Vasco Caretta – The Swan Boat

Dugana Lohit, R..K. Daniel, S. Srinath
Department of electronics and communication Engineering
Periyar Maniammai Institute of science and technology
Thanjavur, India

Abstract

Today's security and surveillance environment calls for scalable robotic systems that can cover a variety of environments, a key requirement for monitoring wide areas Despite the limited use of devices for such purposes, if necessary, the need for monitoring and identification is paramount. Introducing an underground solution, our hybrid robot seamlessly integrates the boat's dynamics with underwater systems. This integration enhances the analytics, data collection and analysis capabilities of streams, and provides a versatile tool for a range of applications. Hybrid robots are important towards aerial survey, archaeology, regional data collection, port and harbor security, disaster management, environmental monitoring, and scientific research Its unique design enabling it to span a variety of landscapes, making it an asset in situations where traditional management approaches fail. Its use of hybrid robots is necessary to enhance national security, especially to combat illegal activities through waterways. By providing robust and scalable solutions, our hybrid robots contribute to more effective security management, ensuring efficient monitoring and responsiveness in a variety of environments a strong. Essentially, it represents technological progress in the wake of protecting territories and preventing illegal activities that threaten security. keywords: Surveillance, Exploration, National Security, Illicit Activities, Challenging Terrains, Boat, Twin turbine jet, Ballistic tank, Adaptability, Versatility, Reconnaissance, Data Gathering, Ocean Exploration, Port & Harbor security, Underwater Archaeology, Navigation, Disaster Response, Defence, Environmental Monitoring, Scientific Study.

keywords: ***Surveillance, Exploration, National Security, Illicit Activities, Challenging Terrains, Boat, Twin turbine jet, Ballistic tank, Adaptability, Versatility, Reconnaissance, Data Gathering, Ocean Exploration, Port & Harbor security, Underwater Archaeology, Navigation, Disaster Response, Defence, Environmental Monitoring, Scientific Study***

I. INTRODUCTION

The significance of unmanned underwater drones in the defence sector is paramount, especially considering the dynamic nature of modern naval and maritime operations. With ongoing technological advancements pushing boundaries, these autonomous systems are undergoing a transformative journey, continually expanding their capabilities and becoming indispensable assets for various defence applications Equipped with advanced sensors and propulsion systems, underwater drones have evolved into highly sophisticated tools capable of navigating ocean depths with unparalleled precision. Their roles encompass vital functions such as surveillance, reconnaissance, and strategic data collection beneath the sea's surface. Similarly, drone boats, known for their agility and versatility, have become integral components of surface operations. Combining mobility with remote-controlled functionalities, they contribute significantly to tasks ranging from patrol and monitoring to tactical interventions. The symbiotic relationship between underwater drones and drone boats represents a paradigm shift in defense strategies, enhancing the overall effectiveness of naval and maritime endeavors. Their adaptability across diverse environments, alongside advancements in communication and data processing technologies, provides defense forces with unparalleled situational awareness and response capabilities. This evolution underscores the pivotal role that these technological advancements play in shaping the future landscape of defense operations, where innovation seamlessly converges with the imperative demands of maritime security. Moreover, the incredible speed and flexibility displayed by underwater drones on the water further augment their underground capabilities. Their remote monitoring abilities make them invaluable assets for tasks ranging from routine surveillance to rapid intervention strategies. Notably, drone submarines and drone networks contribute not only to enhancing maritime operations but also to ensuring a comprehensive and integrated approach to combat strategy. As these technologies continue to evolve, their impact on naval capabilities becomes increasingly pronounced, reshaping the narrative of maritime security and highlighting its central role in the ongoing pursuit of innovation and effectiveness within the security sector.

Building an autonomous boat: a multidisciplinary design engineering approach. The paper details the design and development of an autonomous boat for competing in the International Aegean Ro-Boat Races. The boat, employing the Sense-Think-Act paradigm, utilizes low-cost sensors, including cameras and LIDAR, for environment mapping. Path planning algorithms ensure collision-free navigation. The use of open-source software and off-the-shelf components highlights cost-effectiveness, and extensive testing, including open water trials, demonstrates the vessel's safe and efficient navigation capabilities. The adaptable design allows for diverse applications [1].

Autonomous Underwater Vehicles: Recent Developments and Future Prospects. This paper tell us about Autonomous Underwater Vehicles (AUVs) find diverse applications in marine geoscience, military, commerce, and policy sectors. Operating independently of host vessels, AUVs excelin exploring extreme environments. This paper provides a comprehensive overview of AUV developments globally and in India, emphasizing future technical advancements. AUVs,distinguished from Remotely Operated Vehicles (ROVs), offer autonomy and constant altitude, making them ideal for geoscience tasks. Their roles span commercial, research, military applications, and environmental studies. The paper aims to review ongoing and completed AUV research, highlighting their evolving significance in various fields [2].

