the tank and draining water out of the tank.

A. The ROV Model

The perspective view (3D view) of the proposed ROV is presented in Figure 1. As shown in the figure, the main body of the ROV is made in silindrical form. The silindrical body is actually the ballast tank, held by a frame made from polymer pipe. Two waterproof boxes are mounted on top of the ROV's body. A wireless camera is put at front section under the ROV's body. The wireless camera can be used for surveilance purpose.

The ROV movements are driven by four motors, where each motor shaft is coupled with a blade. The motor and the blade is covered by a silindrical housing as shown in the figure.

Two motors are mounted at the front and back section at each side (the left and the right side) of the ROV. The housing of the motor blade is used not only to cover and secure the blade from external disturbance or collision, but also to keep the ROV body in balance conditions.

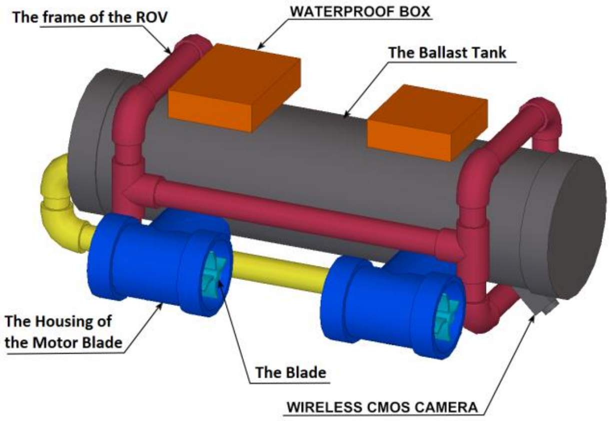

Figure 1. The perspective view of the ROV.

The front view and the side view of the ROV is presented in Figure 2. As shown in the front view section, the ROV's frame is built in rectangular form and hold the ballast tank. The wireless CMOS camera is attached below the ballast tank at the front section.

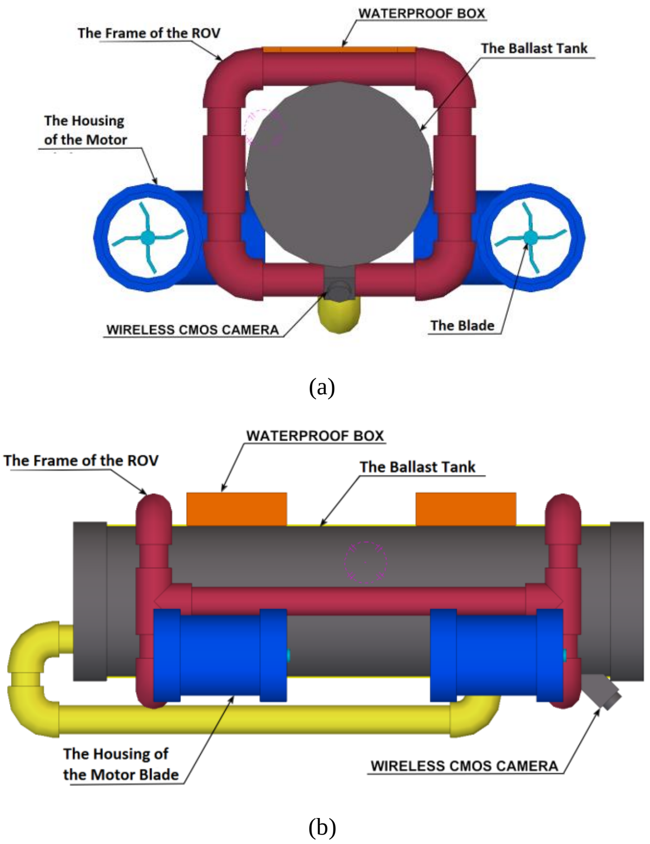

Figure 2. The 2D view of the ROV. (a) The front view. (b) The side view.

B. The Ballast Tank System

Figure 3 presents the ballast tank structure, where two motors, as shown in the figure, are embedded in the ballast tank used for pumping water into the tank and draining water out of the tank. When water is filled into the ballast tank, a few mechanism can be implemented. For example to pump, a special piston can be used to compress air in the ballast tank while the pumping motor pumps water into the ballast tank. In our current configuration, we just use a simple mechanism, where a pump-in motor is used to pump water into the ballast tank and a pump-out motor is used to drain water from the ballast tank. This mechanism is certainly simple but could have a specific problem.

