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MINI SUBMARINE FOR UNDERWATER OBJECT DETECTION– A Review

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ABSTRACT

Aquaculture has become an essential source of food for millions of people worldwide, and it is also a significant contributor to the global food economy. According to recent studies, the aquaculture sector has been growing rapidly, and it currently accounts for almost 50% of the fish consumed globally. However, fish farmers face significant challenges, such as inadequate water quality control systems, major illnesses, and environmental pollution, which can lead to substantial losses. Open net cage and land-based fish farms discharge wastewater containing harmful substances into the surrounding environment, highlighting the need for regular water quality monitoring. Ensuring a safe and controlled environment for fish production is critical, and intelligent monitoring and control systems are necessary to achieve this goal. These systems can lead to economic benefits, reduced risks, and increased yields, making aquaculture a more sustainable and profitable industry. One promising technology that can improve monitoring efficiency and reduce human error is the use of autonomous underwater vehicles (AUVs) in cage aquaculture. AUVs can operate in harsh and challenging environments, such as underwater areas with low visibility, and they can collect data on water quality, temperature, and other environmental factors. This data can be transmitted in real-time to a control center, allowing farmers to monitor the condition of their cages continuously. Additionally, AUVs can be equipped with cameras, sensors, and other instruments to provide detailed information on the fish's health and behavior. Implementing AUVs in cage aquaculture can improve the industry's sustainability by reducing waste and minimizing environmental pollution. AUVs can also provide a valuable tool for surveillance activities, allowing fish farmers to detect illegal fishing and other unauthorized activities. Furthermore, AUVs can aid in infrastructure inspection, helping to identify and repair damaged cages and other equipment. In conclusion, the aquaculture industry faces numerous challenges, including water quality control, environmental pollution, and disease control. Intelligent monitoring and control systems, along with the use of AUVs, can help mitigate these challenges by providing farmers with real- time information on their cages' condition, fish health, and the environment. Implementing these technologies can promote a more sustainable and profitable aquaculture industry, ensuring a reliable source of food for millions of people worldwide. Problem Statement.

I. INTRODUCTION

Underwater vehicles, often called unmanned underwater vehicles (UUVs) or autonomous underwater vehicles (AUVs), are versatile submersibles designed to operate in aquatic environments. These vehicles can perform a wide range of tasks, from oceanographic research and environmental monitoring to defense and industry applications. Their autonomy and adaptability make them essential tools for exploring and working in the world's oceans and water bodies, often in places too deep or hazardous for human divers. The hydrographic industry has often been adopting several techniques like Synthetic Aperture Sonar (SAS) and variable resolution surface creation for conduit channel scrutiny projects as the suite for underwater imagery and video capture via Autonomous Underwater Vehicles (AUVs) or Remotely Operated Vehicles (ROVs). Also, tracking underwater objects during active circumstances can be done by signal processing methods such as sector scan sonar, side scan sonar, and SAS, where, the acoustic formation is done i.e., echoes are reflected by the target and are analyzed by the receiver, to detect the object's presence. This acoustic analysis involves the approximation of the time-of-flight of the reflected signal in water, therefore requires the absolute value, known as amplitude techniques. However, amplitude techniques possess several drawbacks that limitate the tracking performance. Underwater applications such as object detection, imaging of wrecks, and underwater tracking have always been a continuous research area with its wide field variance. Nevertheless, due to interference processes and formation methods, there is always some noise introduced into the area of interest, which reduces the effectiveness of the wide applications of underwater acoustics. Hence, there is a limit in the dexterity of couth interpretation of underwater images, restricts edge separation, image segmentation, target recognition, and classification, and it introduces ambiguity in underwater navigability and texture parametric inversion. However, this paper proposes a method where the underwater images are processed to detect objects.

II. LITERATURE REVIEW

[1] Object Detection: There have been ample researchers and marine biologists who counted the number of objects in the present frame or identified them in the streaming videos. To that end, object detection is needed. The main hindering met was to make the correct preference of the object detection algorithm, as it is the one, that influences the performance of the object detecting and counting systems. The main optimization problem found is the processing time and data acquired i.e., the algorithm's pliability is restrained at the points where application of filter and parameter sequence needs to be followed up, reflecting the inadequacy of these algorithms due to the large processing time required. Therefore, a moving average algorithm is explored, based on removing a reference image exhibiting the background, from the current input image. A specific object's detection can be done, based on finding point relations between the reference and the target image. There are several advantages of comparing the Target image and the Reference image despite detecting them randomly as it can detect objects despite a scale change or in-plane angular rotation. It is also manifest in trivial out-of-plane rotation and occlusion.