Toward an Autonomous Sailing Boat. This paper introduced a comprehensive hardware and software framework for autonomous robots, focusing on long-term missions. Hardware includes sensors, actuators, solar panels, and wind turbines. The new technique provides segmentation from a mobile camera, a static measurement system, and obstacle detection sonar. A probabilistic-based approach is proposed for navigation planning considering the kinematic constraints of navigation. Field tests validate the design components, demonstrating autonomous navigation robotics' capabilities and new understanding of renewable energy [3].

Platforms**:** Autonomous Underwater Vehicles. An Autonomous Underwater Vehicle (AUV) is an unmanned, autonomous vehicle used to map the ocean floor or study water properties without human intervention AUVs ranging in size from tens of kilograms to thousands for high-quality data for oceanographic research. AlthoughAUVs have been developed since the 1960s, conventional scientific applications have increased in recent years, forcing rapid technological development and increased commercial acceptance Continued development promise to provide new AUV prototypes and applications [4].

Research into the development of autonomous boats with vision capabilities offers significant and invaluable benefits to humanity. This study aims to enhance underwater surveillance by implementing image processing on autonomous boats. Through the utilization of a single vision system, supported by algorithms and coding, vast amounts of data can be extracted for environmental research underwater, as well as for detecting depth and obstacles to improve navigation. The primary focus lies in analyzing the effectiveness of single vision cameras in providing data for environmental research underwater, obstacle detection, and depth measurement. Mechanical structures are simulated using Catia V5 Edition software, and real-time coordinate points are captured using a global positioning system receiver. Additionally, the project incorporates additional sensors and actuators to further enhance the current design [5].

This article offers a broad outline of the research endeavors into Autonomous Underwater Vehicles (AUVs) conducted within the Perceptual Robotics Laboratory (PeRL) at the University of Michigan. Established in 2007, PeRL focuses on enhancing AUV autonomy through algorithmic advancements in perceptual feedback based on the environment, aiming at real-time mapping, navigation, and control. The laboratory's primary research areas include: real-time visual simultaneous localization and mapping (SLAM); cooperative multi-vehicle navigation; and perception-driven control.

To achieve these research goals, PeRL has developed a novel multi-AUV SLAM testbed using a modified Ocean-Server Iver2 AUV platform. Additional navigation and perceptual sensors have been integrated into the vehicles to facilitate underwater SLAM research. This article provides a detailed account of the testbed's development, outlines the main research thrusts, and discusses how the modified AUV testbed facilitates experimental real-world validation of these algorithms [6].

II. PROPOSED SYSTEM

Our innovative approach, crafted through thorough analysis of existing systems, introduces a drone boat and underwater module that offer diverse functionalities within a single system. This system embodies the convergence of cutting-edge technologies, each meticulously crafted to tackle specific challenges and push the boundaries in robotics. Combining a boat and underwater vehicle module opens avenues for developing a versatile marine vehicle that harnesses the benefits of both surface and underwater operations. Such a system holds promise for applications in marine research, surveillance, exploration, environmental monitoring, and defense. Presenting a conceptual proposal for integrating a boat and submarine module, the Swan boat emerges as a modular marine vehicle featuring interchangeable surface and underwater modules. This integration facilitates smooth transitions between surface and subsurface operations, enhancing flexibility across various marine missions. The integration mechanism relies on modular connections and transition capability, ensuring secure and watertight connections through a sealed interface to preserve the integrity of both modules.

Our proposed system insists with two operational modes which are **Surface mode** and **underwater mode**

A. *Surface Mode***:** In surface mode, the swan boat operates like a conventional boat, suitable for rapid transit, surface surveys, and data collection above the waterline.

B. *Underwater Mode***:** In underwater mode, the swan boat submerges to explore the underwaterenvironment. The submarine module allows for controlled and precise underwater navigation.

III. OBJECTIVES

This work highlights the significance of hybrid robotic systems in addressing the evolving challenges of security and surveillance in diverse environments. By introducing a novel solution that seamlessly integrates boat dynamics with underwater systems, the content aims to emphasize the importance of versatile tools for monitoring wide areas effectively. Through the use of keywords such as surveillance, national security, exploration, and illicit activities, the objective is to underscore the critical role that hybrid robots play in enhancing security management and combating illegal activities through waterways. The content seeks to elucidate how hybrid robots offer a scalable and adaptable solution for a range of applications including aerial survey, archaeology, disaster management, and environmental monitoring. By emphasizing the unique design and capabilities of hybrid robots to navigate challenging terrains, the objective is to showcase their effectiveness in situations where traditional approaches may fall short. Furthermore, the work aims to stress the importance of technological progress in safeguarding territories and preventing illegal activities that pose threats to security. By providing robust and scalable solutions, hybrid robots contribute to more efficient monitoring and responsiveness across diverse environments, thereby bolstering national security efforts. Overall, the aim is to advocate for the widespread adoption of hybrid robotic systems in security and surveillance operations, highlighting their versatility, adaptability, and contribution to enhancing security management in an increasingly complex and dynamic landscape.

