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Design and Construction of an Underwater Robot

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Abstract*—This paper describes a wirelessly controlled underwater robot that can move under water and it can be even controlled by an android smart phone very easily. An Arduino based platform in used to process, transmit and receive all information. There are many kinds of robots that have been designed and constructed with the development of computer and information processing technology. A low cost underwater robot and its Propulsion System are complete wirelessly using the combination of a pair of Arduino board and a pair of RF module that makes our project different. Six handmade waterproof thrusters control the Propulsion System horizontally and vertically of this robot. The camera of this robot works as eyes. This robot can be used in various purpose such as underwater environmental monitoring, oceanographic survey, pipeline and subsea structure inspection, debris inspection and more related purpose.*

Keywords*—Underwater robot, Low cost, Wireless system, Waterproof, Underwater monitoring*

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I. INTRODUCTION

In recent years, apart from other robots a variety of underwater robots have been designed and constructed, which was developed by many researchers. The main aim of this underwater robot was to solve various kinds of difficult work in oceans or other source of water. The main challenge of this project was that every part of this robot should be waterproof.

Researchers of CSIRO ICT Centre of Australia have successfully constructed a new robot for environmental monitoring on the Great Barrier Reef which has been focused at truly low cost robot [1]. A cylindrical shaped autonomous underwater vehicle whose main purposes are real-time visual simultaneous localization and mapping (SLAM), cooperative multi-vehicle navigation and perception-driven control was designed and constructed at University of Michigan [2].

A long and Cylindrical-shaped autonomous underwater vehicle was designed by the researchers of Technical University of Malaysia and University of Malaysia. The Propulsion System of this robot is very smooth. A horizontal propeller of this robot moves the vehicle forward and backward, a servo turns it left and right, a water pump system moves it up and down. When water injects into the water tank in the vehicle, the vehicle get down and when water injects out of the vehicle from the water tank, the vehicle flood on water [3]. There are various shaped underwater vehicle that have been designed in different area of robotics. An electrical system has designed for a spherical underwater robot. It has used three vectored waterjet thrusters for its Propulsion System. Thrusters are driven by one high power DC motor and a servo motor that can change the direction of thrust [4].

For the purpose of localization and tracking system, a team of researchers have done an experiment with underwater robot whose speciality is acoustic localization system [5]. A semiautonomous submarine is used specially for marine environmental research [6]. A remotely operated vehicle (ROV) which has a camera system and a gripper system has been constructed by PVC is designed by some researchers [7]. A navigation technology for autonomous underwater vehicle has been developed with advance battery capacity and the development of hydrogen fuel cell. The navigation system of this is accurate and it can be part of a longer mission [8].

Another remotely operated vehicle has constructed which includes a manipulator arm, water sampler, light penetration, temperature and depth [9]. The researcher of Kyushu Institute of Technology has developed an AquaBox series for shallow water observation [10]. After some years the researchers of University of Science and Technology of China have been designed a mini underwater robot which detects the underwater situation by

high definition camera [11]. There are various controlling systems for underwater vehicles such as Zigbee communication, light approach etc [12].

In our laboratory, we have designed and constructed of an underwater robot (Fig. 1 & 2) which can control wirelessly by an android smart phone via software. Six propeller propulsion the robot forward, backward, right, left, up and down. A camera has attached with it and a pair of light for brightens underwater darkness. The body of robot has made by PVC.

Fig. 1. Top view of Underwater Robot

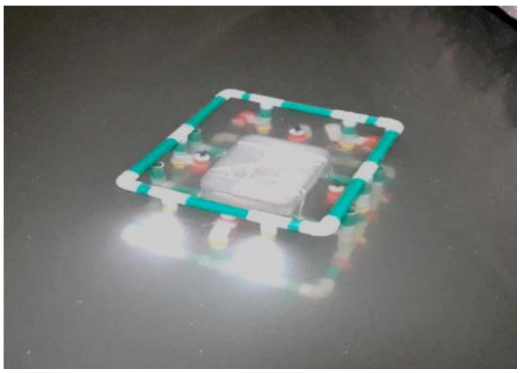

Fig. 2. Robot under water

II. METHODOLOGY

An underwater robot is a waterproof robot which can move in water that depends on user command. This robot has a transmitting part and a receiving part.

