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Under Water Vehicle

REMOTELY OPERATED UNDER WATER VEHICLE

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Abstract: Remotely Operated Underwater Vehicle (ROV) is a sophisticated robotic system designed for underwater exploration, inspection, and data collection, typically in environments that are hazardous or inaccessible to humans. This project aims to develop an ROV capable of performing a range of tasks, including oceanographic research, subsea inspection, underwater surveillance, and environmental monitoring. The design of the ROV incorporates a robust mechanical structure, advanced control systems, high-definition imaging capabilities, and a reliable communication interface to ensure effective operation in underwater conditions.

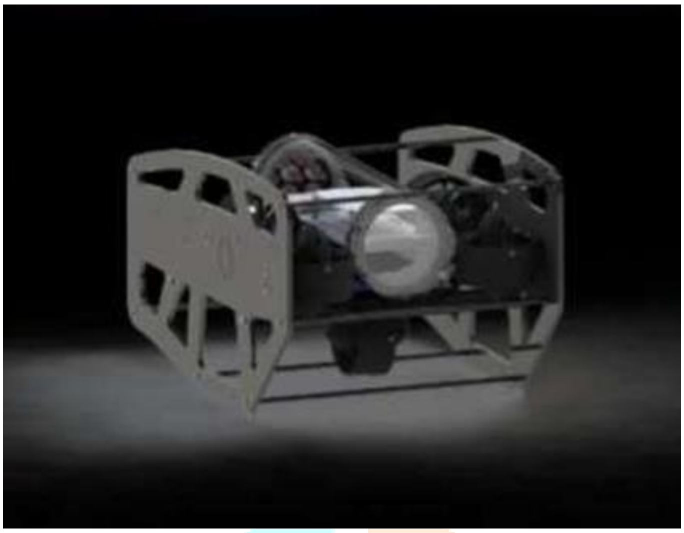
I. INTRODUCTION

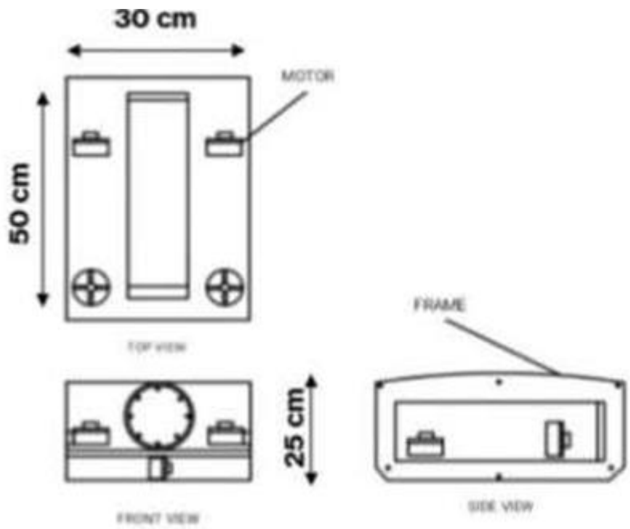
Remotely Operated Underwater Vehicles (ROVs) are advanced robotic systems that play a pivotal role in modern underwater exploration and intervention. These vehicles are specially designed to operate in harsh aquatic environments, such as the depths of oceans, lakes, and rivers, where human presence would be impossible or too dangerous. ROVs are equipped with cameras, sensors, and specialized tools that allow them to perform a variety of tasks, ranging from scientific research and marine biology studies to underwater construction, maintenance, and even search and rescue operations. Unlike Autonomous Underwater Vehicles (AUVs), which operate independently, ROVs are remotely controlled by operators located on the surface. They communicate via intricate umbilical cables that transmit data and power, enabling real-time control and feedback. This combination of cutting-edge technology and human oversight makes ROVs invaluable in exploring and working in deep-sea environments, advancing our understanding of the underwater world.

