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Underwater Inspection and Exploration Rov

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ABSTRACT—Remotely controlled underwater robot vehicles, sometimes known as ROVS, are widely used in the offshore industry and other purposes. The primary goal of this class of underwater mobile tethered robots is to replace people in risky or challenging-to-reach underwater environments for a range of specialized tasks like inspections, site surveys, and the search for important individuals or goods. Umbilical cables, also known as copper or fibre optic cables, are frequently used for the remote control of ROVs. Underwater search robots have been a popular option for peering into the depths of ponds, lakes, and oceans alike. The purpose of the study is to design and produce a device that can scan and analyze tiny lakes. The remotely controlled vehicle (ROV) that is the topic of the following research contains modules that are dedicated to the gathering of data, such as movies, images, etc. The device will also find and identify any undesirable items that are buried in the bottom. We recommend a low-cost approach that use wired media for communication and a more straightforward thruster configuration. A network camera, a bore scope, and four motors powered by a 12 volt battery system will be included in the low-cost ROV. The ROV will have the capability of diving up to 20 meters under the surface to conduct underwater inspection and observation activities.

Keywords: Remotely operated vehicle, Umbilical cables, Underwater search robots, low- cost ROV

I. INTRODUCTION

A remotely operated vehicle (ROV) is a type of vehicle that is designed to be operated remotely using a remote control. ROVs are often used in situations where it is not practical, safe, or possible for a human operator to be present, such as in hazardous or inaccessible environments, such as deep oceans or in space. They are also used in a variety of industries, including oil and gas, marine research, military, and media production. ROVs are equipped with a variety of sensors and tools that allow them to perform tasks such as inspection, maintenance, repair, and scientific research. They may also be equipped with manipulators or other specialized tools to perform specific tasks, such as cutting or welding. ROVs are usually connected to a control console or computer on shore or on a vessel, from which the operator can control the vehicle and view its surroundings through cameras or other sensors. An inspection and exploration ROV (Remotely Operated Vehicle) is a small, unmanned submersible vehicle that is remotely controlled by an operator from a surface vessel or from a control room on shore. These vehicles are typically equipped with cameras, sensors, and manipulator arms to allow them to inspect, survey, and perform tasks underwater. They are used in a variety of applications including oil and gas exploration, scientific research, underwater construction, and environmental monitoring.

II. METHODOLOGY

The methodology of the project is illustrated as a flow chart in figure 1. The methodology of the project includes generation of 3D design, procurement of different materials and parts, fabrication and field testing.

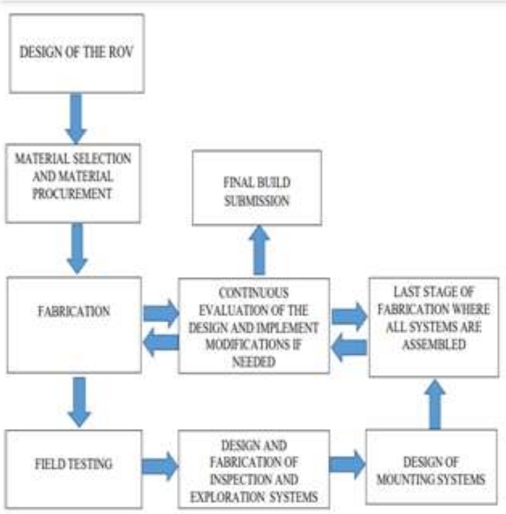

Fig 1 Methodology of the project

III. DESIGN

As shown in Fig 2, the components of the underwater inspection and exploration ROV include:

- Frame
- Thrusters
- Buoyant tank
- Sensors and camera system
- Control system

The isometric view with labeled parts of the ROV is shown in Fig 2 shows the layout design of the ROV

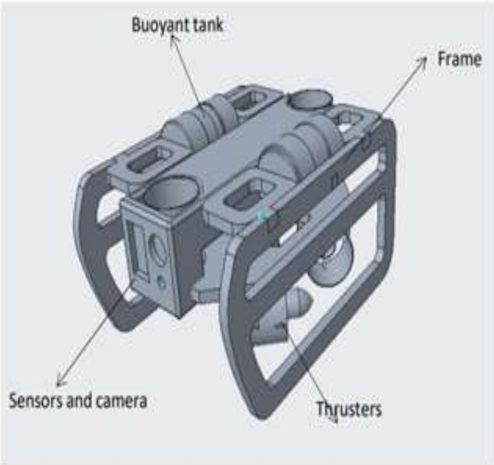

Fig 2 Design of ROV

IV. FABRICATION

Fabrication of the ROV was done during the months of March and April 2023. The fabrication was carried out in different steps.

I. Electronics parts and material procurement: According to the design, specifications and requirements, various electronic components and materials were purchased.

II. Fabrication of the frame: The frame material was selected based on the properties of the materials such as density and strength. The material selected was 18mm PVC fiber board which had a density less than that of water, which helps it to float in water and its strength can resist the pressure forces up to a depth of about 100m. The dimensions of the frame were designed in such a way that it gave good clearance for the water that was passing through the propellers and it does have a good aesthetic design. PVC boards can be easily machined using wood working machines, The frame was cut to shape using a jig saw at a carpentry shop. The fig 3 shows the frame structure of the ROV.

