Physical based model of an underwater ROV based on LabVIEW

Mohamed Hany Ahmed, Mohamed Ibrahim El-zayat, Eslam Mohamed elbinbawy

MTC, Egypt, mohamedhanyahmed1998@gmail.com, mido301054@gmail.com, eslammohmedmohamed59@gmail.com

Supervisor: Ahmed A. Badawy, Mohammed A. H. Abozied

MTC, Egypt, mohammed.abozied@mtc.edu.eg

Abstract-Remotely underwater vehicles are currently being utilized for scientific, commercial, and military underwater applications due to the large areas of water in our plant and many usages of the sea environment in the commercial field or military field which the unmanned underwater vehicle can perform the safety to the user in different fields. These vehicles require remote guidance by using a joystick modified with LabVIEW software to show the graphical user interface between the joystick and the motion of the ROV and control systems from the ground station and onboard station according to the mission and position of the ROV to perform underwater tasks. Modeling the system to ensure its required functions and all coupling between the components before making the deployment, system identification to the controller to create the transfer function of the controller (PID) and control of these vehicles are still major active areas of research and development.

This paper represents the steps to design and control a low-cost ROV and shows the full steps to design a low-cost ROV starting from choosing the materials, selecting the design, applying control and the used software

I. Introduction

ROV refers to a Remotely Operated Vehicle equipped with suitable sensors and actuators which enable it to navigate in the sea. This is a remotely operated vehicle because it executes the assigned mission with an external human to drive the vehicle from its position and it's the most important rule at present because about 70% of the Earth's surface is covered with water which is like an empire of natural resources[1]. To utilize these resources, mankind depends on developing underwater vehicles and employing them. The idea of submersible vehicles originated a long time back. Various types of underwater vehicles can be categorized into two categories namely manned and unmanned systems. In a manned system, we have military submarines and non-military submersibles operated for underwater investigations and assessment[2].

The type used in the paper is called Remotely Operated Vehicle (ROV) which is a tethered vehicle. The tether supplies power and communication to the ROV and it is controlled directly by a remote operator. These vehicles have their onboard power but are controlled by an operator through a communication link, many applications can be done using ROV like Unmanned Undersea Vehicle UUV identified the following missions: Intelligence, surveillance, and reconnaissance, Mine countermeasures, and Anti-submarine warfare[3].

in this paper, the software used is LabVIEW and chosen according to simplicity and provides a useful graphical user interface(GUI) that is also easy to implement by embedded systems such as myRIO to make the interface between the computer and the body of the vehicle.

II. HARDWARE IMPLEMENTATION

Mechanical Design: -

This is probably the most important step of all. every part is joined together to make sure that they don't come apart when it is underwater. To start, cut 14 sections of 25cm. Then cut 2 sections of 30cm.

Material	number
25cm	14
30cm	2
T connectors	4
90deg connectors	8

Table 1 Component of Mechanical Design

This table shows the components that are used in the mechanical design using PVC material which has the specific properties to achieve the required buoyancy under pressure and motion of the ROV underwater.

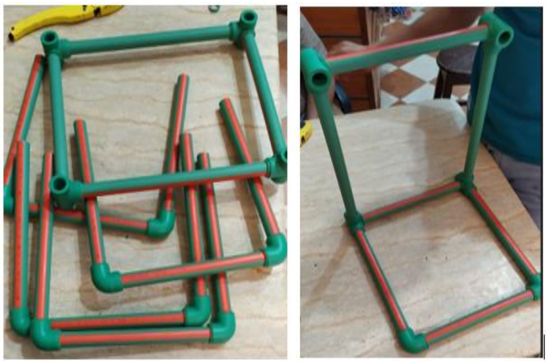

Fig 1 Cutting and joining the PVC

Fig 1 shows the real mechanical design steps starting from cutting the pipes into sections and then joining these sections with the “T connectors” and “90 deg connector” to reach the final body of the ROV

Fig 2 The final design of the ROV

the hull represents the structure and arrangement for the pipes to stand alone underwater with extended thrusters and embedded systems connected to the ROV and also achieve stability according to principles[4].

ELECTRICAL DESIGN: -

the type of the thruster used to provide the ROV motion is a bilge bump to achieve the low-cost ROV design and it is used as a thruster after modification is done to it using propellers 6 bilge bump is used 4 to provide forward, backward, right and left motion and 2 for up and down motion. The bilge pump is a ready-made DC motor in a watertight housing, the lower blue part is removed, Remove the little propeller so the metal axis is free[5].

Fig 3 Bilge Pump before and after cutting

cut around the white plastic, about 3 mm or so from the red area, Remove burrs with a sharp knife, preparing the propeller. remove its propeller due to the small shape and small effort to ROV. Using the threading tool, make a 4mm thread in the coupling bush up to halfway deep. Insert the decapitated bolt. then fasten a spring washer and the propeller. Put the propeller assembly on the motor axial, and fasten with the supplied little sideways screw.

