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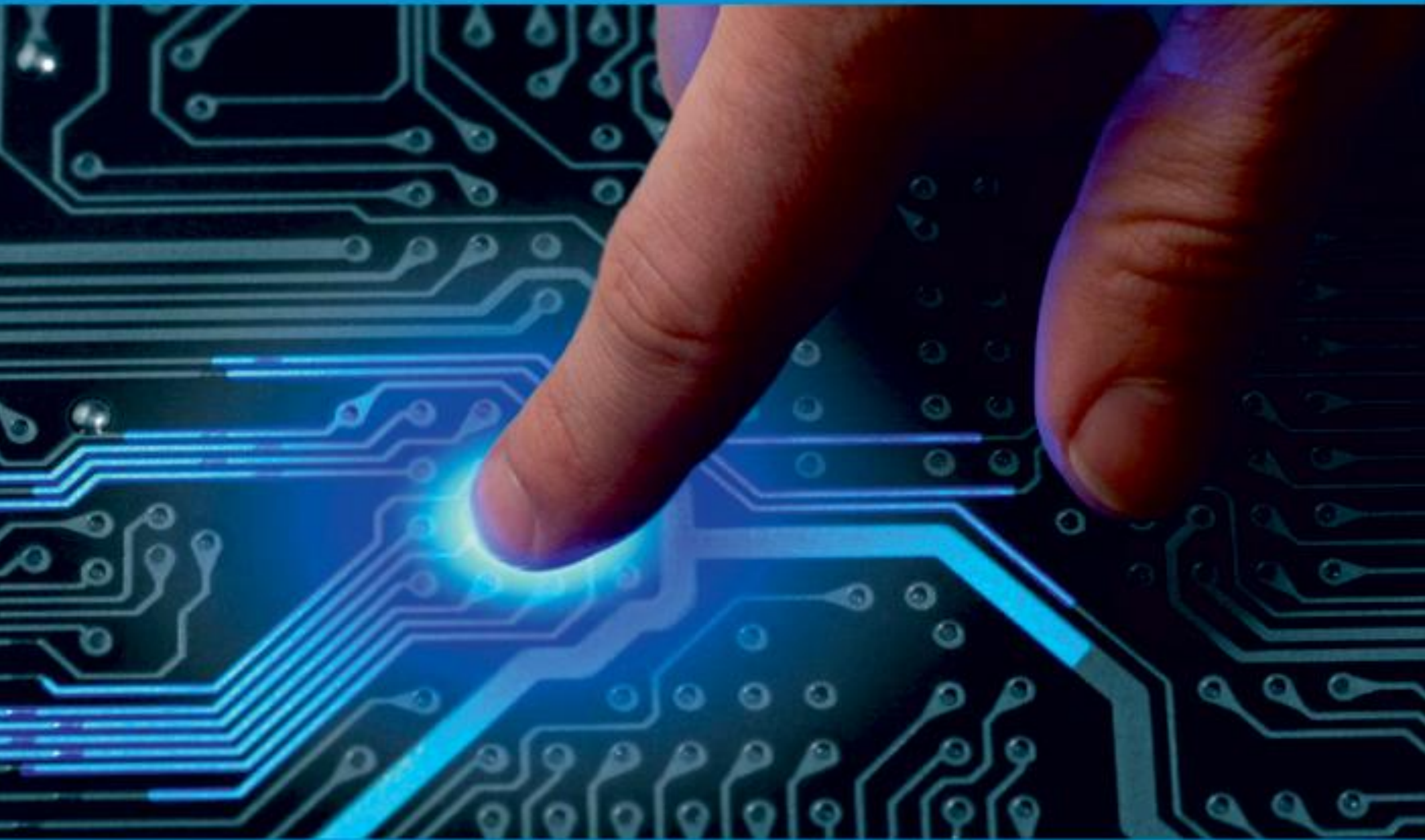

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Aquatic Remote Operator

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ABSTRACT: The Aquatic Remote Operator (ARO) system represents a significant advancement in underwater exploration and intervention. This paper provides a comprehensive evaluation of the ARO technology, its components, and its applications across various industries. The ARO system enables remote operation of aquatic vehicles, equipped with cameras, sensors, and manipulators, allowing for precise control and data collection in challenging underwater environments. Key features such as real-time feedback, maneuverability, and adaptability are explored, alongside recent developments and future prospects. Additionally, this review highlights the diverse range of applications for ARO systems, including marine research, offshore inspections, underwater construction, and environmental monitoring. By leveraging ARO technology, researchers and industry professionals can effectively navigate and manipulate underwater environments with increased efficiency and safety.