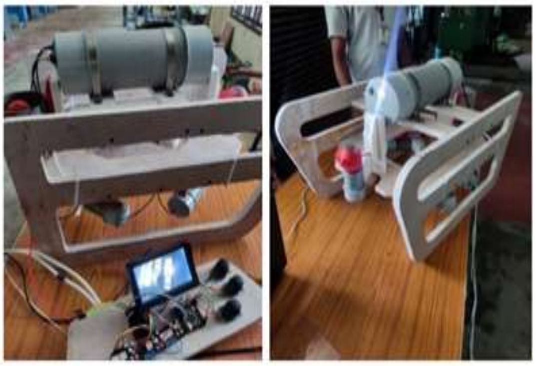

Fig 3 different view angles of the frame

III. Fabrication of thrusters: The design of the ROV is such that there are 6 thrusters with 4 arranged in a x- orientation for the lateral movements and 2 at the top arranged vertically for horizontal movements,

The thrusters is designed such that it offers bi-directional rotations as well as variable speed control. The different parts of the thrusters are as follows: -

Propeller: After determining various propeller parameters required from a similar sized ROV, we designed the propeller using PTC Creo Parametric 9. The propeller was then 3Dprinted. The Fig 4 shows the design and the 3D printed propeller, respectively

Fig 4 Printed thrusters

Specifications:
Material: Polylytic acid polymer
Blade diameter: 50mm
Pitch angle: 20 degrees
Number of blades: 3

Motor: Each thruster is powered by a 12v DC brushed motor which is directly connected to the propellers.

The motor used works well underwater, but with prolonged time, under water corrosion can set in, therefore water proofing is required. A

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PVC pipe enclosure was used and the inside was filled with thick grease and oil.

Fig 5 Motor

Specification:
Make: Thermisto
Model: RS 775
RPM: 7000
Voltage: 12-24v

Amp rating under water: 5Amp
Diameter: 43mm
Motor driver module: A motor driver module is a device used to control the speed and direction of rotation of a DC motor using a micro-controller. The motor drivers must be powered separately for them to work. A total of 3 motor drivers are used to control the 6 motors, Each motor driver can control the speed and direction of two motors. Fig 6 shows ZK5AD motor driver shield which is used in the ROV.

Fig 6 Motor driver

Specifications:
Make: Generic
Model: ZK5AD
Working voltage:6-14V
Maximum current supplied at each channel:5Amp
Voltage drop at each channel:0.4v
Other parts: These include the thruster supports which were 3D printed out of PLA, 50mm PVC pipe for the motor casing and 50mm PVC end cap

IV. Control system wiring: The ROV has 5 degrees of freedom, all of which are controlled using 3 joysticks marked as A, B and C. The different controls associated with each joystick is given below.
Joystick A: Heave (translational movement in up and down direction).
Joystick B: Yaw (rotational movement to left and right on the y axis). Pitch (rotational movement to up and down on the x axis).
Joystick C: Surge (forward and backward movement). Sway (left and right movement). Fig 7 shows the control
board of the ROV along with the camera display.

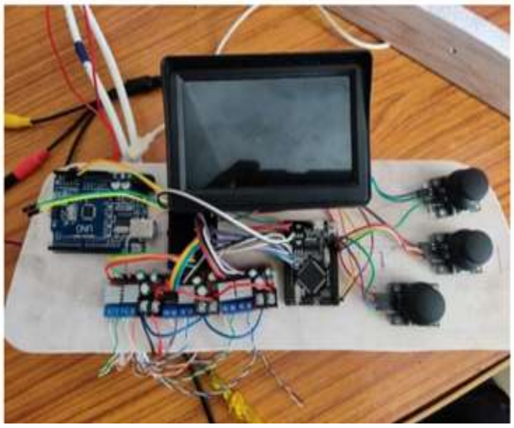

Fig 7 control board with electronics fixed

The joystick coverts mechanical signals into analog inputs for the micro-controller, which then interprets the signals and gives output signals to the motor drivers and the motor drivers to the motors. The micro-controller used is an ARDUINO MEGA 2560 PRO, which has 54 io pins out of which 15 are PWM pins, which are required for the speed control of the motors. Fig 8 shows the micro-controller which is used in the ROV.

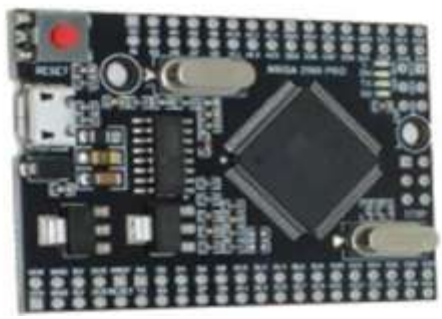

Fig 8 Arduino mega

All the control systems are made into the control board which is connected to the ROV using two 10m Ethernet cables providing 8 channels of communication. The detailed wiring of the control circuitry drawn using CIRCUIT IO is shown in Fig 9