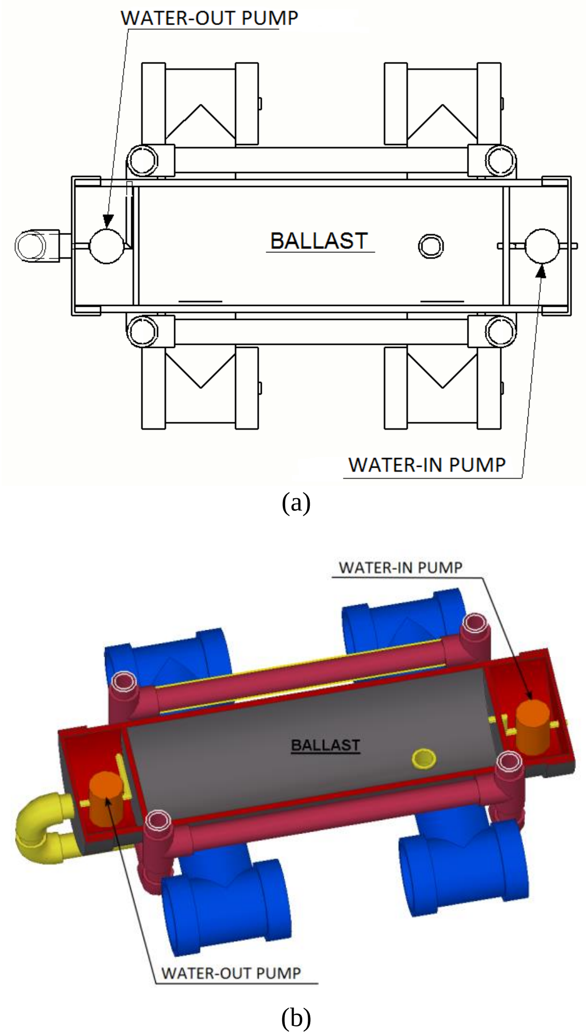

Figure 3. The ballast system for the ROV. (a) The top 2D view. (b) The perspective (3D) view.

IV. Hardware Implementation

The ROV consists of several important components such as the motor actuators, motor power drivers, ECU (electronic control unit) and transceiver circuits. We use local components to design the ROV's body. Six motors are used as the prime movers and two motors are used for the ballast tank systems. For remote operation, the ROV is equipped with a wireless communication system.

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A. The ROV's body

We have designed the ROV body as presented in Figure 4. The diameter of the ballast tank is 4inch, and length is 43cm. The size of the motor/blade housing is 12cm length and 2inch diameter. The blade housing is made from PVC pipe as well as the ballast tank. The first waterproof box or the larger one contains the electronic control unit (ECU) of the ROV, receiver module and other electronic instruments. The second box or the smaller one contains the trasmitter module of the CMOS camera used for trasmitting information from the camera to remote user host.

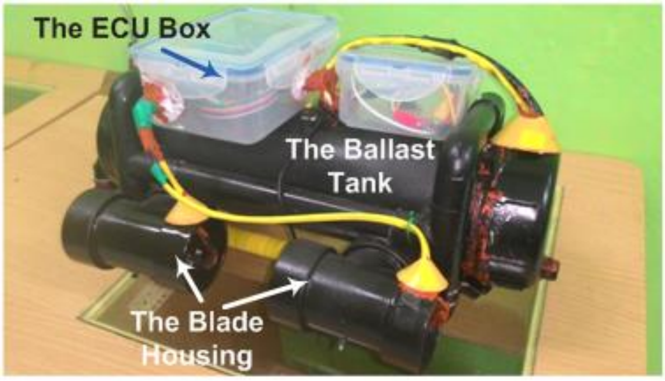

Figure 4. The photograph of the ROV.

B. Electronic Control Unit (ECU) and Wireless ReceiverModule

Figure 3 present the ECU (Electronic Control Unit) of the ROV. The main control equipment is an 8-bit microcontroller. Figure 6 present the schematic of the control unit circuit. The microcontroller from Arduino is used to control six motors. The microcontroller will use the guide or reference control signal from the receiver module, which receives the signal wirelessly from joystick transmitter hold by user from remote host. The microcontroller will then read the guiding signals and forward them to the motors via the power driver modules. The microcontroller pins connection with the receiver module pins are shown in Figure 6.

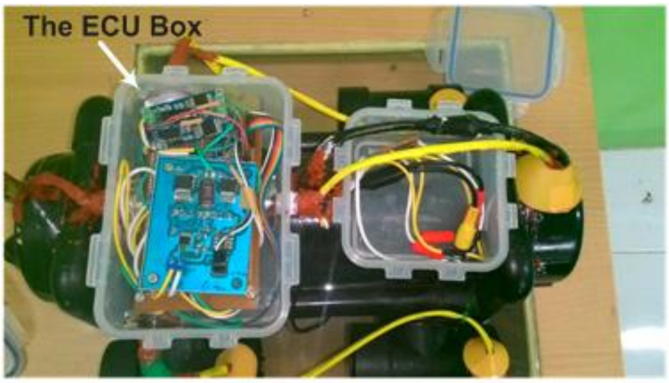

Figure 5. The Electronic Control Unit (ECU) of the ROV.

