# Design and Fabrication of a Low-Cost Multi-Purpose Underwater Remotely Operated Vehicle

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# Design and Fabrication of a Low-Cost Multi-Purpose Underwater Remotely Operated Vehicle

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***Abstract*—** Remotely Operated Underwater Vehicles (ROVs) are emerging potential technology for ocean research, environmental and geochemical studies, mine hunting, surveillance, and commercial usage. Due to their affordability, simplicity in handling and deployment, appropriateness for deep-sea diving, increased mobility, and ability to operate in harsh settings, underwater vehicles—both autonomous and remotely controlled—have grown in popularity. The goal is to develop and test a remotely operated underwater vehicle (ROV) that is lightweight, affordable, and capable of conducting surveys in shallow waters. The design, production, and experimental findings of such an ROV are the focus of this paper. The mechanical design, thruster characteristics, electrical systems, and software architecture of the graphical user interface (GUI) for the proposed vehicle are all thoroughly explained. In contrast to autonomous underwater vehicles, the planned ROV is totally controlled from the base station using a live camera feed and other sensors (AUV). In contrast to the majority of AUVs, it provides real-time results from its various sensors and takes human commands via two-way communication. Comprehensively addressed, the results and answers are provided. Constraints on the mechanical design's weight and portability, electronics' power requirements, and the length of the umbilical cord are all addressed. It is also explored how to strengthen the paradigm and make it a for-profit enterprise with more improvements.

***Keywords—Marine, Robotics, Underwater Vehicles, Autonomous Robots, ROV***

## I. INTRODUCTION

In the beginning, manned underwater vehicles were utilized for the investigation and comprehension of various biological, chemical, geological, and geophysical phenomena taking place in the depths of oceans, rivers, and lakes. Project FAMOUS [1] was the first human underwater vehicle to be used to examine various underwater phenomena along the Mid Ocean Ridge (MOR) [2] in the 1970s. Robotic manipulators are becoming increasingly adept at interacting with settings and industrial applications that humans have created [3]. Current capabilities include deducing complex manipulation goals and movements, exploring unknown objects tactilely, and interacting with both humans and robots [4]. However, compared to humanoid, terrestrial, and aerial robots, the likelihood of using these improvements in underwater applications appears to be lower. It is only logical to ask what challenges need to be resolved in order to fully realize the potential of underwater manipulation. To ascertain whether manipulators can facilitate the difficult, or maybe impossible, human labor needed for underwater rescue, intervention, and maintenance operations, it is vital to understand the limits [5]. Over the past few decades, there have been a number of notable breakthroughs in the field of underwater manipulation [6]. Most of the research into remotely operated vehicles (ROVs) was funded by the US Navy in the 1960s, and one of their vehicles, the Cable Controlled Underwater Recovery Vehicle I (CURV), was used to recover an atomic bomb from the Mediterranean Sea following the crash of the Palomares B-52 [7]. However, the first academic ROV, known as JASON, and a relay vehicle known as MEDEA were developed in 1982 [8]. The majority of significant developments in the field's applications have come about as a result of multi-partner research partnerships. One of the earliest projects to carry out a predetermined valve-turning task was ALIVE (2001-2004), which was followed by TRIDENT (2010-2012), which performed teleoperated manipulation tasks. Most recently, OCEAN ONE (ongoing since 2016) has focused on improving the operator experience during manipulation via human-robot interaction, in contrast to PANDORA (2011-2015), which had a target on semi-autonomous manipulation [9]. The act of communicating underwater is challenging. The base station and ROVs have communicated using a variety of wired and wireless communication methods. One type of wireless communication uses sound waves, or acoustics, although there are issues with communication speed and bandwidth [8]. It also has difficulty with the energy of the signal, which decreases with the square of the travel distance. Although radio waves are also utilized for communication, they have several drawbacks [10]. Since water is not pure, increasing the frequency weakens the signal, making low frequencies preferable. Larger transducer sizes, however, are necessary at low frequencies it is unrealizable [11]. Point-to-point wireless underwater communication also uses optical transmission, but it disperses, which is a problem [12]. The best method of underwater wireless communication is acoustic. Although these techniques are useful, their cost is higher. Therefore, for this project, the tethered connection is chosen over wireless. Different types of wires, such as optical fiber or Ethernet cable, can be utilized in tethered communication [13]. Recently, a range of underwater robots in addition to other robots have been conceived, built, and produced by a number of dedicated researchers. With an underwater robot, a variety of difficult tasks can be completed swiftly in the ocean or any other body of water [14]. Every component of this robot must be waterproof, which is both a key necessity and the project's main problem because cleaning canals and rivers requires a lot of people and expensive equipment each year[15]. With a small crew, ROVs are beneficial for several uses. For many years, hydel power plants have provided the majority of the country's energy demands. These vehicles can be used to find silt, cracks, corrosion, and defects because these facilities are old and need routine maintenance [16]. For operations involving manufacturing, assembling, packaging, and inspection, robotics has been applied in a number of industries [17]. Numerous tasks can be carried out underwater. Such tasks must be done by trained people and are difficult, and additional safety measures must be adopted. A coastal area has seen a fiber optic cable break. Since there isn't much oxygen present underwater, getting to it is difficult for people [18]. Robotics can carry out the same operation without using oxygen. Fiber optic cable inspection may be done by robots submerged in water. They can also be used to search beneath the seas for precious jewels [19].