II. WORKING

At the heart of a Remotely Operated Vehicle (ROV) system is the intricate communication between the control unit on the surface and the submersible body beneath the water. The control unit, typically stationed on a boat or platform, is responsible for sending commands to the ROV, guiding its movement, and adjusting its operations. This communication is facilitated through a tether, a robust umbilical cable that serves multiple critical functions. The tether not only provides the ROV with the necessary power to operate its systems but also acts as the conduit for control signals, data transmission, and video feedback between the surface operator and the vehicle. The submersible body of the ROV is equipped with an array of essential tools and sensors. Among the most important are the cameras and lights, which provide operators with the ability to visually navigate the underwater environment. The cameras capture high-definition video, relaying real-time footage back to the surface, allowing operators to observe their surroundings as if they were present in the depths themselves. The lights ensure visibility in the often-dark and murky waters, illuminating the ROV's path and objects of interest.

In addition to visual feedback, ROVs are equipped with a variety of sensors that provide crucial information about the environment. These can include sonar for mapping underwater topography, temperature and pressure sensors, and depth gauges, among others. This sensor data is transmitted back to the operator, offering a detailed understanding of the ROV's environment, which is vital for performing precise tasks. Through this combination of video feeds, sensor data, and control signals transmitted via the tether,





the operator can skill fully maneuver the ROV to complete a variety of tasks. These may range from collecting samples, conducting scientific research, inspecting underwater infrastructure, to performing intricate repairs. The operator's ability to manipulate the ROV with such dexterity is a testament to the vehicle's complex design and the seamless communication between the surface and the underwater vehicle. This collaborative interaction between human expertise and robotic precision allows ROVs to function effectively in some of the most challenging and remote environments on Earth.

III. DESIGN

The design structure of an underwater robot, particularly when created using tools like AutoCAD for 2D drafting and SolidWorks for 3D modeling and simulation, is a precise and methodical process that ensures the vehicle can function effectively in challenging underwater environments.AutoCAD is primarily used in the initial stages of design for 2D drawings, which provide detailed layouts and blueprints of the ROV's various components. These drawings are essential for defining the overall structure and dimension of the robot. The following elements are typically designed using AutoCAD:

- **Frame Design:** The basic structure, including dimensions and materials for the frame, is first created. The frame needs to be durable, resistant to pressure, and lightweight for efficient movement.
- **Component Placement:** In the 2D design, the placement of components such as motors, sensors, cameras, and lights are mapped out. Proper placement ensures stability, balance, and accessibility for maintenance or repairs.
- **Internal Wiring & Cabling:** The 2D drafts also show how the wiring and tether are arranged within the robot's frame, ensuring that they don't interfere with other systems and are protected against water and pressure damage.

Once the 2D drafts are finalized, SolidWorks is used to create a detailed 3D model of the underwater robot. The 3D design allows for a more realistic visualization of how all the parts and components fit together. Some critical aspects of 3D modelling and simulation include:

- **Body Design:** The outer casing and structure of the ROV are modeled in 3D to ensure that it is streamlined for movement through water, with minimal drag. The material selection is crucial in this step, as it must be both lightweight and pressure-resistant to withstand the depths it will operate in.

- **Hydrodynamics:** SolidWorks allows for simulations of how the robot moves through water, analyzing its buoyancy, stability, and drag coefficients. By testing various body shapes and orientations, designers can optimize the ROV's movement and energy consumption.
- **Component Integration:** The 3D design enables the precise integration of mechanical parts like thrusters, motors, and manipulators, ensuring they are optimally positioned for balance and functionality. This allows for effective maneuverability and precise control over underwater tasks.
- **Electrical Systems:** Detailed 3D simulations can also model the robot's internal electrical and control systems. The flow of power from the tether is mapped to ensure that each component, from sensors to cameras, receives adequate power.
- **Testing and Simulations:** SolidWorks also allows for virtual testing of the ROV's performance in simulated underwater conditions. These tests help evaluate how the vehicle reacts to different pressures, currents, and obstacles, and adjustments can be made before the actual physical prototype is built.