IV. DESIGN REQUIREMENT ANALYSIS

Mathematical calculations for drone boat, also known as Unmanned Surface Vehicles (USVs) or Autonomous Surface Vehicles (ASVs), require the same considerations as underwater vehicles but different environmental dynamics on the vehicle Key components include hydraulics, triggers, and controls.

A. Hydrodynamic Resistance (R):

Like the drag force in underwater vehicles, the hydrodynamic resistance for a surfacevehicle is often modeled using the same drag equation:

$$R = 1/2 \times C_d \times A \times \rho \times V_2$$

where:

- Cd is the drag coefficient,
- A is the reference area,
- ρ is the density of the fluid (usually water),
- V is the velocity of the USV.

B. Propulsion Force (P):

The thrust or propulsion force generated by the USV can be modeled similarly tounderwater vehicles:

$$P = m^{\circ} \times V_e$$

where:

- m˚is the mass flow rate of water through the propulsion system,
- V_e is the effective exit velocity.

C. Frictional Resistance (F):

In addition to hydrodynamic resistance, there may be frictional resistance between thehull of the USV and the water. This can be modeled as:

$$F = \mu \times N$$

where:

- μ is the coefficient of friction,
- N is the normal force

D. Buoyancy (B):

Like underwater vehicles, the buoyant force is related to the displaced water volume:

$$B = \rho_{water} \times g \times V_{displaced}$$

E. Equation of Motion:

The overall equation of motion for the USV can be expressed using Newton's secondlaw:

$$m \times a = P - R - (F+B)$$

where:

- m is the mass of the USV,
- a is the acceleration.

These equations provide a basic framework for modelling the capabilities of a drone boat. As with UUVs, specific criteria for parameters such as drag coefficients, reference areas, and friction coefficients will need to be determined based on the type of drone boat. The hydrodynamics of a UUV moving underwater involve various factors, including drag, buoyancy, and propulsive forces. Some key equations in hydrodynamics include

F. Drag Force (D):

The drag force is often modeled using the drag equation:

$$D = 1/2 \times C_d \times A \times \rho \times V_2.$$

where:

- Cd is the drag coefficient,
- A is the reference area,
- ρ is the water density,
- V is the velocity of the UUV.

G. Buoyant Force (B):

The buoyant force is related to the displaced water volume:

$$B = \rho_{water} \times g \times V_{displaced}$$

where:

- ρ_{water} is the water density,
- g is the acceleration due to gravity
- Vdisplaced is the volume of water displaced by the UUV.

H. Thrust Force (T):

The thrust generated by UUV propulsion systems can be expressed as:

$$T = m^{\circ} \times Ve$$

where:

- m˚is the mass flow rate of water through the propulsion system,
- Ve is the effective exit velocity.

I. Equations of Motion:

The overall equation of motion for the UUV can be expressed using Newton's secondlaw:

$$m \times a = T - D - B$$

where:

- m is the mass of the UUV
- a is the acceleration.

J. Power Consumption:

$$P = I \times V$$

Where:

- P is power,
- I is current
- V is voltage.

These equations provide a basis for modeling the hydrodynamics of a UUV moving underwater. Specific values for parameters like drag coefficient, reference area, and others would need to be determined based on the UUV's design and characteristics.

V. WORKING PRINCIPLE

The operating principles of unmanned vessels (surface vehicles or USVs) and underwater vehicles (unmanned underwater vehicles or UUVs) may differ depending on the design and intended use

A. Drone Boats (Unmanned Surface Vehicles - USVS):

Water jet thrusters are utilized in boats for their advanced propulsion system, offering exceptional maneuverability and versatility. The process begins with a specialized intake system located at the boat's hull bottom, drawing water into the vessel while incorporating protective measures like grates to prevent debris damage. Once water enters, it's directed towards an impeller a rotating component with curved blades inside a pump casing. The impeller imparts kinetic energy to the water, pressurizing it for efficient expulsion. The pressurized water then passes through an adjustable nozzle, crucial for controlling the water jet's direction. The adjustable nozzle enables precise steering and agile maneuvers by allowing operators to modify its angle. This control is invaluable for scenarios requiring rapid acceleration, precise navigation, and shallow water operation. Thrust is generated as high-velocity water exits the nozzle, propelling the boat in the opposite direction. This propulsion system offers advantages like shallow draft, reduced risk of underwater obstacles damage, and improved safety for marine life. Boats equipped with water jet thrusters find application in military operations, high-speed ferries, patrol boats, and luxury yachts. Their bladeless design makes them environmentally friendly, particularly in areas with vulnerable marine ecosystems.