### *A. Statement of Purpose*

For operations involving manufacturing, assembling, packaging, and inspection, robotics has been applied in a number of industries. Numerous tasks can be carried out underwater. Such tasks must be

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done by trained people and are difficult, and additional safety measures must be adopted. A coastal area has seen a fiber optic cable break. Since there isn't much oxygen present underwater, getting to it is difficult for people. The same tasks can be completed by robots without the need for oxygen. Fiber optic cable inspection may be done by robots submerged in water. They can also be used to search beneath the seas for precious jewels. The main goal of this project is to construct a unique underwater robot that can be operated remotely underwater for monitoring and inspection requirements. When immersed, it ought to be able to grasp and grab objects. Undersea drilling is also included in the proposed design. The robot should be able to perform challenging tasks that are challenging for humans, such as underwater surfing. Human-free underwater driving while surfing, examining underwater sensors, wires, and drills, Looking for lost items like airplanes, boats, and submarine wrecks, Exploring the seas' hidden resources, Locating undersea gas and oil sources, Underwater treasure and pearl hunting, etc.

### B. *Modularity*

Prior underwater vehicles had fixed platforms or point designs, which limited their ability to adapt to changing mission needs. There were two ways to add new equipment to these vehicles. Fitting the equipment within an already-existing void is the first method for increasing the payload on a permanent platform. There isn't much space for fresh payloads because AUVs are normally made as small as possible. The only other option is to add equipment externally to the vehicle's body or fairings if cargo cannot be added internally. The performance and characteristics of a vehicle could be drastically changed by adding equipment to the body. For instance, REX II has recently been modified with new sensors to support additional research goals. The new sensors were mounted to the port and starboard sides of the vehicle using specialized mounting brackets because there wasn't much room for further payload. The vehicle's speed decreased as a result of higher drag caused by adding more sensor payload. This has little effect on runtime and top speed for a slower non-cruising vehicle. The Didemnum Cruiser [20] is designed to travel vast distances, therefore adding a sensor outside the primary the vehicle's speed decreased as a result of higher drag caused by adding more sensor payload. This has little effect on runtime and top speed for a slower non-cruising vehicle. The module concept was used to create the design that was put forth in this paper. The overall layout is divided into important elements (modules) that when combined form the overall design. The beginning design is composed of numerous fundamental modules. Without drastically altering the general body style, the base vehicle can simply take additional modules to increase its overall flexibility and capability. The battery module, electronic module, and thruster module are the modules that make up the basic design. The base vehicle includes a number of features that make modular construction possible. Pass-throughs are incorporated into the frame sections for the battery and electronics modules to allow signal and power cables to run from the power supply for the sensors and thrusters and a central computer.

## II. MECHANICAL DESIGN

Major considerations including man mobility, drag force, and overall cost are taken into mind when designing the mechanical body for the ROV enough room for the payload, onboard power, and electrical components. The vehicle is made to be readily recovered by two to three people and may be launched, controlled, and handled without the use of complex equipment. Off-the-shelf parts are employed to keep the price of the car down. The first design only allows for mobility in two directions: forward/backward (surge) and upward/downward (heave). The ROV's thruster, which is placed on the back side of the main hull, propels it forward while changing the vehicle's overall density causes it to move vertically. Parallel to the main pipe, two water chambers are placed. The water is between 0 and 28 °C and between 28-31% Salinity [11]. At the moment, useful objects can only be manually caught. To hunt for goods, workers must tie more than 30 kg of lead lump to the ocean floor. The team captures the item when it is discovered and puts it in a net. The crew raises to the surface and delivers the net to a boat partner after the net is full. After that, they keep entering the water and repeat the process repeatedly. Because there are no safety precautions in place and employees only have access to tens of meters of breathing tubes and shore contact, fishing mishaps are common. In addition, because the deep sea is cold and under tremendous pressure, workers' health is seriously endangered.