Fig 4 Modified thruster with propeller

Assemble the cable two wires are coming out of the motor, it would be one round cable that can be put through a waterproof cable gland. I used the Raychem cable repair kit to make a waterproof connection to a round cable and also can glue-filled heat-shrink tubing of different diameters. Soldering the connections is the safest way to make the coverage of the wire from any leak of water to don’t make an electrical interrupt, after making the coverage to the wires the motors be able to operate underwater sufficiently as shown in Fig 5. one of the cables which used in communication is an ethernet cable connected with a small router to update the information and commands comes from the station which all the system coupled with each other “computer, power supply, driver, myRIO, the body of the vehicle and the joystick" with human driver to control on the system[6]

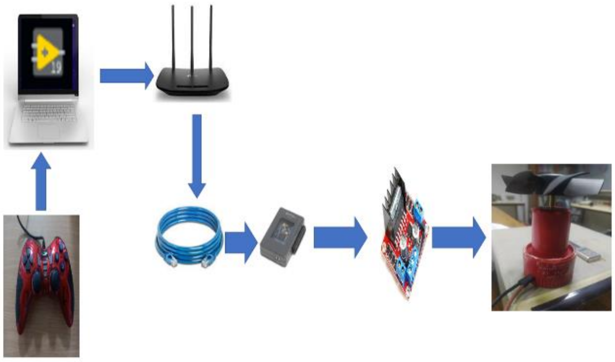

Fig 5 Electrical Design Implementation

To test the motor of the blidg pump, put the motor with the propeller into a box filled with water and by the power supply give 12V to the motor then the propeller turn in a specific direction. When changing the polarity of the motor, the direction of the propeller will turn in the opposite direction as shown in Fig 6.

Fig 6 Thruster under water

The driver used in the project is the "L298 module read board (dual H-bridge motor driver)" as shown in Fig 6. which achieves the low-cost design and best function required to interface between thrusters and myRio to provide the required voltage to the motor. fig.6 provides the terminals of the driver to enhance the connections between the other devices " myRio& motor".

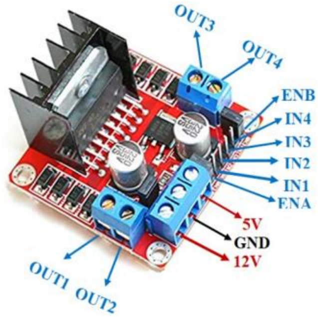

Fig 7 L298 Driver

III SOFTWARE IMPLEMENTATION

In this project, we use LabVIEW software as it provides a good GUI as well as is easier than other software as it uses blooks that perform a function and build the block diagram to control the 6-DOF of the underwater vehicle remotely by the joystick to provide its motion from the station.

the code provides a GUI to show the vehicle states it also shows the speed of each thruster these speed and states is controlled by a specified bottom as shown in Fig 7. which represents a different motion or state to the underwater vehicle and it is shown in the front banal, the code also provides 3 emergency bottoms which resets the code to default if any problem occurred through the experiment or any interrupts as follow in Fig 7.

Also shows the position of the thrusters and maximum and minimum speed values to be able to rotate and make a pitch, yaw, and rolling motion to make the vehicle free underwater and do the specific tasks cleverly, the design of the code depends on the system identification for the motors to set up the transfer function which defined as a (PID) control.

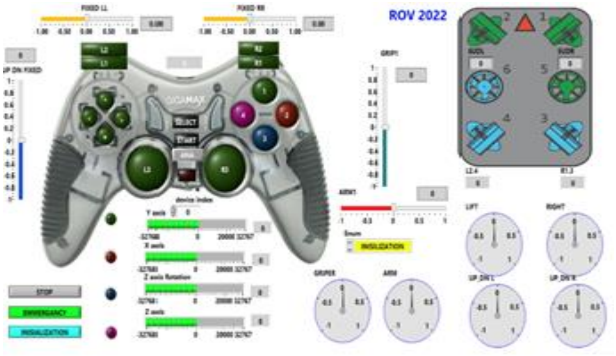

Fig 7 Software Implementation

IV Conclusion

The ROV was constructed and designed using inexpensive, readily accessible parts.

PVC pipes were used in the creation and implementation of the vehicle's mechanical design. The NI MY RIO 1900 was utilized to construct a full controller in the ROV to establish a complete control system for the vehicle. Depending on an external power source to provide the electricity, An easy and sophisticated user interface was provided through a wired communication system between the control station, which had a receiver, and the display unit. Last but not least, the system as a whole has been tested and will take part in a number of international contests.

V References

[1] T. I. Fossen and O.-E. Fjellstad, "Robust adaptive control of underwater vehicles: A comparative study," *IFAC Proceedings Volumes,* vol. 28, no. 2, pp. 66-74, 1995.

[2] A. J. Healey and D. Lienard, "Multivariable sliding mode control for autonomous diving and steering of unmanned underwater vehicles," *IEEE journal of Oceanic Engineering,* vol. 18, no. 3, pp. 327-339 %@ 0364-9059, 1993.

[3] S. M. Ahmad and R. Sutton, "Dynamic modelling of a remotely operated vehicle," *IFAC Proceedings Volumes,* vol. 36, no. 4, pp. 43-48 %@ 1474-6670, 2003.

[4] R. D. Christ and R. L. Wernli Sr, *The ROV manual: a user guide for observation class remotely operated vehicles*. Elsevier, 2011.

[5] C. R. Rocha, R. M. Branco, L. A. da Cruz, M. V. Scholl, M. M. Cezar, and F. D. Bicca, "Design aspects of an open platform for underwater robotics experimental research," 2014, pp. 318-325.

[6] J. Liu *et al.*, "Development of AUV Mechatronics Integration for Underwater Intervention Tasks," 2021, pp. 322-326 %@ 1665435763: IEEE.