B. Design For Drone Boat:

The design of the hull depends on the intended use. Consider a flat-bottomed, V-shaped, systemfor stability and performance. Hull size affects stability, speed, and maneuverability in differentwater conditions.

C. *Propulsion Equipment**:***

UUVs employ diverse propulsion systems tailored to their operational depth and mission objectives. Electric thrusters, propellers, or water jets are commonly utilized, often with the inclusion of advanced technologies like AUVs (Autonomous Underwater Vehicles) are designed to operate independently of direct human control, navigating underwater environments for a variety of purposes such as oceanographic research, surveying, and data collection.

D. Communication:

Communication for UUVs poses unique challenges due to the limited range of underwater signals. Acoustic communication is commonly employed for underwater data transmission, allowing UUVs to communicate with each other or with a remote-control station by wired. Satellite communication is utilized when the UUV surfaces, enabling data exchange with a central control system or operator.

E. Mission Payload:

UUVs are equipped with a diverse range of mission-specific payloads, including high- resolution cameras, sonar systems for mapping the seafloor, environmental sensors for data collection, and even manipulator arms for interacting with underwater objects. These payloadscontribute to various applications such as scientific research, underwater exploration, and defense operations.

F. Power Source:

Powering UUVs requires careful consideration due to the limitations imposed by the underwater environment. Lithium-ion batteries are commonly used for shorter missions, whilelong-endurance UUVs may incorporate fuel cells or rechargeable energy sources for extendedoperational capabilities.

G. Integration of USVs and UUVs:

The combination of Unmanned Surface Vehicles (USVs) and Unmanned Underwater Vehicles (UUVs) in collaborative operations further enhances the capabilities of autonomous marine systems. Through coordinated missions, USVs can deploy UUVs for underwater tasks, creatinga comprehensive unmanned system for both surface and subsurface operations. This integration is particularly valuable for applications such as environmental monitoring, seabed mapping, and security surveillance in maritime environments. Collaborative efforts between USVs and UUVs underscore the synergistic potential of unmanned platforms in addressing complex challenges in marine exploration and defense.

H. Underwater Vehicles (Unmanned Underwater Vehicles – UUVs):

The operational framework of an underwater module is meticulously engineered to support its versatile functionalities in aquatic settings. Housed within a watertight enclosure to withstand the pressures of the deep, the module incorporates a propulsion system, typically composed of electric thrusters or propellers, enabling precise maneuvering in various directions. For depth management, a buoyancy control system is integrated, facilitating the module's ascent or descent through the water column. Power, sourced from rechargeable or disposable batteries, is essential for sustained operations, with advanced modules possibly incorporating renewable energy solutions such as solar panels. A comprehensive array of sensors and instruments, including cameras and environmental sensors, ensures thorough data collection. Meanwhile, a robust communication system, primarily acoustic for underwater transmission, enables real-time data exchange with the surface or remote operators. Accurate navigation is achieved through inertial navigation systems and magnetic compasses, ensuring precise positioning. Remote operation capabilities allow operators to control the module's movements and sensor configurations. Data gathered during missions are stored within the module and transmitted to the surface for analysis. Incorporating safety protocols, such as emergency ascent procedures, enhances the module's secure operation. Through the intricate integration of mechanical, electrical, and navigational components, underwater modules are equipped to perform a wide range of tasks, including scientific research, environmental monitoring, and surveillance.

I. Design for UUV:

Unmanned Underwater Vehicle (UUV) design considers various factors such as mission requirements, operational depth, payload capacity, and control system. The tank type module will act for compression and decompression by which our Swan boat will go beneath the surface of the water and similarly comes up the water surface.

J. Propulsion:

UUVs use a variety of propulsion techniques, such as electric propulsion, propulsion driven by electric motors, or even gliding. Electric propulsion is common because it offers precise control and relative silence, which is important for many underwater applications.

K. Navigation:

Underwater navigation is challenging due to the absence of GPS signals underwater. UUVs rely on a combination of sensors and navigation systems to determine their position and move autonomously.

L. Inertial Navigation Systems (Ins):

UUVs typically use inertial sensors (accelerometers and gyroscopes) to measure changes in speed andheading to help calculate their position over time.