[2] Overview of Object Detection and Tracking System on AUV: An Autonomous Underwater Vehicle (AUV) is an undersea unmanned vehicle used for special purposes i.e. underwater surveys, underwater inspection, military, etc. AUV is also known as an unmanned cable robot, which is equipped with various sensors for a specific purpose. In its application, AUV contributes by helping humans in efforts to empower marine exploration in Indonesia, by inspecting underwater pipelines, mapping underwater areas, and for military purposes. In the construction of an underwater vehicle, considering every aspect and element of the vehicle is important to avoid overdesigning the vehicle. The right and appropriate design of AUV including its control system can make operational costs more efficient. The main element that needs to be emphasized in the design is the propulsion system. The propulsion system must have a high thrust ratio. Every component of the propulsion system needs to be designed with care because the greater the motor power used, the heavier the propulsion system on the vehicle. Another aspect is the placement and number of motors used on the rides. Generally, the three motors on the rides will make the rides have forward, backward, up, and down motions; the four motors on the ride will give additional lateral thrust; and the five motors on the ride will make the ride have thrust in all horizontal directions. Placing the motor off the longitudinal axis of the vehicle will allow the vehicle to have a better turning moment.

[3] Grounded Passive Visual Underwater Surveillance: A Survey transmission function, which largely depends upon many underwater parameters. In a situation, where there will be global motion (an object in the scene and the camera changes its position) and the scene of view is not clear due to atmospheric haze, it is very difficult to detect the moving objects present in the scene. Further, the identification of the object of concern and tracking of that becomes more challenging. Block diagram representation of an underwater surveillance system. The source of illumination is here sunlight. The black dots represent the suspended particles or haze present in the medium. When a light incident on the water's surface it bends towards the normal. The deflected light rays get incident on the object and then reflected from it. The camera lens captures the direct, forward-scattered, and backscattered lights. These lights are then sensed by the image-sensing grids and fed to the processing unit for further analysis of the scene content. Underwater Cameras: Visual cameras can be broadly classified into two categories depending on their use in different environments. The first one is the outdoor camera, whereas the second type of camera is called the underwater camera which has strong housing to make them waterproof. Different types of underwater cameras

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are available nowadays.

[4] Hovering is a manipulation mode maintaining depth and attitude for underwater vehicles in zero speed or extreme-low speed state. The manipulation effectiveness of the rudder under this mode is limited, and the control is mainly based on the ballast tank and propeller. Hovering is a very important capability for autonomous underwater vehicles (AUV) and large underwater platforms. In the past few years, several hovering unmanned underwater vehicles have been developed. Hover manipulation extends the capabilities of underwater robots, allowing them to perform more complex tasks. These tasks, including underwater target identification, communications, and underwater docking, require the ability to hover at a fixed point. In particular, future underwater robots will replace humans to do most kinds of underwater work. Hover control is one of the most important underwater capabilities The associate editor coordinating the review of this manuscript and approving it .