In transmitting part, an android phone is used instead of joystick. The android phone is connected with a Bluetooth module BC-05. The Bluetooth module is connected with a microcontroller (Arduino) and an Arduino hold a RF Transmitter (RF433Tx).

In receiving part, we have a RF receiver (RF433Rx). The receiver is connected with microcontroller (Arduino mega). Arduino mega hold motor driver IC.

When user sends a command through android phone, the transmitter transmits the command to receiver in the form of program which has already been defined. The receiver receives the command and gives it to Arduino. Arduino process the command by pre-set program. Then Arduino commands to motor driver and the robot starts to move. To move forward, horizontally installed motor of both side have to rotate in clockwise direction. To move backward these motor have to rotate in anti-clockwise. The vertically installed motors will remain in stop. To move left, one motor rotates in clockwise and another in anti-clockwise. To move right, one motor rotates in anti-clockwise and another in clockwise. The upper motors will remain in stop. To move upward, all upper motor have to rotate in anti-clockwise. To move downward, all upper motor have to rotate in clockwise. The both side motors will remain in stop.

III. SYSTEM DESIGN

A. Block Diagram of the Underwater Robot

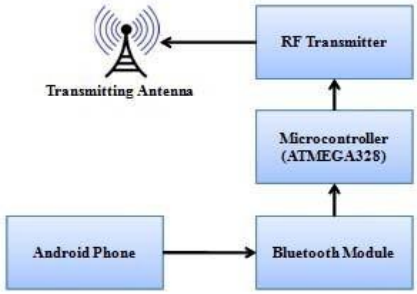

Fig. 3. Block diagram of controller of Underwater Robot (command transmitting part)

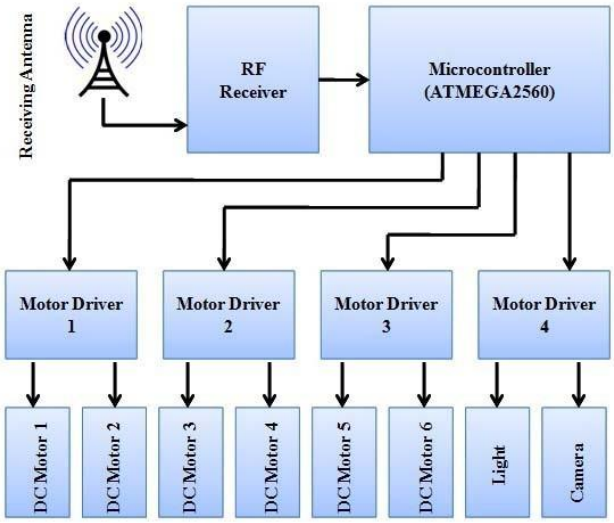

Fig. 4. Block diagram of Underwater Robot (receiving part)

As remote controller joystick, an android phone is used. ATC software is an android software which can control Arduino via Bluetooth. Firstly, commands send via android phone with ATC software to Bluetooth module in remote controller part. Bluetooth module sends these commands to Arduino and Arduino process the commands as pre-set programs. Then Arduino transmit the commands to main robot via RF transmitter with transmitting antenna. Fig.3 shows the controller system of this robot.

The main parts of a robot contains an antenna, RF receiver, Arduino, motor drivers, motors, lights, and camera. RF receiver receives the transmitted command from remote controller part of Robot via receiving antenna. Then RF receiver sends the command to Arduino. Arduino process the commands as pre-set programs and send command to motor drivers. Motor drivers drive the motors clockwise and anticlockwise as pre-set programs. Fig.4 shows the operation system of this robot.