M. Acoustic Positioning:

Sonar systems are used for underwater positioning. By generating sound waves and measuring the repetition time of the signal, the UUV can determine the distance between the surrounding objects andmove through the water

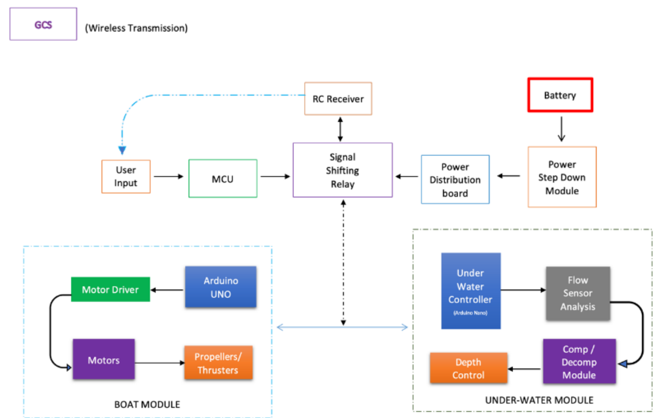
N. Communication:

Underwater communication is more challenging because radio waves do not penetrate well in water. Acoustic communication is a common method and Wired, with UUVs transmitting and receiving soundwaves. This allows them to communicate with users or other underwater vehicles.

O. Power Supply:

Typically, UUVs use rechargeable batteries to generate electricity. The choice of battery technology depends on factors such as energy level, weight, and duration. Advanced battery technology is critical to expanding mission endurance.

VI. BLOCK DIAGRAM



VII. METHODOLOGY

The creation of a hybrid robot combining boat and underwater capabilities begins with clearly defined objectives and specifications, considering intended applications and environmental conditions. Designing the architecture involves integrating boat and underwater platforms, considering factors like buoyancy and propulsion systems. A robust communication system is essential for seamless data exchange and remote control. Advanced navigation and autonomy features ensure adaptability to various operations. Efficient power management, incorporating renewable energy sources, is crucial for sustainability. Adherence to regulations and ethical considerations is vital before deployment. Post-deployment, data analysis informs mission success and upgrades. A durable mechanical structure and software development optimize performance, validated through testing and calibration. This comprehensive approach establishes a resilient, adaptable, and reliable hybrid robot, suitable for diverse aquatic tasks.

A. PROPULSION SYSTEMS:

- Surface Propulsion: Carefully select and design an efficient surface propulsion systemthat aligns with the hybrid robot's requirements. Consider factors such as speed,ensuring the chosen propulsion method allows for swift and stable surface navigation.Stability is crucial for surface operations, ensuring the robot can navigate varying waterconditions effectively.
- Underwater propulsion: Choose underwater propulsion systems tailored for precise navigation and controlled submersion. Opt for technologies that provide accurate maneuverability, allowing the robot to navigate underwater environments with precision. The selected underwater propulsion system should facilitate controlled submersion and ascent, ensuring the robot can perform tasks effectively beneath thewater's surface.

B. CONTROL AND NAVIGATION:

- User interface: Design a user-friendly interface facilitating seamless control transitions between surface and underwater modes. Prioritize intuitive controls that enable operators to easily switch between modes, ensuring a smooth and efficient userexperience. The interface should provide clear feedback on the robot's status, enhancing situational awareness during transitions.

- Autonomous operation: Implement advanced autonomous navigation capabilities for both surface and underwater operations. Integrate sensors and algorithms to enable therobot to autonomously navigate, adapting to the environment in real-time. This autonomy ensures the robot's versatility, allowing it to execute predefined tasks independently, optimizing efficiency and reducing the need for constant manual intervention

C. *HYDRODYNAMIC DESIGN:*

- Surface Module: Design the boat module with a primary focus on hydrodynamics, ensuring optimal efficiency in surface navigation. Prioritize stability in varying water conditions, allowing the module to navigate seamlessly across different surfaces. The design should maximize efficiency, promoting swift and stable movement while considering the impact of hydrodynamic forces on the surface module.
- Submarine Module: For the submarine module, prioritize considerations for underwater maneuverability, buoyancy control, and pressure resistance. Design the module to navigate precisely underwater, allowing controlled movements in different directions. Ensure robust buoyancy control mechanisms to enable controlled submersion and ascent. Additionally, focus on pressure-resistant design elements to withstand underwater environments effectively.

D. *SAFETY SYSTEMS*:

- Emergency Procedures: Develop comprehensive emergency procedures to address various scenarios, including system malfunctions, loss of communication, orunforeseen challenges during both surface and underwater operations. Outline step-by-step protocols to guide operators in responding to critical situations, ensuring a systematic and efficient approach to mitigate risks and minimize potential damage to the hybrid robot.
- *Safety protocols*: Implement rigorous safety protocols to safeguard both the system and operators. Define measures for obstacle detection, collision avoidance, and emergency landing procedures. Prioritize operator safety by incorporating fail-safes and clear guidelines to enhance overall operational safety during surface and underwater mission

VIII. IMPLEMENTATION

A. *Integration Mechanism:*

Create and implement a modular connection system linking the boat and submarine modules, rigorously verifying the sealed interface for water-tight connections. Conduct thorough testingto ensure the integrated system's ease of assembly and disassembly, prioritizing user-friendly features. This meticulous approach guarantees a robust connection that seamlessly transitions between surface and underwater configurations. The emphasis on watertight integrity and simplified modular assembly enhances the overall reliability and adaptability of the hybrid robot, crucial for its effective and efficient performance in diverse aquatic environments.