KEY WORDS: ARO, Real-time feedback, Precise, Camera, ATmega 328p Microcontroller.

I. INTRODUCTION

In recent years, there has been a considerable shift, the exploration and utilization of underwater environments have gained significant importance in various industries and scientific endeavors. However, the challenges shared by the aquatic realm, including extreme pressures, limited visibility, and accessibility constraints, have historically hindered human intervention and exploration efforts. To overcome these challenges, the development of aquatic remote operator (ARO) systems has emerged as a promising solution. ARO systems allow for the remote operation of underwater vehicles equipped with cameras, sensors, and manipulators, enabling precise control and data collection in otherwise inhospitable conditions. This introduction provides an overview of ARO technology, its significance in underwater exploration and intervention, and the potential applications across different sectors. Furthermore, it outlines the objectives and structure of this review, aiming to highlight the advancements, challenges, and future prospects of ARO systems in underwater operations.

This introduction sets the stage by providing an overview of the significance of underwater exploration, the limitations of traditional methods, and the function of AROs in overcoming these challenges. We begin by highlighting the significance of underwater habitats, encompassing over 70% of the Earth's surface and are home to a rich diversity of ecosystems, resources, and geological features.

Next, we discuss the historical methods used for underwater exploration, including manned submersibles, divers, and tethered remote systems, and their inherent limitations regarding cost, safety, and operational constraints. These traditional approaches have often restricted the scope and scale of underwater research and development.

We then introduce AROs as a revolutionary alternative, enabling remote operation and observation of underwater environments from the safety and comfort of a control center on the surface. AROs encompass a wide range of technologies, including remotely operated vehicles (ROVs), autonomous underwater vehicles (AUVs), sensors, communication systems, and advanced control interfaces.

Finally, we outline the objectives of this paper, which aims for supplying a comprehensive review of ARO technologies, applications, challenges, and future directions. By exploring the capabilities and potential of AROs, we seek to inspire further advancements and innovations in underwater exploration and utilization.

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II. RELATED WORK

Sanjib Kumar Deb; Jahed Hossen Rokky; Tuton Chandra Mallick; Juliana Shetara Proposed "**Design and construction of Underwater Robot**". The included paper outlines the development and construction of an underwater robot operated wirelessly. Utilizing an Arduino-based platform for processing, transmitting, and receiving data, our project stands out by employing a pair of Arduino boards and RF modules for control. The propulsion system, comprising six homemade waterproof thrusters, enables both horizontal and vertical movement. Equipped with a camera functioning as its eyes, this versatile robot finds application in tasks like underwater environmental monitoring, oceanographic surveys, pipeline inspection, and debris assessment, among others.

Rongxin Cui; Demin Xu; Meng Shen Proposed **"An Obstacle avoiding control strategy for Autonomous Underwater vehicle".** Proposed strategy for obstacle avoidance in autonomous underwater vehicles (AUVs) integrates a fuzzy inference system (FIS) with a path following control law. Using a forward-looking sonar for measurement, the FIS determines the obstacle-avoidance angle based on the AUV's position relative to obstacles. This angle is then used as the heading error for the pathfollowing control law. Simulation results demonstrate the effectiveness and ease of implementation of this integrated strategy.

Mohd Shahrieel Mohd Aras; Muhamad Khairi
Aripin; Muhammad Wahyuddin Nor Azmi;Alias Khamis;Proposed **"3DOF small scale underwater manipulator gripper for unmanned underwater vehicle"**. The paper introduces the design and development of a three-degree-of-freedom (3DOF) underwater manipulator gripper for an unmanned underwater vehicle, aiming to enhance flexibility by adding an additional degree of freedom. Micro Arduino serves as the controller, with a thumb joystick used for waist and arm movement control.

Experimental tests underwater indicate that the 3DOF manipulator gripper can lift up to 700 grams for a circular shape and 400 grams for a square shape. Another paper focuses on the modeling and motion control system research of a mini autonomous underwater vehicle, establishing a spatial motion mathematical model controlled by thrusters and fins. The embedded motion control system details the hardware and software architecture, with experiments in a lake validating the system's basic performance. Additionally, a variable structure control law is proposed for path control of the AUV.