B. Main Hardware

Arduino: Two Arduino boards are used in this project. Arduino is used for controller circuit and Arduino mega is used for the main robot as its brain.

Bluetooth Module: A Bluetooth module (BC-05) is used to connect smart phone with controller circuit. Any joystick software can be used from an android smart phone to control the robot. In this project ATC software is used as joystick. ATC software is a joystick controller software which can be configured as per requirement.

RF Module: A pair of RF module (RF433MHz) is used to connect controller to the robot. RF module is very good for low cost communication. It can communicate and send command up to 100 metres distance in an open space.

Motor Driver: Motor drivers (L293D) are used for driving motors, light and camera. In this project the supply voltage of motor drivers is 9 volts and the logic voltage is 5 volts.

DC Motor: Small and 9 volt DC motors are used to make thrusters. A big challenge was to make the motors waterproof and it was successfully done. Tape, wax, grease, glue stick and glue gun is used to make the motors waterproof.

Propellers:

Fig. 5. Thruster with propeller

In this project, thrusters are fully handmade. Turnigy 3 blade boat propellers (R3Px31x11), cartridge of empty pen, steel epoxy and sharp blade are used to make thrusters.
Camera: Camera is eyes of a robot. There are some waterproof cameras in market. A camera is connected in front of robot body. It requires 9 volts power supply. An important thing of this project is the camera and lights need not to be always on. The User can do ON/OFF anytime by sending commands using the controller. No wires are sighting outside of robot that is the beauty of robot.
Battery: Because of power hunger, battery as power supply is an important issue in a robot. Two 6 volts and 4.5Ah rechargeable battery in series (total 12 volts and 4.5Ah) are used to feed power to the robot.

C. PCB Design

Fig. 6. PBC of controller of Underwater Robot (command transmitting part)

Every robot has a motherboard. Motherboard commands a robot for movement. In this project, a PCB is designed as a motherboard of robot. Designing PCB is the main work of electrical circuit. Drawing PCB layout in Proteus is the 1st step of PCB design. Then the PCBs are printed & installing the electrical components is the final stage of the completion of PCB circuit.

The controller circuit (Fig.6) contains RF module, Bluetooth module, Arduino and an Omni-directional antenna. It also contains a charging system. Its input voltage is 6 volts.

Arduino input 6 volts. Rx pin in Bluetooth module is connected with Tx pin in Arduino & Tx pin in Bluetooth module is connected with Rx pin in Arduino. VCC pin of Bluetooth module is connected with +5 volts of Arduino and ground to ground. Then VCC of RF module is also connected with +5 volts of Arduino. RF module data pin is connected with Arduino digital pin12. RF module antenna pin is connected with an Omni-directional antenna. An LED (green) is connected with Arduino digital pin13 to indicate command transmission. Another LED (green) is connected in parallel with the power supply to show the power ON and a LED (red) is connected with the charging portion to show charger connection.

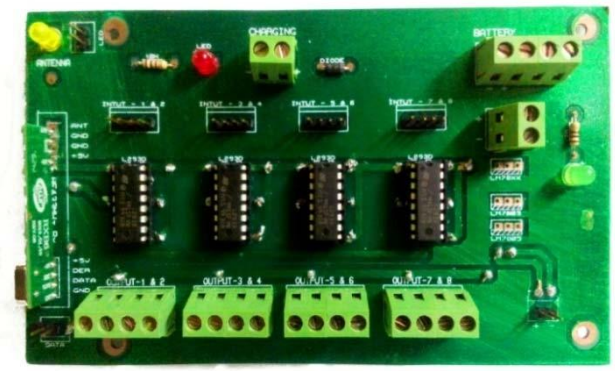

Fig. 7. PCB of Underwater Robot (receiving part)

The main circuit (Fig.7) of robot contains RF receiver, Arduino mega, motor drivers (L293D), 3 LED, Diode. VCC of RF module is connected with output of Arduino +5 volts. Data pin of RF module is connected with digital pin11 of Arduino. RF module antenna pin is connected with an Omni-directional antenna. An LED (green) is connected with Arduino digital pin13 to indicate for command transmission. Another LED (green) is connected in parallel to the power supply to show the power ON. And an LED (red) is connected with charging portion to show charger connection.