B. *Comp/De-Comp and Floatability Control*:

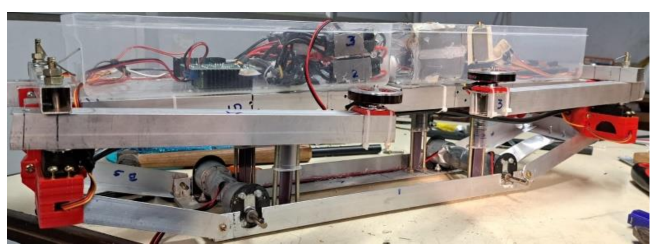
Integrate the compression system into the submarine, ensuring its ability to maintain desired depths effectively. Verify the system's functionality through rigorous testing, confirming its capability to control the submarine's depth accurately. Evaluate floatability control mechanisms to guarantee stability during transitions between surface and underwater modes. This meticulous integration and verification process ensures the submarine's buoyancy controlsystems are reliable, contributing to the overall stability and performance of the hybrid robot during dynamic shifts between aquatic environments.

C. *Testing and Validation:*

Initiate simulations to comprehensively test system performance across diverse conditions. Develop prototypes for both boat and submarine modules, subjecting them to extensive testing to identify potential issues. Address any issues discovered during testing, implementing necessary revisions to enhance overall system functionality. This iterative process, involving thorough simulations and prototype testing, ensures the hybrid robot's resilience and adaptability. By addressing challenges and refining the system, this approach contributes to thecreation of a robust, high-performance solution capable of meeting the demands of various real-world aquatic scenarios.

D. *Construction:*

Fabricate the boat module following hydrodynamic design specifications, incorporating the surface propulsion system, sensors, and communication equipment for optimal performance. Simultaneously, construct the submarine module with a pressure-resistant hull, ensuringdurability in underwater environments. Integrate underwater propulsion systems, tank control mechanisms, and observation equipment into the submarine module. This comprehensive fabrication and integration process aligns with design specifications, resulting in a hybrid robot with a well-engineered boat and submarine combination, equipped to navigate and operate efficiently both on the water's surface and underwater.



E. Communication:

1) *Surface Communication*:

a) *Frequency Adaptability*: The 2.4 GHz frequency is chosen for surface communication due to its versatility and common use in radio-controlled applications. The boat's communication system dynamically adjusts to different frequencies within this range based on signal strengthand interference.

b) *Antenna Diversity*: Employing multiple antennas enhances signal robustness, minimizingthe impact of signal blockages or reflections on the water surface.

c) *Real-Time Telemetry*: Enables the boat to transmit real-time telemetry data, including GPS coordinates, speed, and operational status, ensuring effective monitoring and control from theground station.

IX. HARDWARE

A. *Battery*

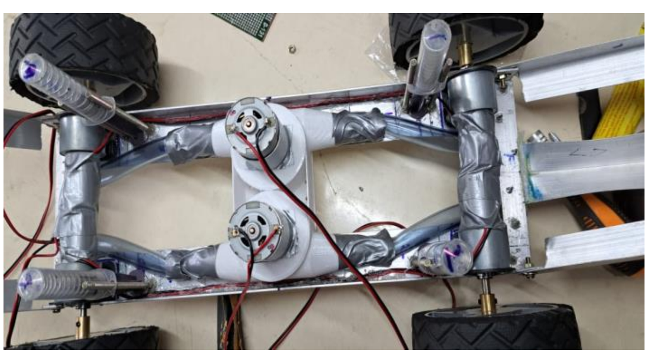
Lithium polymer (LiPo) batteries, typically rated at 22.2V, are widely used in boats and underwater modules due to their energy density, weight efficiency, and rechargeability. These batteries feature a lithium-based cathode and anode separated by a polymer electrolyte. Their selection depends on factors like size, weight, intended use, and operational duration. 22.2V LiPo batteries offer a balance of characteristics suitable for both surface boats and underwater modules. They are lightweight yet provide robust energy output for propulsion and electronics. Capacity, measured in milliampere-hours (mAh) or watt-hours (Wh), determines stored energy capacity and influences operational duration. Higher capacities extend operational time, making 22.2V LiPo batteries preferred for boating and underwater exploration