III. BLOCK DIAGRAM

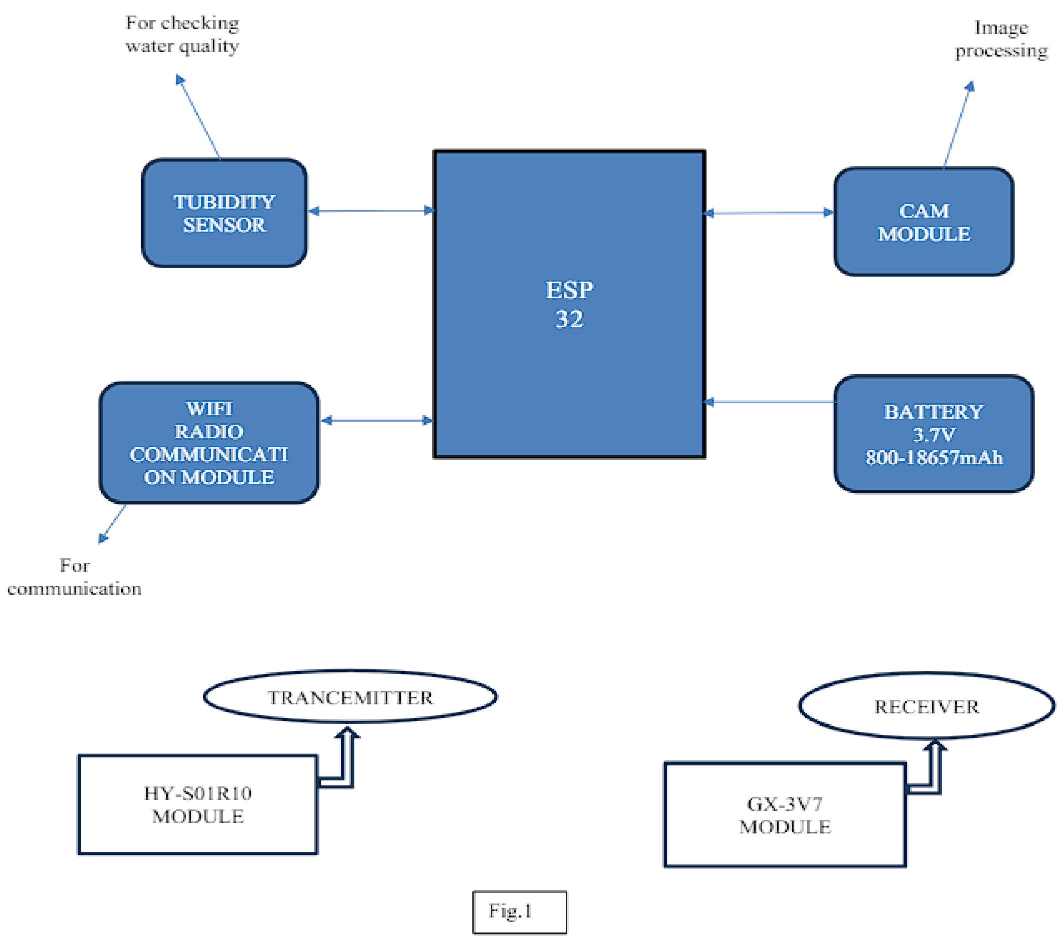

Figure 3.1: Block diagram

The above figure shows the block diagram of the mini-submarine for underwater object detection. In this proposed methodology we have two different modules in this methodology. The first module i.e., fig.1 will tell about the computation of image processing and object detection. Here we are using the ESP32 CAM module to capture the image and this captured image will be detected. In this module, the quality of water will be monitored and sends the data to the user. We have used the wifi/radio communication module to communicate with the autonomous vehicle to the person who will operate it. Finally, the 3.7v battery has 800 mAh to 18650 mAh capacity which will make the battery consumption low. The next module is defined for the controlling of the mini-submarine i.e., forth and back left and right. In this, we are using the HY-S01R10 module for transmitting the controlling signals and this act has a transmitter. We are using the GX-3V7 module which is placed in the mini-submarine and will be receiving the control signals from the HY-S01R10 module this GX-3V7 module will act as a receiver. The operating frequency of this transmitter and receiver is 2.4G H.

HARDWARE USED

ESP 32 BOARD: -The ESP32 is a series of low-cost, low-power system-on-chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. These microcontrollers are popular for a variety of applications, including IoT (Internet of Things) devices, robotics, and more. The ESP32 is developed by Espressif Systems.
CAM MODULE: -A CAM module, or Conditional Access Module, is a hardware component used in digital television receivers to decrypt and access encrypted channels. It typically works with a smart card to authorize access to specific content.
TURBIDITY SENSOR: - Turbidity refers to the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye. It is a measure of the scattering and absorption of light in the fluid due to these particles. In various fields, including environmental science and water quality monitoring, turbidity is often used as an indicator of water quality. High turbidity levels can result from suspended solids, such as silt or organic matter, and can impact the clarity and health of water. Instruments like turbidimeters are used to measure turbidity quantitatively.