The procedure is as follows: the camera identifies the object; and the propeller directs the robot to pass directly over the object. The position is adjusted; the fishing gadget is lowered to catch the object; it is retracted, and the item is placed in the storage box. The fishing system, transmission system, propulsion system, and balancing and positioning system are the four main components that make up the underwater anonymous robot's overall system. The propulsion system has a propeller and a redirection mechanism, while the fishing system has an end effector and a mechanical arm. The transmission system also has a transmission device and a sea items storage box. The method for balancing and positioning comprises a positioning device and an attitude stabilization device. The subsystems are strongly coupled during the design phase rather than being comparatively independent. When designing, it is necessary to consider how they are related and come up with a roughly optimal design strategy outlining the concepts for anti-collision airbags, conveyor systems, propulsion systems, fishing systems, and balancing and positioning systems [13] [14].

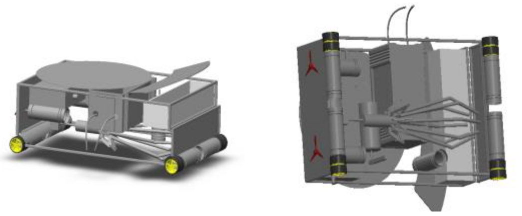

*Figure 1. (a). Top [left] (b). Bottom [right] view of UAV*

Each subsystem has the following functions:

- The end-design, with effectors that can seize items in the sediment and reef of the seabed.
- Due to the mechanical arm's design, this subsystem may convey the end-effector and carry out the task of fishing for items.
- By utilizing a conveyor belt and storage box, this component may group gathered items to increase fishing productivity.
- The design of the reversing mechanism, which can alter the direction of the driving force to control the direction of movement.
- The design of the propeller can provide the driving force for the underwater robot.
- The propulsion system's propulsion system is designed with an attitude stabilization device and positioning device that can determine the attitude and location of the underwater robot.
- With its airbag design, this component can shield an underwater multi-purpose robot from a strong hit.

An autonomous underwater vehicle with a cylinder and a long form has been developed by researchers from the Technical University of Malaysia and the University of Malaysia. The propulsion system on this robot moves smoothly. The car is driven both forward and backward. By a horizontal propeller, a servo for left and right turning, and a water pump system for raising and lowering. A vehicle sinks when water is pumped into its water tank, and it floats on water when water is injected out of the water tank [7]. Numerous robotics sectors have produced a variety of underwater vehicles. The electrical system of a spherical underwater robot has been developed. There were three vectored waterjet thrusters in its propulsion system. The thrusters are driven by a single, powerful DC motor, and the thrust direction is managed by a servo motor [8]. The electrical system of a spherical underwater robot has been developed. There were three vectored waterjet thrusters in its propulsion system. The thrusters are driven by a single, powerful DC motor, and the thrust direction is managed by a servo motor [8]. In order to create a localization and tracking system, a research team tested an underwater robot employing an auditory localization system [9]. A semiautonomous submarine is used to conduct studies on the marine environment [10]. A PVC-made remotely operated vehicle (ROV) with a camera system and a gripper system has been developed by some researchers [11].

## *A. Drag Force*

Drag force is the force that opposes an object's motion relative to the surrounding fluid in fluid dynamics. Both torpedoes and submarines have a streamlined body with a central cylinder that serves as storage for a variety of instruments, weaponry, and precious life[21]. Due to its strength and capacity to adapt to the dynamic forces exerted on it, the hull utilized is typically cylindrical in shape [22]. Although it is more structurally efficient than other designs with the same geometrical dimensions, the space it offers for the systems residing inside is smaller. This is because every system installed there is typically square or rectangular. We shall provide two approaches for calculating the drag force. Two types of drag, namely skin friction drag and form drag or pressure drag [23], are said to act on the body using this technique. Both increase the body's experience of viscous drag [24].

$$C_D = C_{D,press} + C_{D,friction} \qquad [1]$$

$C_D$, $C_{D,press}$ and $C_{D,friction}$ represent coefficients of viscous drag, pressure drag and friction drag respectively [25]. Skin friction drag coefficient (CF) is a function of Reynolds number (Rn) which is given by the following expression. [26]

$$C_F = \frac{0.075}{log\, R_n - 2} \qquad [2]$$

$$R_n = \frac{pVL}{\mu} \qquad [3]$$

$p$ is the density of the fluid, $V$ is the velocity of the vehicle, $L$ is the diameter of the vehicle and $\mu$ is the dynamic viscosity of the fluid. Viscous resistance coefficient $c_v$ is then computed to find the drag force. For this, we use the following expression [26],

$$c_v = C_F[\, 1 + 0.5\left(\frac{d}{L}\right) + 3\left(\frac{d}{L}\right)^3] \qquad [4]$$