D. Structure Design

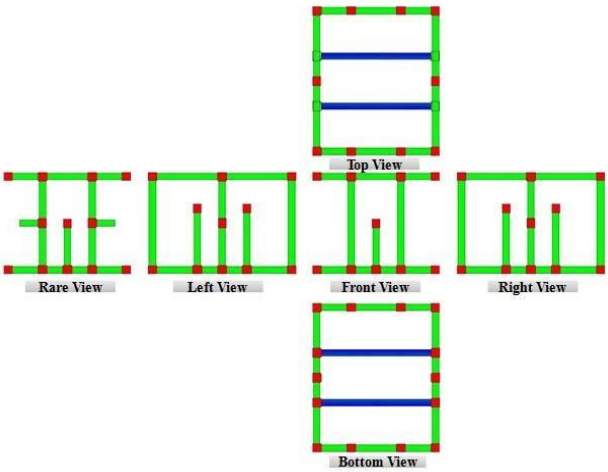

Fig. 8. Structure of Underwater Robot in AutoCAD

A mechanical structure is an important issue in designing a robot. Designing a structure in AutoCAD (Fig.8) is the first step of mechanical structure design of a robot. In this project a rectangular shaped mechanical structure is designed for robot. All mechanical view represents in figure 6 and the Isometric views of Underwater Robot. Measurement is important to indicate the robot size.

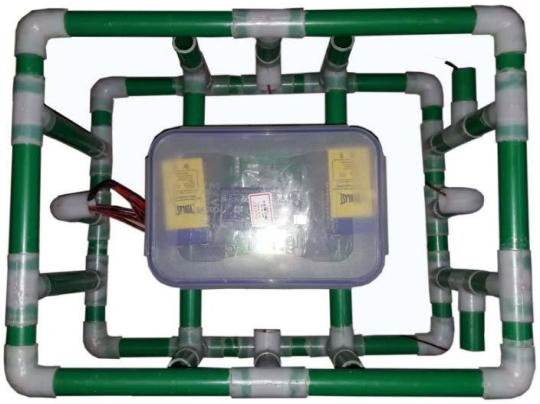

Fig. 9. The Structure of Underwater Robot

Fig.9 shows final mechanical structure of Underwater Robot. It is made of PVC pipe, pipe joint and glue. Rectangular shaped structure is easy to build with PVC so that this shape is chosen for this project.

IV. ADVANTAGES

The main advantages of this project are its simple design, low cost, wireless system and easy controlling. Applications of this robot are underwater environmental monitoring, oceanography survey, telecommunication support, underwater life inspection, pipeline and subsea structure inspection, debris inspection.

V. CONCLUSION

Being full charged, The Underwater Robot can run about 25-30 minutes. This duration increases if camera and lights remains OFF. The overall power consumption of this robot is 16 watts.

In this paper, we focused on the design of low cost controller and the motherboard of robot for easy and wireless controlling. There was some challenge to make every parts of this robot waterproof. After Overcoming challenges the robot was successfully constructed and tested in a big pond. The controlling system of this robot is very easy, smooth and fully wireless. Approximately the robot can be controlled from 50 metre distance. One of the master side of the robot is constructed by local parts instead of ready robotic kits such as thrusters, RC controller.

Currently, our team is working for enlarging the range of robot and minimize the size of the structure. We also planned to change the shape of mechanical structure into cylindrical for better stability and fast movement. A 4k camera, an arm and some sensor will be connected with this. We are going to have an experimental drive in the ocean to observe oceanographic environment and take data, images and videos.

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