C. Motors and Driver Module

Four motors are used for maneuver on water surface and two motors are used to pump and drain water to/from the ballast tank for vertical movements. Two motor driver ICcs are used to power up the control signal from the microcontroller. The first one is used to drive two motors for the ballast tank, and the other one is used to drive four motors for the on-water-surface maneuver. Figure 6 presents the motor and driver module configuration.

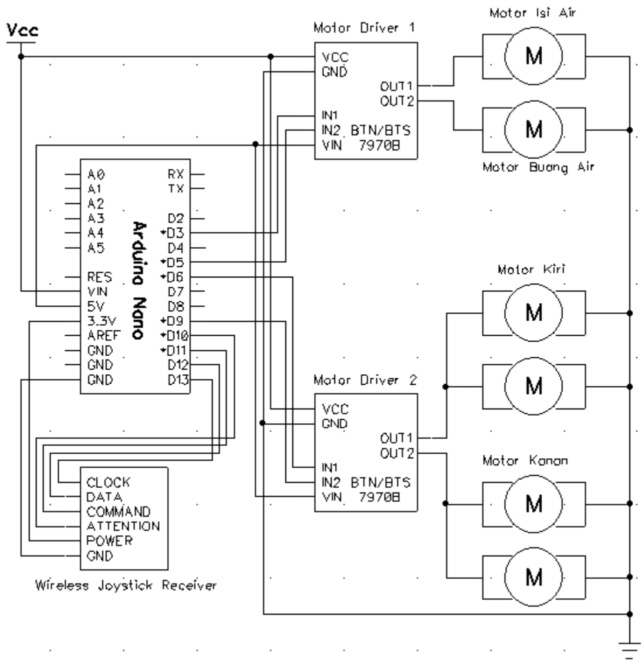

Figure 6. The schematic of the ROV's ECU and drive system based on microcontroller.

V. PERFORMANCE TEST RESULTS

There are four motors used for ROV's movements on water surface. The right turn of the ROV is enabled by sending actuating control signal to motors on the left-side, while the left turn of the ROV is enabled by sending actuating control signal to motors on the right-side. Sending concurrently actuating signal to motors on both-side moves the ROV to front direction. The control signal has been succesfully sent from the joystick to the receiver module mounted on the top of the ROV's body. The ROV is designed with simple control algorithm. In the future The ROV's mathematical model should be made [5]. [6]. This model is helpful to design a modern control mechanism that can ease the system navigation or handle ROV's maneuver with disturbance such as waves, underwater small turbulance, etc.

The ROV's performance has been tested on water surface. The test results present that the ROV can move on water surface with limited performance. The performance test result presents that for data communication on water surface, the maximum effective communication between the transmitter and receiver module is only 5 meters.

The performance test for under water movement has also been undertaken. For the vertical movements below water surface, the ROV can be controlled at maximum of 1.5 meters. This vertical move capability could be improved by using a sonar-based communication system. Moreover, the use of motors having better torque capacity is also recommended. The

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test result presented that the motor's temperatures became higher. The ballast tank pumping mechanism should also be improved.

The current ROV communication system uses 2.4 GHz wireless system. It seems that we should use a GPS system in such a way that the ROV can be controlled for further distances. The use of sonar communication system will also be considered.

VI. Conclusion and Outlooks

The ROV is built by using locally available materials. The selected material is probably not the best choice to design the ROV. In the future we hope that the best material can be used to design the ROV in such a way that its performance can be improved. Moreover, the motors selection as the prime movers of the ROV can be made better. Hence, the calculation of the total ROV weight can be optimally suited with the capacity and capability of the motors.

The designed ROV body will also be improved by taking into account the aquadynamics or hydrodynamics of the ROV's frame and body. Hence, the mathematical modeling of the ROV should be made and its parameters can be estimated using numerical computaional methods. The parametric mathematical model will be then used to optimize the ROV structure. The optimal aquadynamics or hydrodynamics can increase the performance of the ROV maneuver under water surface and ease the ROV's navigation..

The maximum effective communication between the transmitter and receiver module is only 5 meters on water surface, and the vertical movements can be controlled at maximum of 1.5 meters. The current ROV is controlled by using 2.4 GHz wireless communication system. In the future, we will use a GPS system such that the ROV can be controlled for further distances. The use of sonar communication system for deeper under water movements will also be recommended.

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