Underwater Rover using IoT to Track Objects and Organisms under the Water

S. Thivaharan[1], S. Suparoopan[1], S. Gopy Prasath[1], S. Sanoj[1], T. Dinojen[1], P.Amrithaa[1], N.Lojenaa[1] and T.Kartheeswaran[2]

[1]Department of ICT, Faculty of Technological Studies, University of Vavuniya
[2] Department of Physical Science, Faculty of Applied Science, University of Vavuniya

Abstract

Since the underwater world is so complicated, monitoring the underwater has always been challenging. A successful underwater robotic technology could aid the discovery of many hidden insights. This may also facilitate the convenient unmanned observation of underwater obstacles, facilities like the underside of bridge pillars, and other installations like monitoring devices and marine cables. An underwater rover is constructed with motors and actuators and aimed to be outfitted with a camera to capture real-time images in a predefined interval, which are then transmitted to the base station for further processing. The base station will be furnished with sophisticated software that can identify unexpected alterations in relayed images. The planned rover has been tested for 3 hours at a speed of 0.3ms1 and up to 6 feet under the water using a Radio Frequency (RF) remote control. The rover may be upgraded with cutting-edge parts in the future to explore deeper underwater and run for longer periods.

Keywords: Arduino, Internet of Things, Image Processing, Monitoring Fishes, Object Tracking, Pipe Leakage, ROV, Sensors, Underwater

1 INTRODUCTION

A Remotely Operated Vehicle (ROV) is an unoccupied underwater robot that is linked to the operator via a series of cables or wireless transmission commands and control signals, allowing remote navigation of the vehicle. Our project is to create an underwater ROV equipped with a camera, sonar sensor, ultrasonic sensor, Light Dependent Resistor (LDR) sensor, video light, thrusters, rope, and frame to hold all components. Images can be captured using the camera installed in this ROV, which will be transmitted wirelessly to a base station (a processing device). These underwater ROVs are typically controlled by a person on the surface via a remote. These ROVs can operate at various depths and for extended periods under the water. These underwater ROVs will be more beneficial to seafood factories, fishermen looking for fish species, underwater construction engineers and architects, and the water supply department. This can also be used for monitoring and frequent inspections under water when necessary.

2 Objectives

The goal of this research is to build an underwater ROV that can detect different types of fish and cracks in underwater structures, which is difficult to do manually. Using a camera mounted on the ROV and image processing techniques, we can quickly identify the species of fish in the area. The image will be captured and transmitted via a wireless medium before being processed with image processing software to identify the fish species. This ROV can also identify cracks or damages in bridge columns or objects like marine cables. It will be more beneficial to the engineers to identify and monitor these objects for maintenance. This is primarily due to the fact that this device will be operated manually via a remote controller.

3 Related Works

We referred to different kinds of literature regarding underwater ROV, suitable technologies and methodologies that need to be studied from the existing works. Aguirre-Castros has conducted research to find or capture underwater videos using real-time remote-control communication via Ethernet protocol[1]. The enhanced thrusters' functions and input controls, as well as path maintenance and acoustic signals for ROV communication, were described [2]. Single beam sonar and multi-model wireless systems were used for obstacle tracking and communication by some of the researchers [3],[4].

Some low-cost underwater ROV implementations have been proposed, and captured images were processed through an algorithm for fish classification[5],[6]. Some of them used optical sensors [7], while others used pressure sensors to record the vibrations of the fishes [8]. Principal component analysis and other machine learning methods were used to track fish using shape and texture[9]. Fishes are tracked with 87% accuracy using a 360-degree camera and a Raspberry PI controller [10]. SURF features were used to track underwater architecture from images captured by a shaking video camera [11]. Barnes and Isaac proposed a method for processing images captured by a smartphone with a waterproof cover. It's intended for snorkelers, aquarium visitors, and fish identification tasks [12]. An ROV and image processing system based on homomorphic filtering and wavelet decomposition is proposed, as well as a curve evolution and filtering mechanism for tracking fishes has also been tried. [13].

Through the literature mentioned above, we learned more about ROVs and image processing in underwater objects and organisms and how others are using these technologies more effectively. For underwater object detection, we chose the sonar module instead of the radar module and powered it with two 11.1-V LiPo batteries. One of them powers the underwater ROV, while the other serves as a backup for emergencies. We intended to use the object identification features of SURF to find objects.