The design must also account for materials that are resistant to corrosion from saltwater and can withstand the high pressure at depth. In the 3D modelling process, the designer selects appropriate materials for each component of the robot (e.g., corrosion-resistant metals, waterproof seals, or pressure-resistant casings).Many underwater robots are designed with modularity in mind. This allows different parts, such as manipulators, sensors, or cameras, to be replaced or upgraded easily. The 3D model reflects this modularity, ensuring that the components are interchangeable and easy to service. After creating the 3D model, the design goes through a process of refinement. Simulation tools within SolidWorks can highlight any potential issues like component interference, weight distribution, or areas that might be prone to wear. Adjustments are made to ensure the vehicle can operate effectively, efficiently, and safely.

IV. PARDUINO THRUST CONTROLER

In an underwater vehicle, thrust control is essential to navigate and maintain movement through water. The thrust control system typically uses thrusters or motors to provide movement, and the Arduino can be used to control the speed and direction of these thrusters. Here's an explanation of how Arduino code for thrust control might work in an underwater vehicle and how it theoretically functions.

In an ROV (Remotely Operated Vehicle) or AUV (Autonomous Underwater Vehicle), thrust control is used to manage the movement of the vehicle, such as:

- **Forward/Backward Movement**: Controlling the vehicle's speed in a specific direction.
- **Turning**: Adjusting the thrust on individual motors to rotate or steer the vehicle.
- **Depth Control**: Controlling the vertical thrust (upward or downward movement).

To achieve this, the thrust is generated by thrusters, and the speed of each thruster is regulated via motor controllers, which the Arduino can control using Pulse Width Modulation (PWM) signals. The Arduino takes input from the operator or autonomous sensors, processes the commands, and adjusts the motor speeds accordingly. The thrust control system allows the underwater vehicle to move precisely through the water. Here's a breakdown of how the thrusters' control works.

Movement Control:

- **Forward and Backward:** The left and right thrusters are operated at the same speed to move the vehicle forward or backward. By adjusting the PWM duty cycle, the speed of the motors can be increased or decreased.
- **Turning (Yaw Control):** To turn, the thrusters on one side (left or right) can be run faster or slower than the opposite thrusters. For example, if the left thrusters are going faster than the right thrusters, the vehicle will rotate or turn to the right.

- **Vertical Movement:**

- **Upward Movement:** The upward thrusters are activated, producing thrust that counteracts the vehicle's buoyancy and causes it to rise. The speed can be adjusted to control the ascent.
- **Downward Movement:** Similarly, the downward thrusters are used to provide additional weight or force to make the vehicle sink. This helps the vehicle dive or adjust depth.

- **Pressure and Current Considerations:** In the actual underwater environment, the vehicle's thrust control is also affected by external factors like water pressure and currents. The Arduino-based system must continuously adjust the thruster speeds to maintain stability and control based on sensor feedback (e.g., depth, water flow, etc.).

V.DRIVING PART

The driving mechanism of a Remotely Operated Vehicle (ROV) is primarily based on controlling its thrusters or motors, which provide the movement needed to navigate through underwater environments. These thrusters are responsible for generating the thrust that moves the ROV in various directions, allowing it to perform tasks and explore underwater environments. Here's a brief explanation of the driving part of an ROV:

Key Components for Driving an ROV:

1. **Thrusters/Motors:** The primary components responsible for driving the ROV are the thrusters or motors. These are strategically placed around the ROV to provide movement in all directions:
2. **Control System:** The operator on the surface controls the ROV's movement using a joystick or control panel that sends signals to the ROV. These signals are transmitted through a communication cable (the tether) to the vehicle, which controls the speed and direction of the thrusters. The control system adjusts the thrusters' power and direction, enabling the vehicle to move in the desired direction.
3. **Directional Control:**
   - **Forward/Backward Motion:** By activating the forward or reverse thrusters, the ROV moves in the intended direction.
   - **Yaw Control (Turning):** To turn, the thrusters on one side of the ROV are adjusted differently than those on the other side. For instance, if the left thrusters are powered more than the right, the ROV will turn left.
   - **Pitch and Roll (Up/Down and Tilting):** By adjusting the vertical thrusters (upward and downward), the ROV can move up or down in the water. Tilting or rolling can be controlled by varying the thrust on different sides of the vehicle.
4. **Feedback and Adjustment:** In real-time, the operator may adjust the thrusters based on feedback from the ROV's cameras, sensors, and the environment. For example, depth sensors may provide data to help the operator maintain a consistent depth, and cameras give the operator visual feedback to adjust the direction and movement of the vehicle.

