Underwater Surveillance Robot with Spiral Arms

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***Abstract*—The underwater spiral drone, designed for surveillance, is among the most innovative systems for complex underwater environments globally. The developers engineered the underwater spiral drone due to their fascination with the way visibility and navigation appear in confined, difficult-to-access spaces. The system involves a Raspberry Pi 5 and Arduino Uno for motor control, and the smooth three-dimensional movement reflects the developers' idea of the connection between robotic processing and aquatic surveillance. The reliable and efficient underwater spiral drone contains various elements of design, such as six brushless motors, a camera module, and LED lights, as well as the principles, for instance, responsive operation and real-time monitoring. By incorporating flexible tentacle-like arms and a USB joystick, the drone delivers an excellent solution for underwater inspection applications.**

***Index Terms*—Underwater Robot, Spiral Drone, Surveillance, Raspberry Pi, Arduino, Brushless Motors, Tentacle Mechanism, Real-Time Monitoring.**

I. INTRODUCTION

Underwater environments are complex and challenging to monitor due to limited visibility, high pressure conditions, and restricted accessibility. Performing surveillance and inspection tasks in such environments is difficult using traditional methods, as human divers face safety risks and operational limitations, especially in deep or confined spaces. These challenges highlight the need for efficient and reliable robotic systems that can operate underwater and provide real-time monitoring.

The fast development of robotics and embedded systems technology led to the creation of underwater drones. This technology can be remotely controlled and allows for navigation under water in very complicated conditions where a person cannot intervene physically. However, most modern robots lack flexibility and cannot maneuver in narrow or complicated underwater zones.

Therefore, in this project, an underwater spiral drone will be developed specifically for surveillance purposes. As mentioned above, it will be based on Raspberry Pi 5 and Arduino Uno microcontrollers for better data processing and system manipulation. Six brushless motors will ensure a full three-dimensional movement that will allow the robot to move freely in any required direction. Moreover, a camera module and LED lighting systems will be installed.

To increase the flexibility of the robot, special tentacles will be attached to the body of the robot, which will help it move in any necessary direction. Furthermore, it is expected to be controlled by means of a joystick connected via USB interface to increase user-friendliness and efficiency. Therefore, the proposed underwater spiral drone will serve as a good platform for real-time monitoring and surveillance activities. Additionally, the system will be built with portability and efficiency in mind such that it can adapt to diverse situations at the ocean bed. Incorporation of sophisticated control methods and video feedback will enhance precision and efficiency in navigation. This makes the design unique because it has flexibility, stability, and simplicity in operation that have eluded other underwater robots.

II. SYSTEM METHODOLOGY

The submarine-based spiral drone operates according to manual operation and real-time monitoring. This device uses Raspberry Pi 5 and Arduino Uno for processing and command operations. The Raspberry Pi gets data input from

III. HARDWARE AND SOFTWARE IMPLEMENTATION

Deployment of the underwater spiral drone entails the deployment of hardware and software solutions in order to optimize underwater monitoring and navigation operations. The design of the underwater spiral drone incorporates the use of embedded controllers, propulsion systems, and mechanical devices.

Hardware Implementation

The hardware implementation uses a Raspberry Pi 5, which serves as the processing core and performs tasks such as video streaming, taking user inputs, and communicating. The Arduino Uno board is employed as a secondary microcontroller that controls the motors and performs lower-level functions, such as sending out PWM pulses for controlling the motors.

The motor system contains six brushless DC motors that drive the robot's motion under water. The speed of operation and rotation of the motors is regulated by Electronic Speed Controllers (ESC) which use pulse-width modulation technology. The choice of brushless motors is attributed to their greater efficiency and durability.

Real time underwater videos are acquired using a camera module, while the use of LEDs facilitates visibility in low light or murky water environments. The robot body is made to be waterproof and durable so as to protect the electronic components within. There is appropriate balancing of weight to ensure steady underwater movements of the ROV robot.

The tentacle mechanism is designed using flexible materials and is mounted beneath the robot. It is capable of rotational motion and is used for object interaction and navigation in confined spaces. Additional components such as battery systems, wiring, and sealed enclosures are used to ensure continuous and safe operation underwater.

Software Implementation

Software design of the system uses several platforms for various tasks. The mechanical construction of the robot such as its body structure, tentacles, pulley system, and the housing for the motors is done through Autodesk Fusion

360. This enables proper modeling and positioning of all parts in 3D before construction.

Arduino Uno programming is done using the Arduino IDE, which is used for the development of control the USB controller, processes it, and transmits commands to the Arduino that operates the motors.