WIFI/RADIO COMMUNICATION MODULE: - A Wi-Fi radio communication module is a hardware component that enables devices to communicate wirelessly using Wi-Fi technology. These modules are commonly used in various electronic devices, such as smartphones, tablets, IoT devices, and other gadgets, to establish a wireless connection to a network. They typically include both hardware and software components for Wi-Fi communication.

BATTERY 3.7V: - A 3.7V battery typically refers to a lithium-ion or lithium-polymer battery, common in various electronic devices such as smartphones, cameras, and portable gadgets. This voltage is a nominal voltage, and the actual voltage can range between 4.2V (fully charged) and around 3.0V (discharged). It's crucial to use and charge these batteries according to the manufacturer's recommendations to ensure safety and longevity.

HY S01R10 TRANSMITTER: - As of my last knowledge update in January 2022, I don't have specific details about an "HY S10R 10 transmitter." It's possible that it could be a product or model released after that date. To get accurate and up-to-date information, I recommend checking the manufacturer's website, and product documentation, or contacting the manufacturer or authorized retailers for the latest details on the HY S10R 10 transmitter.

GX 3V7 MODULE: - As of my last knowledge update in January 2022, I don't have specific details about a "GX 3V7 module." It's possible that it could be a product or module released after that date. To get accurate and up-to-date information, I recommend checking the manufacturer's website, and product documentation, or contacting the manufacturer or authorized retailers for the latest details on the GX 3V7 module.

SOFTWARE USED

RASPBERRY PI: - The Raspberry Pi is a series of small, affordable, single-board computers developed by the Raspberry Pi Foundation. These credit card-sized computers are designed to promote computer science education and facilitate DIY projects. Raspberry Pi boards can run a variety of operating systems, with a wide range of applications, from programming and learning to media centers, home automation, and more.

PYTHON PROGRAM: - Python is a versatile and widely used programming language known for its readability and simplicity. It supports multiple programming paradigms, including procedural, object-oriented, and functional programming. Python is commonly used in web development, data analysis, artificial intelligence, machine learning, scripting, and more.

APPLICATION

This chapter defines applications of mini submarine

• Underwater Surveillance: Deploy underwater vehicles for monitoring and securing naval bases, ports, and critical underwater infrastructure.

• Border Protection: Underwater vehicles can contribute to border protection by monitoring and securing maritime borders. They can detect and track suspicious underwater activities, helping to prevent illegal incursions or smuggling operations.

• Fish Stock Monitoring: Monitor and assess fish populations, behavior, and health in aquaculture farms and natural habitats.

• Emergency Response: Use underwater vehicles to search for and locate objects or individuals in distress, such as sunken vessels or missing persons.

• Accident Investigations: Investigate underwater accidents by identifying and documenting relevant objects.

• Underwater Exploration for Tourists: Provide unique underwater experiences for tourists, allowing them to explore underwater environments without diving.

• Underwater Pipelines and Cables Inspection: Inspect the condition of submerged pipelines and cables for maintenance and early detection of issues.

IV. CONCLUSION

The development and implementation of a mini-submarine for underwater object detection marks a significant milestone in the realm of marine technology. This project aimed to design a compact and versatile underwater vehicle capable of navigating through challenging aquatic environments while employing advanced sensing technologies for object detection. The following conclusion summarizes the key achievements, challenges, and future prospects of the mini-submarine project. One of the major accomplishments of the project is the successful construction of a minisubmarine that combines maneuverability and efficient sensor integration. The submarine's compact design allows it to navigate through confined spaces, making it suitable for a variety of underwater tasks. Equipped with state-of-the-art sensors, including sonar and imaging systems, the submarine demonstrates the ability to detect and identify objects in its surroundings with remarkable accuracy. During the testing phase, the mini-submarine exhibited reliable performance in different underwater conditions. Its adaptive control system enabled seamless transitions between various navigation modes, ensuring stability and precision in movement. The integration of real-time communication capabilities further enhanced the submarine's usability. However, the project was not without its challenges. Developing a mini-submarine that can effectively operate in complex underwater environments requires overcoming technical hurdles related to pressure resistance, power management, and communication reliability. These challenges demanded innovative solutions and thorough testing to ensure the submarine's functionality and durability in real-world scenarios.

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