The drag coefficient and drag force can be calculated from the given formula,

$$F_D = \frac{1}{2} pV^2 A C_D \qquad [5]$$

## *B. Thrust Force*

The vehicle is propelled by thrust force in order to overcome any drag or friction. There are several ways to supply this force. Using an underwater vehicle as an example, a brushless DC motor Among these is buoyancy-driven propulsion [21], jet pumps [22], [23], modified bilge pumps, and (BLDC) based propulsion [29]. We have used a straightforward propeller to generate the necessary thrust for our vehicle. The propeller's angular velocity, blade profile, sweep area, medium density, and advance ratio are the key variables controlling this force. For the theoretical computation of the thrust force, various methods have been described in the literature [21] [24]. Thrust force is calculated, it is the propeller thrust, T is the thrust coefficient, $K_T^a$ is the propeller disk diameter and $\Omega$ is the propeller shaft speed.

$$T = K_T^a p^{D^4} \Omega^2 \qquad [6]$$

Thrust coefficient is a function of the advance ratio ( $J_0$ ), velocity, D is the propeller disk diameter and $\bar{y}$ is the propeller shaft speed [25],

$$J_0 = \frac{\mu}{D\Omega} \qquad [7]$$

*Table 1. Vehicle Parameters and Value*

| Vehicle Parameters | Value | Unit |
|---|---|---|
| Vehicle Material | Aluminum | |
| Total Mass of Vehicle | 15.3 | Kg |
| Length of main hull | 878.34 | mm |
| Length of water chamber | 900.45 | mm |
| Diameter of water chamber | 120 | mm |
| Density of water | 998.2 | Kg/m$^3$ |
| Dynamic Viscosity of water | 1.002x10$^{-3}$ | Pa.s |
| Nominal Speed | 0.265 | m/s |

## *C. Density Change*

As was already noted, water chambers are utilized to alter the vehicle's density, which makes it easier for it to sink and float. Pumps for water are used to fill and empty the chambers. The relationship between the vehicle's density and cylinder mass is depicted in Figure. The graph shows that when the cylinder mass passes the 5 kg threshold, the entire vehicle approaches the density of water. Pumping water into the chambers of the vehicle increases its bulk, causing it to sink. Water is pushed out of the water chambers to make the vehicle float.

## *D. Sealing and Waterproofing*

The most crucial aspect to take into account for the integrity of the vehicle's operations is waterproofing. The primary hull has two translucent acrylic discs mounted on either end. These discs have an unbreakable seal. These discs are set up to allow for a fast visual assessment of the main hull's interior. By removing the cap on the backside of the main hull, the electrical plate can be removed. Threads on the cap and the main hull act as mechanical seals. In addition to using threads to waterproof the main hull, O-ring seals are also utilized. This aperture is used to pass the water pumps' umbilical cord and connectors. Prior to deciding on the best housing material, a cost and weight comparison of CPVC and Aluminum 6061 pressure housing designs was done. Equations regulating pressure housing for a 30-meter depth rating needed relatively small housings because matching materials were housed in cylinders with thin walls. From the figure below, we see that aluminum offers a slight weight reduction at shallow depths. To verify the outcomes based on the ASTM computation, further Finite Element Analysis was done on the CPVC housing. To verify the outcomes based on the ASTM computation, further Finite Element Analysis was done on the CPVC housing, Table 2 displays the FEA Analysis's findings. The maximum calculated collapse pressure comes out to be 117 psi at 50 m with a safety factor of 2.45, while the ASTM has a value of 125 psi with a 1.96 factor of safety. The vent plug performs two crucial tasks for the vehicle's operation in addition to sealing the end caps. To verify the O-Ring seal before usage, a vacuum can be drawn through the vent plug. Additionally, it enables pressurization of the system, which makes it simple to remove the end caps. The SAE #4 bolt with two O-ring seals serves as the foundation for the PREVCO vent plug.

*Table 2: Pressure Housing Strength Analysis*

| | **FEA Results** | **ASTM Results** | **% Diff** |
|---|---|---|---|
| **Collapse Pressure [psi]** | 117 | 125 | 7% |
| **Collapse Depth [m]** | 50 | 50 | - |
| **Factor of Safety** | 2.45 | 1.96 | - |