B. *Motors:*

The 385 DC motor, tailored for drones and underwater modules, transforms electrical energy into mechanical energy through electromagnetism. Operating on magnetic field interaction, it utilizes electric current to generate a magnetic field, inducing mechanical motion. Known for simplicity, control ease, and versatility, the 385 motor is integral inpropelling and controlling movement in these applications. Its precise speed and torque control, achieved by adjusting applied voltage, make it ideal for varied tasks, enhancingefficiency in both aerial and underwater environments. In drones and underwater modules, the 385 DC motor stands as a pivotal component, driving operational effectiveness and maneuverability across diverse applications

C. *Propellers And Water Jet Thrusters*:

Propellers and jet water thrusters are vital propulsion systems for both boats and underwater modules, each offering distinct advantages in aquatic environments. Propellers, commonly used in both surface vessels and underwater modules, function by spinning blades to generate thrust. They are efficient and versatile, providing straightforward maneuverability. On the other hand, jet water thrusters utilize high- velocity water jets expelled through nozzles for propulsion, offering precise control



and agility. Jet thrusters are particularly advantageous in underwater modules, as they eliminate exposed rotating parts, ensuring safety and maneuverability in confined spaces. The choice between propellers and jet thrusters depends on specific application requirements, with propellers excelling in simplicity and jet thrusters in precise control and safety for underwater exploration.

D. *Boat Controller:*

An underwater controller refers to a specialized device or system designed for the remote operation and management of underwater vehicles or equipment. Widely employed across diverse underwater applications, such as remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs), submarines, and underwater drones, these controllers facilitate the seamless command and monitoring of underwater vehicle movements and functions. In this context, the Arduino Uno serves as a crucialcontroller, enabling both human operators and autonomous systems to exert precise control over underwater vehicles. This technology is instrumental in underwater exploration, research endeavors, and various industrial applications, providing a means to navigate and oversee operations in challenging underwater environments where direct human intervention may be impractical or unsafe.

E. *Depth Control*

The compression and decompression mechanism within an underwater vehicle container ensures efficient movement across depths and stable operations. It dynamically manages volume, crucial for buoyancy control and safety. Controlled by an Arduino Nano, it adjusts volume based on user input and sensor feedback. Constructed from underwater-compatible materials, it protects sensitive equipment and personnel. Customizable features like armor plating enhance protection. This innovative system, with smart control and adaptive volume adjustment, optimizes functionality for diverse underwater scenarios.

F. *Flow sensor:*

The flow sensor deployed in the unmanned underwater vehicle (UUV) depth control system plays a pivotal role by analyzing the volume of the container. Unlike traditional flow sensors measuring water movement around the vehicle, this sensor focuses on assessing the water volume in the UUV's vicinity. This innovative approach allows theUUV to precisely control its depth by monitoring changes in water volume. Real-timedata from the flow sensor empowers the UUV to make rapid adjustments, ensuring optimal depth control, orientation, and navigation in various underwater environments.By integrating this information with other sensor inputs, such as GPS and inertial sensors, the UUV achieves enhanced accuracy in maintaining desired depths, proving indispensable for missions requiring meticulous depth navigation and precise data collection

.

G. *Power Distribution Board*:

The power board plays an important role in controlling and distributing electricity in drone boat and unmanned underwater vehicle (UUV) integration systems The PDB actsas the primary power distributor, and connects power sources, as batteries or other energy generation systems Ensure that voltage regulation circuits are included to prevent damage from voltage spikes or drops. The PDB typically incorporates current-limiting features to prevent overloading of components. It may include protection mechanisms such as fuses or circuit breakers to safeguard against short circuits and overcurrent situations. The PDB plays a role in optimizing energy usage by efficiently distributing power based on the operational needs of different components. The PDB may be integrated with emergency systems, such as emergency shutdown circuits or power cutoff mechanisms, to address critical situations. To enhance system reliability, the PDB may incorporate redundancy features, ensuring that power distribution remains functional even in the case of a component failure. the Power Distribution Board is a crucial component in an integrated drone boat and UUV system, providing a centralized and controlled distribution of electrical power to ensure the safe and efficient operation of all subsystems and components

H. GCS

GCS (Ground Control Station) plays a vital role in the integration system of a drone boat and Unmanned Underwater Vehicle (UUV). The GCS is the onshore facility responsible for monitoring, controlling, and communicating with the vehicles during their missions. The GCS is used to plan and coordinate missions for both the drone boatand UUV. Operators can define waypoints, set mission parameters, and plan the overalltrajectory of the integrated system. Operators at the GCS can remotely control and maneuver both the drone boat and the UUV. This is particularly useful for adjusting thecourse, speed, or depth based on real-time conditions. The GCS provides a user-friendly interface for operators to visualize real-time data from both the drone boat and UUV. This includes sensor readings, camera feeds, and other relevant information The GCS serves as the central communication hub for the integrated system. It facilitates bidirectional communication between the onshore operators and the vehicles, ensuring a reliable link for data exchange and control commands. In the event of emergencies or unexpected situations, the GCS provides operators with tools to initiate emergency procedures. This may include activating fail-safes, returning the vehicles to a safe location, or shutting down specific systems.