4 Methodology

The underwater rover in this work is primarily made of high tensile steel to withstand water pressure as the device moves in depth. Furthermore, the steel is lightweight to avoid the pressure caused by extensive weight, allowing the rover to go deeper. The ROV is designed to move vertically and horizontally using a 12V motor. The rover also includes an inexpensive sonar to measure depth and locate objects and organisms. A high ampere lithium battery supports the rover's motion. Waterproofing agents are also used to prevent water from entering the instruments. There are many different types of motors available, including 3V, 5V, 6V, and 12V. Instead of Arduino, the ESP 32 microcontroller is used because it incorporates both Bluetooth and Wi-Fi modules that operate at low voltage. The relay was altered in a way to obtain high voltage and ampere because the ESP 32's output (voltage and ampere) is insufficient for the motor. LED headlights are used to avoid excessive power consumption. Compared to other batteries, lithium batteries were chosen for the construction of this ROV because they are lighter, smaller in size, and have a high ampere with a long life. An RF receiver and transmitter were used to obtain the signal from deep water. We used two different sizes of gear wheels to handle the rover's motions. Figure 1 shows how the wheels are linked together. In this case, wheel A serves as an input, while wheel B serves as an output. Wheel B is fixed to increase the motor's torque due to the fact that as the speed decreases, the torque increases. The diagram of the circuit is illustrated in Figure 2 below.

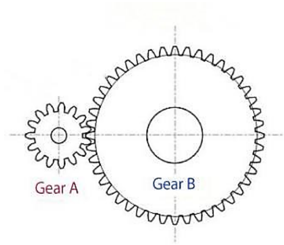

Figure 1. Torque control mechanism with gear wheels

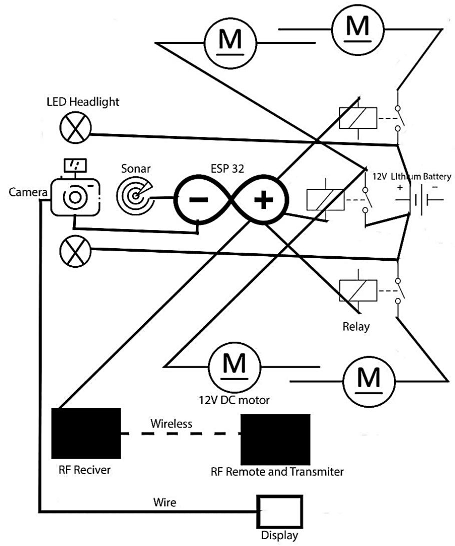

Figure 2. Circuit Diagram of the Under Water ROV (The symbol M indicates the motors used)

5 RESULTS AND DISCUSSIONS

An underwater ROV is constructed using the methodology we discussed above. The structure of the ROV is given in Figure 3 below.

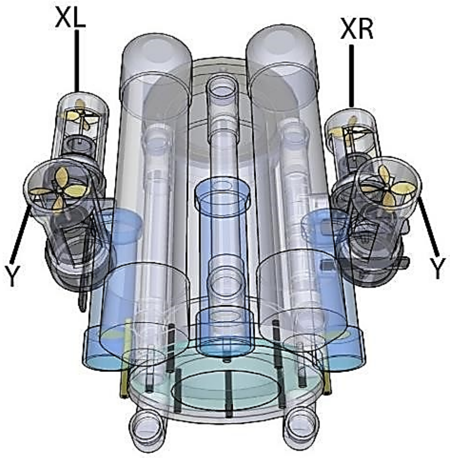

Figure 3. The overall structure of the Underwater ROV

Figure 4 depicts the underwater ROV's components. When the thruster Y is rotated to the right (clockwise), the ROV moves downwards; similarly, when it is rotated to the left (anticlockwise), the ROV moves upwards. Only when the XL thruster is activated does the ROV turn to the right or clockwise, whereas when the XV thruster is activated, the ROV turns to the left. The prototype

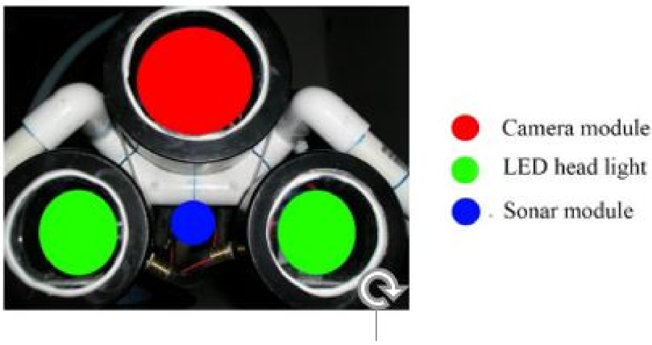

Figure 4. Components of the Under Water ROV

version of the proposed ROV is shown in Figure 5 below.
The prototype of ROV was tested in different depths up to five feet under the water with 0.3 ms-1 speed for three hours with RF remote control. The velocity of the ROV increased with the depth of the water until some level and then it became constant as shown in the graph given in Figure 6.