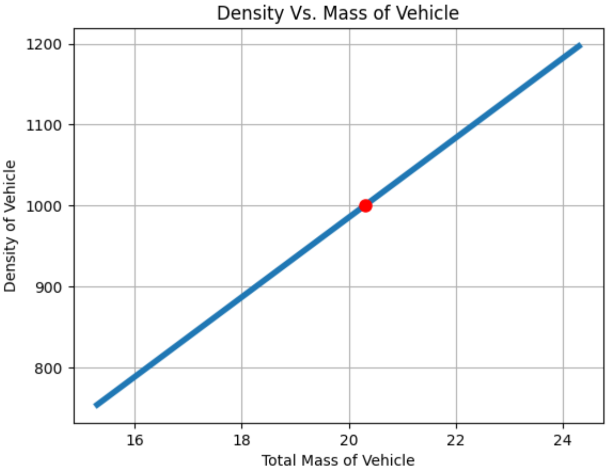

*Figure 2. Mass vs. Density of the Vehicle*

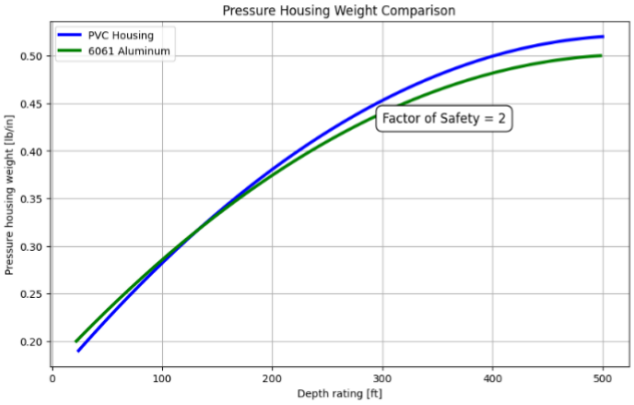

*Figure 3. Pressure Housing Weight Comparison*

## III. ELECTRICAL SYSTEM

### A. *Arduino Uno R3*

Based on the ATmega328P CPU, the Arduino Uno is an open-source microcontroller board created by Arduino.cc. The board has input/output (I/O) pins for both digital and analogue signals that can be used to connect to other circuits and additional boards (shields). Six of the board's fourteen digital I/O pins and six of its six analogue I/O pins can be used to produce PWM. The Arduino IDE (Integrated Development Environment) and a type B USB connector can be used to program it. A USB cable or an external battery with a voltage range of 7 to 20 volts can power it. The Arduino board serves as the robot's main work surface in this project and all of the modules and sensors are connected to the Arduino board.

### B. *GPS*

At least 24 satellites make up the Global Positioning System, a satellite-based navigation system (GPS). GPS operates throughout the world, 24 hours a day, in all weather conditions, with no setup or membership fees. The u-blox NEO-6M GPS chip serves as the module's brain. With the highest level of sensitivity in the sector (-161 dB tracking) and only 45 mA of supply power, it can monitor up to 22 satellites on 50 channels. The Time-To-First Fix (TTFF) of the U-bloc 6 positioning engine is likewise below one second. Power 24 Save Mode is one of the chip's finest features (PSM). It reduces system power usage by selectively turning ON and OFF individual receiver components. The module's power consumption is thereby drastically reduced to just 11mA, making it appropriate for power-restricted applications like GPS wristwatches. The NEO-6M GPS chip's core data pins are separated out onto headers with a "0.1" pitch. This also has the pins needed for UART communication with a microcontroller.

*Table 3: Arduino Uno R3 Specifications*

| **Hardware** | **Arduino** |
|---|---|
| Type | UNO R3 |
| Microcontroller | Atmega 328P |
| Functionality | Collect and Manage Data |

*Table 4: NEO 6M GPS Module Specifications*

| **Hardware** | **NEO 6M GPS Module** |
|---|---|
| Update Rate | 1 – 5 Hz |
| Sensitivity | -161dBm |
| UART Baud rate | 9600 |
| Operating Voltage | 3 – 5 V |
| Function | Location Tracking |

### C. *nRF Module*

A wireless communication module is called nRF. This module can be used to build RC cars, RC boats, drones, robots, and airplanes. It can send and receive data up to 100 meters away from an open area. It employs radio waves to function. SPI is the method of communication used to send and receive data between the Arduino board and the module, and the 2.4GHz frequency is also employed in the design of these modules. A pair of nRF modules are used in this project to transmit and receive data to and from the user terminal and robot.

### D. *ESP32 Camera*

The ESP32-CAM is a fully functional microcontroller with an inbuilt video camera and microSD card connector. For Internet of Things (IoT) devices that need a camera with sophisticated features like image tracking and identification, it is useful. It is also affordable and simple to use. In this project, we've utilized an ESP32 camera to wirelessly track the robot's movements and the underwater environment.

### E. *Light Source*

The light-emitting diode is the most energy-efficient and rapidly developing type of lighting technology currently accessible (LED). High-quality LED bulbs perform better than other types of lighting in terms of durability, lifespan, and light output. An LED light is powered by a 12V battery. Since sunlight cannot travel very deep beneath the ocean's surface, it is used as light. We came to the conclusion that employing green light in parallel to regular lights with a range of about 10 meters would attract marine creatures and increase the likelihood that we would be able to capture them after studying the psychology of fish and other sea creatures [15].