Weijia Ma; Yongjie Pang; Chanjuan Jiang; Xin Du Proposed **"Research on the optimization of PID control of remotely operated underwater vehicle"**. The included paper presents Ant colony algorithm (ACA) is a heuristic evolutionary algorithm, which is on the bionic population, and PID controller of remote operator underwater vehicle (ROV) can be optimized by it. Optimal combination of PID control operators can be determined by simulating the way ants find the shortest path, and then these operators can be improved by ACA. The results show that PID controller optimized by ACA will rise faster and overshoot smaller. The PID parameters improved by ACA will be better controlled than before.

Masahiko Sasano; Shogo Inaba; Akihiro Okamoto; Takahiro Seta; Kenkichi Tamura; Tamaki Ura; Proposed **"Development of a regional underwater positioning and communication system for control of multiple autonomous underwater vehicles"**. The included paper presents, A new complex system of underwater positioning and system communication that has been developed for control of multiple autonomous underwater vehicles (AUVs). It consists of a semi-submersible autonomous surface vehicle (ASV), a hovering type AUV, and three surface buoys. The operational concepts for control of multiple AUVs are discussed.

Li Ye; Tang Xu-dong; Pang Yong-jie Proposed **"S Plane Control of underwater vehicle and its hybrid training algorithm".** This paper presents, For the particular control object. For automatic underwater vehicles (AUVs), an S-Plane control method based on fuzzy control combined with PID control is introduced. This approach is simple and effective, though parameter adjustments are necessary. Additionally, an algorithm based on a single neuron cell is proposed. This improved method is proposed on which improved PSO algorithm is used offline first for optimizing which can avoid the phenomenon of precocity and stagnation during evolution, followed by online adjustment with single neuron cell algorithm. The feasibility and benefits of the proposed approach method are demonstrated by simulation test results.

Bo Wang; Yumin Su; Lei Wan; Yueming Li Proposed **"Modeling and motion control system research of a mini underwater vehicle".** This Paper presents, Spatial motion mathematic model of a mini autonomous underwater vehicle

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(in short, AUV) controlled by thruster and fins was established. The forces acting on the AUV were analyzed and the main hydrodynamic coefficients were determined both theoretically and experimentally. The embedded motion control system was introduced in detail, including hardware architecture, software architecture, information flow and etc. Considering the characteristics of the vehicle, the basic motion controller was designed based on S control method. Finally, a series of the AUV control system experiments in lake were done to verify the basic performance or the control of the motion control system.

III. METHODOLOGY

The development and operation of a Aquatic Remote Operator (ARO) for inspection represent a multifaceted process. This section will delve into the methodologies involved, emphasizing the core features of the ARO.

The block diagram in fig 1. Shows, the working of the robot.

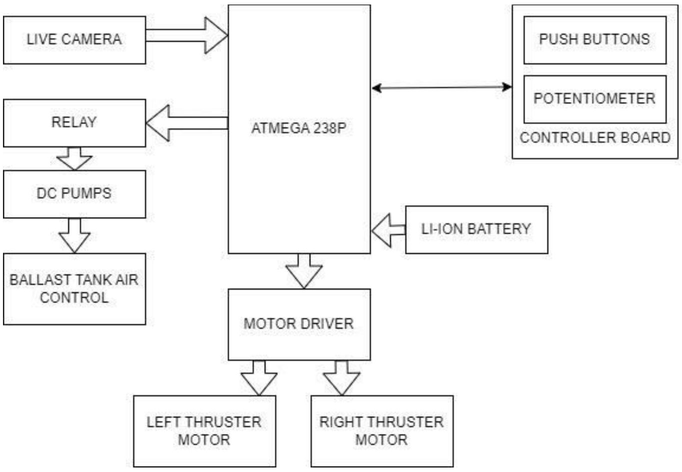

Fig 1. Block Diagram

ATmega 328328P Microcontroller: The heart of the ARO's operations, the ATmega 328p microcontroller, acts as the central processing unit (CPU) for controlling various functions. It receives and processes commands from the operator and translates them into actions performed by the ARO.

Fig. 2: Arduino board having ATmega 328P Microcontroller.

Live Camera: A key feature of the ARO is the live camera system. This component allows for real-time video transmission from the underwater vehicle to the operator, enabling them to visualize and assess the underwater environment during inspection tasks.