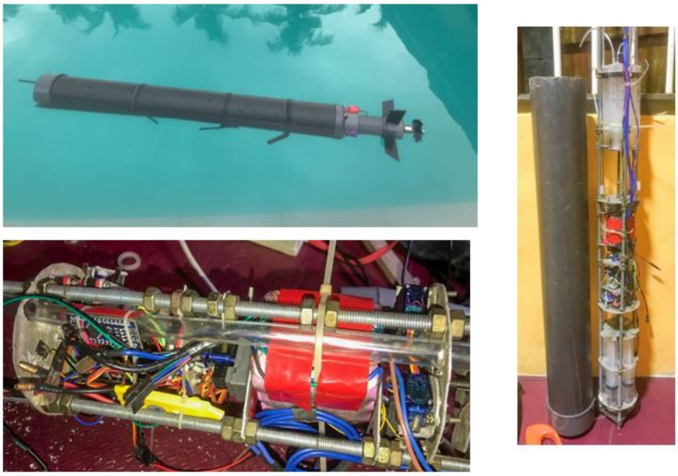

Figure 5. Prototype of the proposed ROV

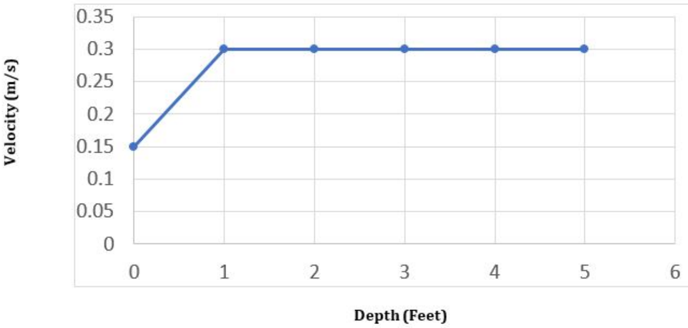

Figure 6. Velocity vs Depth Graph

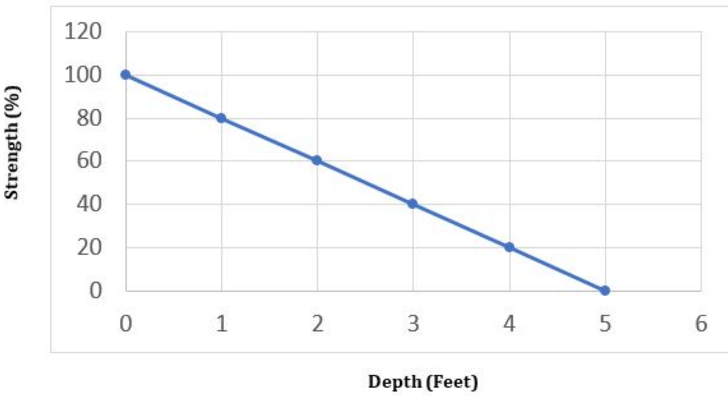

Figure 7. Strength of the ROV vs Depth Graph

Meanwhile, the strength of the radio signal received from the ROV in different water depths was also tested. The signal strength of the ROV decreased with the depth of the water. The following graph shown in Figure 7 is the result when mapping the signal strength received against the depth of the water.

Some challenges were faced during the implementation of the underwater ROV and while testing it inside water. The challenges arose during the implementation have been solved using alternative recommendations explained and listed in Table 1 below.

Table 1. Solution for the challenges faced

Challenges	Solution
Losing signal while going into deep water.	Building an external antenna.
Waterproofing.	Using a silicon tube.
Gap between the relay terminal.	Decreasing the terminal gap.
Coupler.	Using spring washer.
Rusting.	Application of oil in every use.
Charging the ROV to work for a longer period.	Used quick charger (used a charger of 3s 20A instead of 3s 10A.)
Syringe dislocation.	Using a cable tied with super glue.

6 Conclusion

An underwater ROV is designed to overcome challenges while working in all four directions such as up, down, left and right. Further, the underwater ROV works up to five feet in depth and is also able to be controlled remotely for three hours. Despite the fact that only the underwater ROV has been created in this work, it could be expanded by adding a 4k UHD-166 for a wide-angle camera to the rover to capture the images with a higher resolution. This underwater ROV can send the captured images to the base station where the images can be processed and help in making decisions. The rover can be used for crack identification, object distance identification, camera signal transmission, wireless camera signal transmission, and fish identification in the future by including the image processing component.

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