*Table 1: ESP32-CAM Specifications*

| Hardware | ESP32-CAM |
|---|---|
| RAM | 520KB SRAM +4M PSRAM |
| Wi-Fi | 802.11 b/g/n/ |
| UART Baud rate | Default 115200 bps |
| Operating Voltage | 5V |
| Security | WPA/WPA2/WPA2-Enterprise/WPS |
| Max Support TF Card | 4GB |

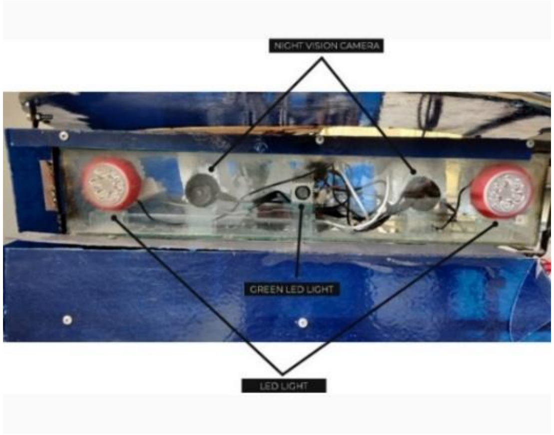

*Figure 4. Light Source Placement*

## F. Power Consumption and Source

The final battery selection leveraged the propulsion powering estimate and hotel load estimate to determine the total power consumed by the vehicle during operation. The total power was used to find the threshold value of energy needed to achieve the desired run time of 3.5-4 hours. Using the energy requirement as a threshold, three potential batteries were selected and evaluated from an energy density, volume, and cost perspective. The first battery option consisted of creating a custom battery pack made of cylindrical Lithium-Ion cells similar to the cells found in the REX II custom battery pack. The second option required 2 prismatic Lithium Polymer battery packs, linked in parallel to provide the requisite capacity. The final option evaluated was a large Lithium Polymer pack. Both Lithium Polymer packs included battery management cards which allow the voltage of each cell to be monitored during both charge and discharge [17, 31]. In our study, we looked into three different types of rechargeable batteries. Cylindrical Lithium-Ion batteries, the first category, with a total volume of 0.0025 m3 and a total weight of 3.67 kg. The combined energy capacity of these batteries was 1.10 kWh, resulting in an energy density of 436.638 kWh/m3. The "Type 1" prismatic Li-Polymer cells made up the second category. These cells weighed 6.23 kg overall and had a higher total volume of 0.0038 m3. With a higher total energy capacity of 1.32 kWh, the batteries in this category had a higher energy density of 345.361 kWh/m3. The "Type 2" Prismatic Li-Polymer cells were found in the third category. These batteries were the lightest, weighing 4.11 kg while having the smallest total volume of 0.0010 m3. They did, however, have a remarkable total energy capacity of 1.10 kWh, which led to an incredibly high energy density of 1142.137 kWh/m3. The optimum battery option from three categories was chosen using a selection matrix. Battery Volume, Total Weight, Total Cost, Total Energy, and Energy Density were among the variables that had weights assigned to them. While Total Energy and Energy Density received larger negative weights (-2 and -3) for higher values, Battery Volume and Total Weight received higher negative weights (-2) for lower values. The weight of Total Cost was -1. This research helped us choose the best battery for a given application, guaranteeing that we used battery technology in the decision-making process.