Propulsion System: The ARO is having with two thrusters, each controlled by the ATmega 328p, enabling the vehicle to thrust forward and control its direction in the underwater.

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Fig.3: Thruster

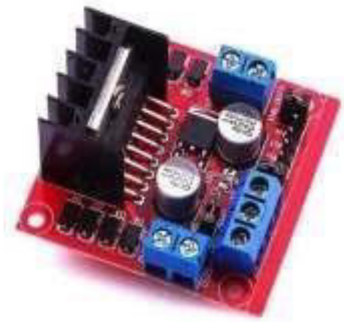

Fig.4: LN298 Motor Driver

Fig. 5: DC Motor

Ballast Tanks and Buoyancy Control: To navigate through various depths, the ROV incorporates a system of ballast tanks. These tanks are outfit with inbuilt pumps that can increase or decrease the volume of air, thereby controlling the vehicle's buoyancy and allowing it to sink or float as required. We use 12 dc pumps which are connected to relay and relay is controlled by micro controller. When ARO has to sink the air pumped out of the ROV via pumps and when ARO has to float up then air is pumped inside the ballast tank.

Telemetry and Control Board: The ARO is connected to the control board through a wired tether. This connection allows for real-time control and monitoring of the vehicle's operations. The control board provides a user-friendly interface through which an operator can control the ARO's movements, and various inspection tasks. It has button and potentiometer to regulate the altitude of ARO and also control the direction.

Versatility and Adaptability: The ARO is engineered to versatility in mind. It can be adapted for various inspection purposes, including marine biology research, pipeline inspections, shipwreck exploration, and more.
Safety and Reliability: Safety is a paramount concern in underwater environments. The ARO is engineered to fail-safes and redundant systems to ensure its reliability and to mitigate risks associated with underwater operations.

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IV. RESULT

The project focuses on developing an Aquatic Remote Operator system designed to navigate and operate in waterbased environments. Through innovative technology and advanced control systems, the project aims to revolutionize remote operations in aquatic settings. Utilizing the potential or tapping into the energy of remote control technology, this system enables operators to manipulate and control aquatic equipment and vehicles from a distance, offering a safe and an effective resolution for diverse applications, including underwater tasks like exploration, environmental monitoring, and marine research. Through rigorous research and development, the project ensures that the Aquatic Remote Operator system meets the highest standards of performance, reliability, and safety, ultimately providing a valuable tool for industries and organizations working in marine and underwater domains.

Fig. 6: Image taken using a high definition camera

V. CONCLUSION

In conclusion, the development of this Aquatic Remote Operator (ARO) represents a significant leap in underwater inspection technology. The ROV, powered by the Atmega 328p controller, offers a comprehensive solution to the challenges posed by underwater inspection, enabling safer and more efficient exploration of aquatic environments. By enhancing mobility, reach, and real-time visual feedback, this project stands as a testament to our commitment to advancing the capabilities of underwater exploration and inspection, ensuring a safer and more productive future in this realm.

VI. FUTURE SCOPE

Looking ahead, the future scope for the Aquatic Remote Operator system is promising, offering abundant possibilities for additional innovation and application. One avenue for expansion is the integration of artificial intelligence (AI) and machine learning algorithms to enhance the system's autonomy and decision-making capabilities. By leveraging AI, the Aquatic Remote Operator can adjust to changing environmental conditions, optimize navigation routes, and autonomously accomplish tasks with enhanced efficiency and accuracy.

Additionally, there is potential to explore new applications and industries where the Aquatic Remote Operator can be deployed. For example, the system could be utilized in underwater infrastructure inspection, pipeline maintenance, offshore energy operations, aquaculture management, and search and rescue missions. By expanding its scope of use, the Aquatic Remote Operator can address a wider range of challenges and contribute to increased productivity, safety, and sustainability in aquatic environments.

Furthermore, ongoing advancements in sensor technology, communication systems, and underwater robotics will continue to drive improvements in the capabilities of the Aquatic Remote Operator. Miniaturization of components and the advancements in ruggedized materials will also enable the system to function within more challenging and extreme underwater conditions.

Overall, the future of the Aquatic Remote Operator holds immense potential for innovation, collaboration, and impact, paving the way for enhanced exploration, monitoring, and management of aquatic ecosystems and resources.

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