The submarine robot possesses six brushless motors, which enable it to navigate in all directions under water. The robot has a camera for capturing real-time images and LED lights for improving visibility. The robot has flexible arms resembling tentacles for maneuvering through tight places.

1.Working Procedure

Fig. 1 Block Diagram of the System Met

IV. METHODOLOGY

1. System Design

Robotic construction, robotic tentacles, and motor case design are achieved through Autodesk Fusion 360. This makes it possible to fit all components together and keep the system waterproof.

2. Hardware Integration

The following components form one integrated system: Raspberry Pi, Arduino Uno, electronic speed controllers (ESCs), brushless motors, cameras, LED lights, and power supply system.

3. User Input System

USB joystick is employed to facilitate the user's control. This information is read by the Raspberry Pi and the required control signals are generated.

4. Signal Processing

The control signals generated by the Raspberry Pi are passed on to the Arduino Uno where they are executed.

5. Motor Control Mechanism

The Arduino creates PWM signals to operate the ESCs that regulate the brushless motors driving the underwater robot.

6. Motor Control Mechanism

The underwater robot achieves three-dimensional motion (backwards, forwards, upwards, downwards, and turning) through the use of six motors.

7. Vision System Operation

The camera unit records real-time video feed, while the LEDs ensure visibility in low-light conditions underwater. algorithms for controlling motor speed and direction through PWM signals. In this way, control over brushless motors is achieved via ESCs, leading to efficient underwater maneuvering.

Programming on the Raspberry Pi 5 is carried out through the Raspberry Pi terminal using python scripts, which manage tasks such as joystick operations, communication, and video streaming. The Raspberry Pi executes all users' requests and communicates with the Arduino to ensure that the entire system operates smoothly. In underwater robotics, Raspberry Pi plays an important role in conducting various activities at once.

The use of both hardware and software helps coordinate all the subsystems effectively.

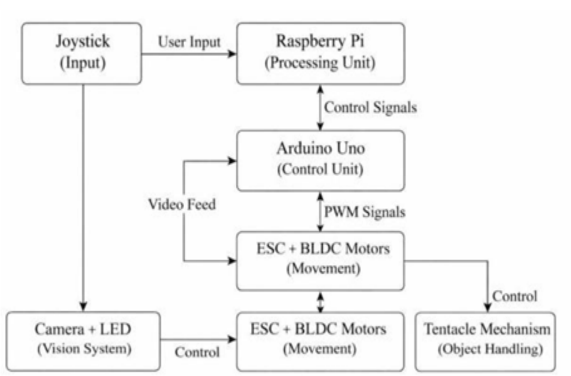

Fig. 2 Block Diagram of Proposed System

V. RESULT & DISCUSSIONS

Designing and building the underwater spiral robot has been achieved by integrating the following parts: Raspberry Pi, Arduino Uno, six brushless motors, camera, LED lighting, and tentacles. All parts were put together to form a sturdy and compact device. Testing was done in controlled environments. Integration has facilitated coordination among all parts.

The robot operated efficiently at depths of 3-4 meters below water. There were no signs of leaks and the robot was stable throughout the entire test. This proves that the robot is capable of working in shallow waters.

The six brushless motors in the drive mechanism provided effective control of the robot's movements.

The machine was able to move both backward and forward as well as upward and downward. There was efficient 3-D movement because of the motors arrangement.

The control system using the joystick offered reliable control inputs. The commands from the user were processed

8. Tentacle Operation

The tentacle system can rotate 360° and serves as the mechanism for handling objects and maneuvering through tight spots.

9. System Testing

The entire system is tested underwater to assess its ability to operate at different depths, maintain stability, and handle objects.

gripping tool that was fitted to the tentacles had the capability of handling objects that were of moderate size. The gripping tool held plastic boxes, cylindrical objects, and light components without posing any problem.

The power supply system was analyzed to ensure that the robot would work continuously and steadily. The power supply system had enough capacity to provide energy to the motor, controller, camera, and illumination system. There were no noticeable changes in voltage.

In addition to that, this system showed great flexibility depending on the underwater environment. Due to the stability of movement and real-time monitoring combined with flexible movement of the tentacles, greater efficiency was achieved. The robot was capable of performing efficiently in limited spaces with little visibility.