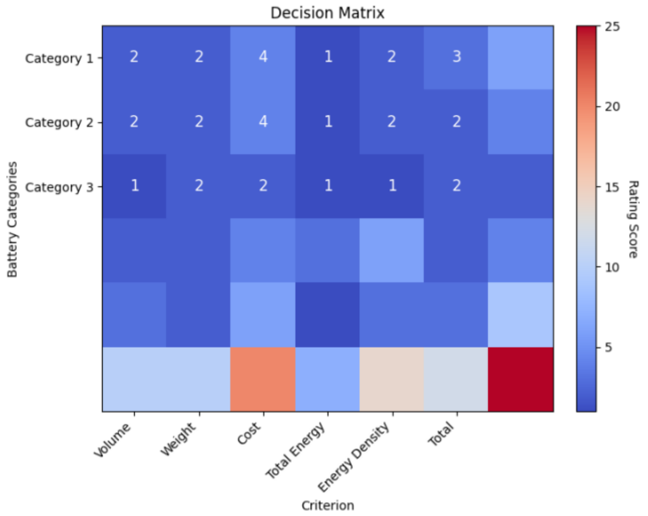

*Figure 5. Battery Decision Matrix*

## G. Propellers and Servo Motor

A propeller is something that moves. It is made up of a central hub and radiating blades that are stacked and twisted to make each one a part of a helical surface (like an aircraft or ship) [26]. The project's propeller is displayed. Its diameter is ten inches. In the underwater robot, we used two propellers. An independent electrical component called a servo motor turns machine parts effectively and precisely. It is employed to move objects at predetermined speeds, angles, or positions. A servo motor is utilised in this project to regulate the movement of the manipulator's arm. The propeller is designed to operate efficiently within a DC voltage range of 12 to 36 volts, drawing a current of 140 mA. Its versatile RPM capability of 30 to 152 ensures optimal performance in various applications, providing reliable and controlled propulsion for a wide range of devices and systems.

## H. Robotic Arm

A manipulator arm, often called a robotic arm or a mechanical arm, is a type of arm that can be programmed and can carry out activities similar to those of a human arm [27]. It might be an independent machine or a part of a bigger robot. In our project, we developed a manipulator arm with the ability to grab, collect, and hold a variety of things or be used for clamping.

## I. Water Pump

The water chambers have been filled and drained using inexpensive aquarium pumps. Each water chamber has two pumps. Since on-board power comes in the form of DC power, the fact that these pumps operate on AC is a concern. An AC-DC converter or a cable is used to remedy this issue. The water chamber with pumps is shown gives the time needed for water chambers to fill, where V, r, and l stand for the volume, radius, and length of the water chamber, respectively, equations [8] and [9],

$$V= 2\pi r2l \qquad [8]$$

$$T = \frac{V}{flowrate} \qquad [9]$$

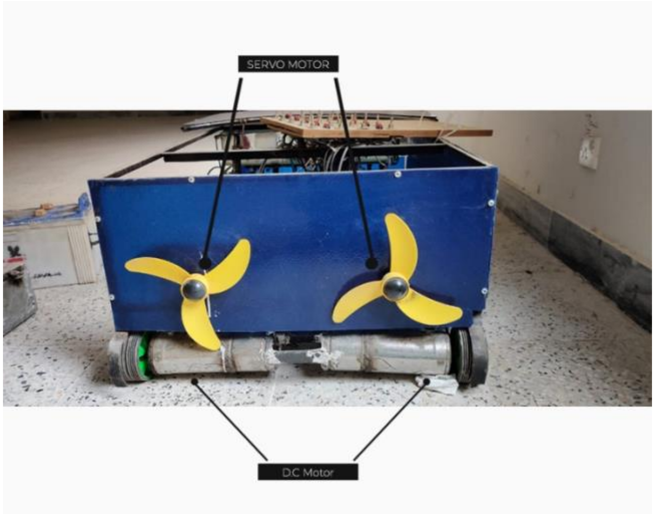

*Figure 6. Servo Motor Placements*

### *J. Relays*

This project employs a 5-volt, 10A electromagnetic relay to regulate electricity flow to motors and lights. The relay establishes and breaks connections between two sources, managing the entire circuit efficiently. Controlled by an Arduino, the relay ensures smooth operation by seamlessly opening and closing the circuit. This mechanism enables reliable and efficient control of various machinery and devices.

## IV. DESIGN OF CAMERA COLLECTION SYSTEM

This design places the camera on the exterior edge of the underwater robot's head, which has a light attached to it. The head of the underwater robot is transparent on the inside. The camera is connected to the main board and the Wi-Fi module, and the image from the camera is sent to the "ESP8266 Controller plus ULTRA" [28] open-source, free Android software that is already built into the device. With the aid of this camera controller, we will be keeping an eye on the direction, the time, and the objects.

## V. DESIGN OF CONVEYOR BELT

The conveyor belt must be able to keep the sea items at the bottom and travel in a circular manner inside the shell of the underwater sea items fishing robot in order for the sea items to fall into the storage box from the flipped conveyor belt. Gears, a bottom plate, a baffle, and a transport gap make up the conveyor belt. The sea items are stored on the bottom plate, and when they are moved vertically, the baffle plate prevents the sea items from dropping. The robot's controllability is improved, the conveyor belt's bulk is greatly reduced, and less energy is used thanks to the transit gap [29]. Although the aforementioned design plan can indeed get rid of the complicated motor control system and lessen the weight gain caused by too many motors, it also adds to the weight of the transmission and conveyor belt control systems. The entire conveyor belt can be created as a multistage conveyor belt with gaps to lower the overall weight of the underwater fishing robot. The mechanical claw simply needs to grip the sea items and enter the inner chamber in this manner, and it is released when the belt passes right underneath the mechanical claw.