I. *BS CONTROLLER*

The BS controller (Boat submarine controller) plays a critical role in the integration system of a drone boat and Unmanned Underwater Vehicle (UUV). Its functions are diverse and essential for ensuring effective communication, coordination, and control between the surface drone and the underwater vehicle. BS controls devices through relays, facilitating the activation and deactivation of various components, thereby enhancing the overall functionality and responsiveness of the integrated system. The efficiency and responsiveness of the entire system are heavily dependent on the capabilities and programming of the BS controller, making it a critical element in achieving optimal performance and control.

X. SOFTWARE

A. Mission planner:

Mission Planner is a ground control station software designed for mission planning,monitoring, and control of unmanned vehicles. It is particularly associated with the Ardupilot open-source autopilot platform, which is used in a variety of unmanned vehicles, including drones (unmanned aerial vehicles or UAVs), rovers, boats, andmore. Mission Planner is widely used in the open-source community, especially with vehicles that run the Ardupilot firmware. It provides a user-friendly interface and a comprehensive set of tools for both novice and advanced users. Keep in mind that the specific features and capabilities of Mission Planner may evolve over timewith software updates and community contributions.

B. User Interface:

A User Interface (UI) refers to the point of interaction between a user and a computer system or a device. It encompasses everything that a user can interact with—whether it's physical hardware components or software applications—and itplays a crucial role in facilitating effective communication and interaction. A well-designed user interface aims to be intuitive, efficient, and visually appealing. It considers user experience (UX) principles to ensure that users can interact with thesystem or application seamlessly and achieve their goals effectively. The field of user interface design is interdisciplinary, involving aspects of psychology, graphic design, human-computer interaction, and usability engineering.

Real-time data visualization in a ground control station (GCS) involves the dynamicrepresentation of critical information from a drone during flight. Through intuitive graphical interfaces, operators can instantly monitor key parameters such as altitude, speed, battery status, and GPS coordinates.

These visualizations often include interactive maps, telemetry graphs, and sensor readings, offering operators immediate insights into the drone's performance and environmental conditions. Real-time data visualization plays a pivotal role in enhancing situational awareness, enabling operators to make timely decisions and adjustments during drone operations for optimal control and mission

XI. CONCLUSION

In conclusion, the integration of adaptable robotic systems designed for traversing diverse terrains, such as the Hybrid robot combining boat mobility with underwater capabilities, addresses the growing demand for advanced surveillance and exploration in defense scenarios.The challenges of monitoring vast territories, particularly across water bodies, have led to the development of innovative solutions. This hybrid robot, with its seamless transition between surface and underwater operations, emerges as a groundbreaking tool for enhanced observation, data collection, and monitoring.

REFERENCES

[1] A. Troupiotis-Kapeliaris et al., "Building an autonomous boat: a multidisciplinary design engineering approach," 2023 IEEE 10th International Workshop on Metrology for Aerospace (MetroAeroSpace), Milan, Italy, 2023, pp. 556-561.

[2] Mondal, Kingshuk, Banerjee, Tanumoy, 2019/11/30

SP - 215, EP - 222, Autonomous Underwater Vehicles: Recent Developments and Future Prospects, VL - 7 International Journal for Research in Applied Science and Engineering Technology

[3] Plumet Frederic, Petres, Clement, Romero-Ramirez, Miguel-Angel, Gas, Bruno Ieng, Sio-Hoi, 2015/04/10, SP - 397, EP - 407, Toward an Autonomous Sailing Boat, VL - 40, IEEE Journal of Oceanic Engineering

[4] J.G. Bellingham, Platforms: Autonomous Underwater Vehicles, Editor(s): J. Kirk Cochran, Henry J. Bokuniewicz, Patricia L. Yager, Encyclopedia of Ocean Sciences (Third Edition), Academic Press, 2009,Pages 159-169.

[5] Debnath, Atanu Nithe, NA Arefin, A Uddin, MN Nezirić, Emir, 2023/06/15, Underwater Surveillance Autonomous Boat

[6] Brown, Hunter, Kim, Ayoung, Eustice, Ryan

PY - 2009/05/01, T1 - An Overview of Autonomous Underwater Vehicle Research and Testbed at PeRL VL - 43, Marine Technology Society Journal