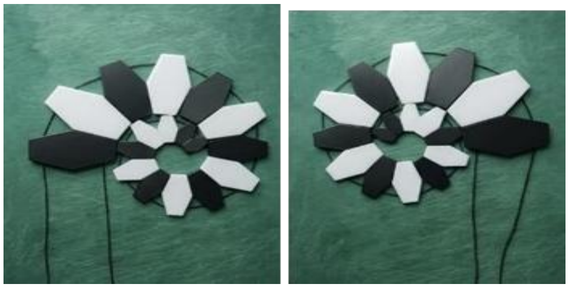

Fig. 3. Design of Tentacles

Fig. 3 Complete Hardware Setup

by the Raspberry Pi and sent to the Arduino effectively. The control signals required for driving the motors were generated instantly by the Arduino.
The visual system, which included a camera module along with the LEDs, worked very efficiently during the tests. It delivered high-quality video outputs in real time, even under poor visibility conditions. The LEDs helped to provide proper lighting underwater.
The mechanism of the tentacles proved successful in being integrated into the robot's body. This could be turned at any angle up to 360 degrees. It would enable the robot to reach into smaller places, which would make the system more efficient.
The mechanism of grip, which is incorporated into the tentacles, can deal with objects of medium size. It was able to grip plastic containers, cylinder-shaped objects, and light weight parts. The process of gripping proved to be controlled and stable.

Table: Result Summary

Parameter	Obtained Value	Remarks
Operating Depth	3–4 meters	Stable performance underwater
Tentacle Rotation	360°	Full rotational flexibility achieve
Movement Type	3D Navigation	Forward, backward, up, down, Turning
Control System	Joystick-Based	Smooth and responsive operation
Propulsion System	6 Brushless Motors	Stable and efficient movement
Vision System	Camera + LED	Clear real-time video in low-light
Object Handling	Moderate Objects	Handles containers and cylindrical items
Communication	Raspberry Pi + Arduino	Reliable with minimal delay
Stability	Balanced Structure	No tilting observed
Power Supply	Battery Operated	Continuous stable operation

VI. CONCLUSIONS

The design and development of the underwater spiral drone has been completed successfully, and it can be used for surveillance purposes in complicated underwater settings. This drone consists of a Raspberry Pi 5 and an Arduino Uno, which makes it capable of efficient computing and control processes. Due to the use of six brushless motors, the robot moved smoothly in three dimensions underwater.
Flexible tentacles made it easier for the robot to work in tight and restricted areas. This made it more flexible as opposed to other underwater robots whose maneuverability is limited. The use of joysticks in controlling the robot ensured accurate and responsive operation. The effectiveness of the system was evident from the results realized after conducting tests on the system.
This paper is an example of how robotics and embedded systems can be used for underwater surveillance. Future improvement of the system can include advanced sensors and autonomous navigation as well as more sophisticated tentacles that will make the system more effective and efficient. The presented underwater spiral drone is an attractive solution to underwater monitoring, surveillance, and exploration.

Future Scope

The improved underwater spiral drone can be further upgraded through the incorporation of more complex sensors like the depth sensor, pressure sensor, and the obstruction detector, which would make the process safer and more efficient. Incorporating automatic navigation using artificial intelligence and computer vision would decrease reliance on joystick controls and allow the machine to work autonomously.

Another way to improve the system is through the expansion of its operational depth, as well as through the advancement of waterproofing methods to facilitate deeper oceanic usage. Additionally, the tentacles could be made sturdier and more robust through the use of more resilient materials and improved actuators capable of lifting heavier loads with greater accuracy.

Furthermore, incorporating environmental sensors would allow for applications such as water quality assessment and oceanographic research. With these advancements, the device can be utilized in a wide variety of applications, including underwater inspection, search and rescue missions, pipeline inspection, and environmental exploration.

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REFERENCES

[1] https://ieeexplore.ieee.org/document/8284522/
[2] https://ieeexplore.ieee.org/document/9611625/
[3] https://www.ijnrd.org/papers/IJNRD2303411.pdf
[4] https://ieeexplore.ieee.org/document/8883017/
[5] https://doi.org/10.1016/j.fmre.2021.03.002
[6] https://doi.org/10.1016/j.robot.2021.103995
[7] https://ieeexplore.ieee.org/document/10661804/
[8] https://www.mdpi.com/1424-8220/19/24/5387
[9] https://ieeexplore.ieee.org/document/8559153/
[10] https://ieeexplore.ieee.org/document/9775489/
[11] https://www.researchgate.net/publication/378687718_Underwater_Robotics_Principles_Components_Modeling_and_Control/