## VI. DESIGN OF MECHANICAL CLAW

The mechanical claw must first satisfy the requirements that both the open width of the claw and the closed width of the claw can be employed to catch the objects or artifacts width to allow for clamping. Additionally, anti-slip patterns are added to the claws' gripping areas to boost friction because seawater will lessen the friction of sea-participating claws, which will lead to items escaping. In stone fissures, objects and substances can also survive [22]. For ease of clamping, a shovel structure with a 45-degree dip angle has been added to the lower portion of the hand claw. The building is capable of efficiently grasping objects and holding them to keep them from falling. The mechanical claw may also be changed; for grasping purposes, we will use this angled claw, but for scientific applications, we will switch it out for a small bucket that will hold samples of underwater particles, etc. The Mechanical Claw also contains an extra built-in poison ejector which ejects poison that partially nebulizes fish, hence getting them caught.

*Figure 7. Mechanical Claw Open (Left) and Closed (Right)*

## VII. DESIGN OF CONTROLLER BOARD

The primary controller board, which will float on top of the water, is an extensible, finished, insulated wire controller board. It includes the wireless module connected to the Wi-Fi system that is being observed by the ESP8266 Controller and an Android application. It also includes the module connected to all the components of the main Raspberry Pi motherboard communicating with the ESP32 Camera and the lamination systems. With the help of the spring-controlled pully, which rotates and wraps the additional wire to prevent tangling, the board can be extended, and the length of the wire is controlled.

## VIII. LIMITATION AND SOLUTIONS

We should keep this project's limitations and challenges in mind as we explore its execution. This project has several issues and limitations that we are unable to address because of the limitations of the prototype hardware.
The concerns and restrictions are listed below.

- The system must be fully watertight.
- Staff must use a user terminal to keep an eye on the robot.
- The system's implementation costs are relatively high.
- Furious creatures, such as sharks, may harm the equipment.
- The robot's battery life is constrained.

The ways to get around these restrictions for the underwater robot are listed below.

- Make the robot completely waterproof to prevent water from getting inside.
- Use a bigger battery to get additional runtime.
- Avoid interacting with sharks while at work.

## IX. CONCLUSION

This article's primary accomplishment is the creation and control of an underwater robot that can do multiple useful tasks. It was designed, put to the test, and intended to be an automated subaquatic robot. Since it is quite difficult for a human to dive under the sea and accurately analyze everything in the low oxygen and hostile environment there, it is more advantageous and dependable than manual monitoring. A user terminal module that allows commands to be issued to the robot from the outside was also developed. We may take immediate action after becoming aware of any irregularity to prevent any possibly dangerous robot breakdowns. We can restore the system quicker and spot any problems early because we won't have to physically dive into the water to investigate, which lowers expenses and increases system dependability. The vehicle's architecture only allows for 2 DOF translation motion. Thrusters are used to move forward or backward, and changes in density are used to move up or down. For filling and emptying water, there are two water chambers—one on each side of the main hull. The density of the vehicle is altered by this procedure. The whole vehicle's electrical system is housed in the main hull. The technology for underwater robots is advanced, but the idea of using them for multitasking is new, and there aren't many articles on the subject. As a result, the essay primarily makes use of various underwater robot technologies and evaluates their viability for application in different fields. After decades of research and development, underwater robot technology has advanced to the point where it can now perform intricate underwater activities rather than just simple underwater navigation. However, since underwater robots are currently not sufficiently commercialized, progress on specialized functional robots like multipurpose robots is modest.

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## XI. DECLARATION STATEMENT

I, Shabahat Hasnain Qamar, affirm that this research paper submitted to Qeios is entirely my own work. I have appropriately cited all sources used, adhered to ethical research standards, and this paper is not currently submitted elsewhere. I understand that any breach of these declarations may result in the rejection of my submission and further actions as per the journal's policies.

## XII. CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest related to this research study. This work was conducted without any financial support or other forms of influence from external organizations or individuals that could potentially affect the impartiality or integrity of the research.

## XIII. ETHICAL STATEMENT

The research team recognizes and acknowledges the importance of ethical considerations in scientific research and ensured that all aspects of the study adhered to the highest ethical standards. Please make sure to incorporate this information seamlessly into your ethics approval statement while still adhering to the specific requirements of your research paper and the journal's submission guidelines.

## XIV. CONSENT TO PARTICIPATE

All participants in this research study provided informed consent prior to their involvement. They were fully briefed on the study's objectives, procedures, and their rights as participants.

## XV. CONSENT FOR PUBLICATION

All co-authors of this research paper have reviewed and consented to its submission for publication. They have agreed with the content, findings, and interpretations presented in the manuscript.

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