V. LIPO BATTERY

A **3300mAh LiPo (Lithium Polymer) battery** is a high-capacity rechargeable battery known for its lightweight and compact design, making it ideal for applications where size and weight are critical, such as in underwater vehicles like ROVs (Remotely Operated Vehicles) and AUVs (Autonomous Underwater Vehicles). The **3300mAh** capacity indicates that the battery can provide 3300 milliamps of current for one hour, or proportionally less current for a longer time, offering a sufficient runtime for demanding tasks such as powering thrusters, cameras, sensors, and lights. LiPo batteries are essential for underwater vehicles because they provide **high energy density**, allowing for powerful output while keeping the overall weight low. This is crucial for maintaining the vehicle's buoyancy, stability, and manoeuvrability in the water. Additionally, the battery's ability to perform reliably under various temperatures and environmental conditions ensures that the vehicle can operate efficiently for extended periods, often without the possibility of quick recharging, making **LiPo batteries** a key component for successful underwater exploration and intervention..

VI. Data and Sources of Data

The **PS2 Remote Set** refers to a set of controls and accessories used with the PlayStation 2 (PS2) gaming console. The PlayStation 2, released by Sony in 2000, became one of the most successful gaming consoles of its era, and the PS2 Remote Set played a significant role in providing users with a more convenient and immersive way to interact with their gaming system. At the heart of the PS2 Remote Set is the **PS2 controller**, a wired or wireless device designed to provide users with a range of controls to navigate the console's interface and interact with games. The original controller was wired, featuring a **USB-style connection** to the PS2 system. It includes:

- **Directional pad (D-pad):** A cross-shaped pad used to navigate menus, control character movements, and execute in-game actions.
- **Action buttons:** Four main buttons (Triangle, Circle, Cross, and Square) arranged in a diamond pattern, used for various functions like jumping, attacking, or interacting within games.
- **Analog sticks:** Two thumbsticks used for more nuanced control, particularly in 3D games, for movement or camera control.
- **Shoulder buttons:** These are located on the top of the controller, allowing for additional actions, such as aiming or acceleration in certain games.
- **Start and Select buttons:** Used for in-game pause or accessing menus.

Another key part of the PS2 Remote Set is the **PS2 remote control**, designed for multimedia use. The PlayStation 2 console was also a **DVD player** (one of the first gaming consoles to offer this feature), and the remote allowed users to control the playback of DVDs, CDs, and other media content with ease. The remote control typically featured:

- **Basic playback buttons:** These include Play, Pause, Stop, Fast Forward, Rewind, and Skip, which are essential for navigating through movie or music content.
- **Volume and Mute functions:** In some versions, you could control the volume of the TV or sound system directly via the remote.
- **Menu navigation buttons:** These allow users to access the PS2 menu or change settings related to DVD playback.
- **Directional pad and Select buttons:** These were used for easy navigation through the DVD menu interface.

This remote was especially useful for users who wanted to use the PS2 as a home entertainment system, as it provided a much more convenient and intuitive way to control media playback compared to the standard game controller. The PS2 Remote Set could include various other accessories to enhance the gaming and multimedia experience:

- **Memory Cards:** These were used for saving game progress, and the PS2 had multiple slots for different memory cards.
- **PlayStation 2 Eye Toy:** A motion-sensing camera that worked with compatible games, allowing players to interact with the game using body movements.
- **Keyboard and Mouse:** Some games and applications on the PS2 were compatible with external keyboards and mice, particularly for online play and web browsing.