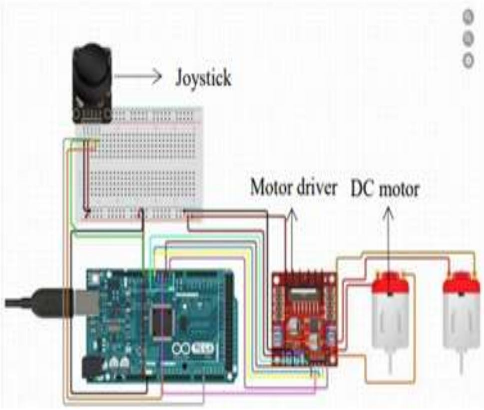

Fig 9 Control circuit for movement

V. Programming the Arduino: We primarily used conditional statements (if, else if, and else) to determine the appropriate motor control action based on the joystick inputs. The motor speed and direction are controlled by varying the PWM (Pulse Width Modulation) values using analogWrite() function, while the motor direction is controlled by setting the digital pins HIGH or LOW using digitalWrite() function The code functionality is given below:
Pin Definitions: d0 to d11: These variables store the pin numbers for the motor driver pins. j1y, j1x, j2y, j2x, j3y: These variables store the analog input pin numbers for the joystick inputs. j1yr, j1xr, j2yr, j2xr, j3yr: These variables store the analog readings from the joystick inputs.
setup() Function: Sets the pin modes for all the defined pins. Configures the motor driver pins as outputs and the joystick pins as inputs.
loop() Function: Continuously reads the analog values of the joystick inputs using analogRead() function. Performs different control actions based on the joystick input readings. The control actions are executed using the analogWrite() and digitalWrite() functions.

VI. Sensors and camera mounting: A temperature sensor and turbidity sensor is mounted on to the ROV to obtain the temperature and clarity of the water at various locations. The sensors give input signals to the micro-controller via the Ethernet cable and the output is displayed on the screen of a smartphone or laptop through a Bluetooth connection. Fig 10 and Fig 11 shows the temperature and turbidity sensors used in the ROV


Fig 10 Temperature sensor


Fig 11 Turbidity sensor

A car rear-view camera was used as a proof of concept. The camera output signal is received by the monitor through a 10m long av cable.

Fig 12 shows the camera and display used in the ROV.


Fig 12 Display and camera

VII. Power unit assembly: The ROV was designed such that there are minimal electronic components inside the ROV, almost all electronics except the two sensors, everything else is integrated into the control board, including the power unit. Also, the ROV can be powered either by a DC battery or directly from a 250v AC power source. In the case of a battery, a 14v20ampbattery should be used. We used a direct AC source coupled with a 12v 20 amp SMPS to power the ROV. The SMPS is integrated into the control board for compatibility
The complete fabrication of the ROV was finished and testing was done. Fig 13 shows the different views of the completed ROV

Fig 13 Completed ROV

V. TESTING

Testing: The testing involved checking the stability and movement of the ROV under water, All the controls worked as expected in the first trial, but due to the large buoyant force acting upwards, the ROV was not able to submerge completely and also, due to some problems with the wiring sensor values were not displaying on screen. Fig 14 shows a picture of the ROV taken during the first trial.

Fig 14 ROV in first trial

On the second trial, after adding dead weight to counter the buoyant force, the ROV was finally able to submerge as shown in Fig 15, also the sensor values were displayed on screen as shown in Fig 16.

Fig 15 submerged ROV

Fig 16 Sensor values

VI. CONCLUSION

ROVs are a valuable tool for inspection and exploration in underwater environments, as they allow humans to access and study areas that would otherwise be difficult or impossible to reach.The use of ROVs for mapping and surveying can provide important data on ocean conditions and help inform decision-making for a range of applications, including environmental monitoring and conservation .Further research and development in the field of ROVs, particularly in areas such as sensor technology and data analysis, can help to improve the effectiveness and efficiency of these vehicles for inspection and exploration purposes. The use of ROVs for inspection and exploration can be enhanced through the development of multi-vehicle systems and collaborative approaches involving both ROVs and other types of underwater platforms .Overall, the continued advancement of ROV technology has the potential to significantly expand our understanding of the underwater world and provide valuable insights into a wide range of scientific and practical applications

VII. FUTURE SCOPES OF INSPECTION AND EXPLORATION OF ROV

- Inspecting underwater structures and facilities: ROVs are often used to inspect underwater structures, such as oil and gas platforms, pipelines, and ships. They can be equipped with sensors and imaging systems that can detect problems and defects, and they can be used to perform maintenance and repair tasks.
- Conducting scientific research and surveys: ROVs can be used to collect data and samples from the ocean floor and other underwater locations. This can help scientists better understand the ocean and its ecosystems, and inform conservation efforts and resource management.
- Exploring uncharted areas of the ocean: ROVs can be used to explore deep-water environments that are otherwise inaccessible to humans, such as the deep sea or remote coral reefs. They can be equipped with cameras and other sensors to collect data and images from these environments.
- Responding to disasters and emergencies: ROVs can be used to assess damage and assist with rescue and recovery efforts in the aftermath of natural disasters or other emergencies, such as oil spills or sunken ships.

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