The PS2 Remote Set was pivotal in enhancing the versatility and functionality of the PlayStation 2 system. It not only catered to the traditional gaming experience with its controllers but also helped transform the PS2 into an entertainment hub by allowing for convenient media playback control. This transformation of the PS2 into a multi-functional system made it an even more attractive option for consumers, broadening its appeal beyond just gamers.

VII. Visual Capturing and Audio Recording

The integration of visual capturing and audio recording capabilities in a Remotely Operated Vehicle (ROV) provides a multifaceted approach to underwater exploration and data collection, greatly enhancing the vehicle's operational efficiency and effectiveness. These technologies work in tandem to deliver a comprehensive understanding of the underwater environment, making ROVs invaluable tools for a wide range of industries, including marine research, oil and gas exploration, underwater construction, and search-and-rescue operations .High-definition cameras are one of the primary visual tools employed in ROVs, offering operators the ability to observe and document underwater environments with remarkable clarity. These cameras are usually designed to withstand the harsh conditions of deep-sea environments, such as extreme pressures, low temperatures, and corrosive saltwater.

- **Camera Types:** ROVs typically employ several types of cameras, including wide-angle cameras for broad field views and zoom cameras for more focused inspections. In addition, specialized cameras like 4K or even 3D cameras may be used for highly detailed exploration or topographic surveys.
- **Real-time Navigation:** Visual capturing via ROV cameras plays a crucial role in navigation, especially in environments with limited visibility. For example, when operating in murky waters or underwater caves, the camera feed allows the operator to control the vehicle's movements accurately. It also helps operators detect obstacles, monitor the ROV’s proximity to objects, and maintain a steady course. This is crucial when performing sensitive tasks such as inspecting pipelines, repairing underwater infrastructure, or surveying wrecks.
- **Surveying and Mapping:** Beyond just providing a view of the immediate surroundings, high-quality visual data collected by ROVs can also be used to generate 3D maps of underwater structures and topographies. These visual data are analysed and processed to create detailed images and models of submerged environments, supporting more informed decision-making during exploration or maintenance work.

Audio recording in ROVs typically utilizes hydrophones, which are sensitive underwater microphones designed to capture sound waves. These devices play a key role in providing additional information that is not visible through visual capturing alone.

- **Equipment and Structural Monitoring:** Hydrophones can also detect operational noises, like the hum of motors or vibrations from equipment. This allows operators to listen for abnormalities that may signal issues with the ROV itself or with the underwater infrastructure being inspected. For example, unusual sounds may indicate wear and tear on machinery or potential issues like leaks in a submerged pipeline.
- **Detecting Anomalies:** Underwater environments can sometimes present unexpected hazards, such as changes in water currents, underwater volcanic activity, or shifts in tectonic plates. Hydrophones help in detecting such anomalies by picking up the sounds of underwater movement or changes in pressure waves, which might be missed through visual inspection alone. This early detection can be invaluable for avoiding potential accidents or ensuring the safety of the ROV during missions.
- **Enhanced Situational Awareness:** The ability to combine visual and auditory data gives operators a richer understanding of the underwater environment. For instance, when inspecting a submerged structure, the combination of the visual feed and the audio from the hydrophones helps operators identify and differentiate between sounds coming from natural sources (like marine animals) versus those caused by human-made structures or equipment.

CONCLUSION

Early underwater robots, such as ROVs and AUVs, were foundational to marine exploration and research. They enabled critical tasks like video surveillance, sample collection, and mapping of the ocean floor. Over time, advancements in sensors, control systems, and energy efficiency improved their capabilities, allowing for more complex and autonomous operations. Despite their limitations, these early robots paved the way for the sophisticated systems used today in marine biology, archaeology, and oil exploration. Early underwater robots were limited by shallow depth capabilities, low autonomy, short battery life, bulky designs, limited payload capacity, and slow speeds, which restricted their effectiveness and range of use.

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