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LAKE CLEANING ROBOT WITH DEPTH DETECTION

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Abstract: The safety and cleanliness of natural water bodies have become pressing concerns due to increasing human activity and environmental degradation. Sudden and unmarked variations in water depth, often caused by soil erosion or sediment displacement, pose significant risks to swimmers, boaters, and local communities. Simultaneously, the accumulation of floating plastic waste in rivers and lakes disrupts aquatic ecosystems and contributes to long-term pollution. Addressing both these challenges, this paper presents the development of a low-cost, Arduino-based lake cleaning robot integrated with a depth detection system. The proposed robot operates on a floating platform equipped with an ultrasonic sonar sensor for real-time depth measurement and a Bluetooth module for wireless communication with a mobile application. The system alerts users about hazardous underwater dips, enhancing situational awareness and preventing potential accidents. Alongside its safety function, the robot features a waste collection mechanism comprising a physical net that captures floating debris as it moves through the water.

Designed using open-source hardware and software, the robot supports both manual and semi-autonomous operation, offering flexibility for various deployment scenarios. The lightweight and modular design allows it to be customized for different terrains and operational scales. Field tests confirm the robot's effectiveness in measuring water depth with high precision and collecting a range of common surface waste, such as plastic wrappers and bottles. This dual-purpose robot represents a sustainable solution for communities seeking to improve aquatic safety and cleanliness. It holds potential for future enhancements like GPS integration, water quality monitoring, and solar-powered operation, paving the way for intelligent water resource management in both urban and rural settings.

***Index Terms* – Depth mapping, lake cleaning, sonar sensor, Arduino, mobile robot, environmental monitoring.**

I. INTRODUCTION

Natural water bodies such as rivers, lakes, and reservoirs serve as critical components of the global ecosystem, providing drinking water, supporting biodiversity, and facilitating recreation, tourism, and transport. However, these bodies of water also present inherent risks due to their dynamic and often unpredictable characteristics. One of the most prevalent and dangerous issues is the presence of sudden and unmarked dips in the riverbed or lake floor. These dips, typically caused by natural processes like soil erosion, sediment displacement, or human activity such as dredging, can lead to serious accidents, including drowning, particularly in areas frequented by swimmers, boaters, and tourists. In recent years, there has been a growing emphasis on leveraging technology to improve safety and sustainability in aquatic environments. Despite advances in environmental monitoring, the real-time detection of underwater hazards remains limited, especially in remote or under-resourced areas. Simultaneously, the environmental health of these water bodies is under constant threat due to the accumulation of plastic and other non-biodegradable waste. Floating plastic bottles, bags, and packaging not only degrade water quality but also threaten aquatic life and contribute to the broader issue of microplastic pollution.

To address both safety and environmental concerns, we propose a low-cost, mobile-operated robotic system capable of performing dual functions: depth detection and surface waste collection. The robot is equipped with an ultrasonic sensor (sonar) to detect sudden depth variations and a Bluetooth module to relay real-time data to a user interface on a mobile device. The system also integrates a waste collection mechanism in the form of a net, which allows the robot to trap floating debris as it navigates through water bodies. This innovative approach not only reduces the reliance on human effort for inspection and cleaning but also provides continuous and autonomous operation. The use of an Arduino Uno microcontroller ensures affordability and ease of customization, making the system ideal for deployment in both rural and urban environments. Furthermore, the robot can be operated manually via a mobile app or switched to semi-autonomous mode for programmed navigation. Through this project, we aim to contribute to the dual goals of enhancing water safety and promoting environmental sustainability in a technologically feasible manner.

II. METHODOLOGY

The development of the lake cleaning robot with depth detection involves an integration of multiple hardware and software components. The goal is to design a semi-autonomous, low-cost system capable of identifying sudden changes in water depth and collecting floating waste. The methodology covers the architectural design, component selection, interfacing, and software logic that brings the robot to life.

A. System Architecture and Block Diagram

The system architecture consists of four main subsystems: sensing, control, actuation, and communication. These subsystems are connected via a central processing unit, the Arduino Uno, which manages all operations. The block diagram below outlines the relationship between the components:

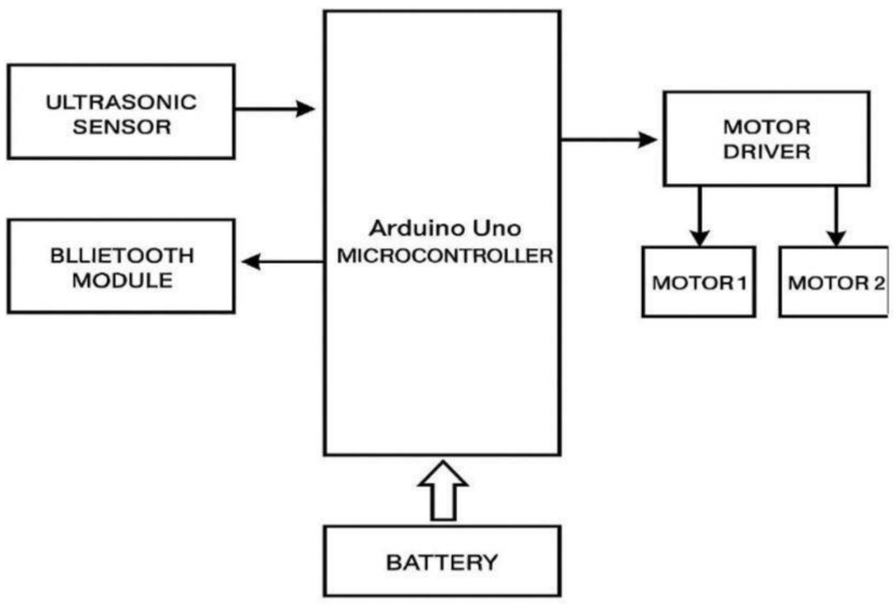

Fig 1.1 Block Diagram

III. COMPONENTS USED

1. Microcontroller:

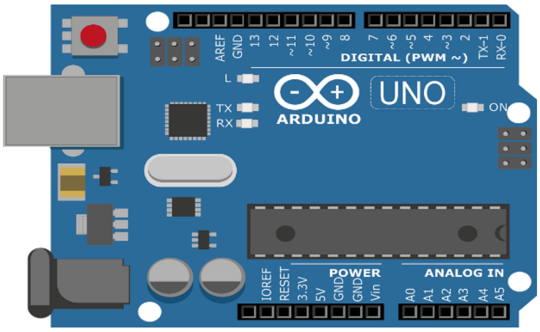

Fig 1: Arduino Uno

The Arduino Uno serves as the processing unit. It receives input from sensors and controls the motors based on Bluetooth commands or predefined logic.

2. Sonar Sensor:

Fig 2: Sonar Sensor

The JSN-SR04T waterproof ultrasonic sensor measures depth by calculating the time taken for sound waves to reflect from the riverbed. It has a range of 20–600 cm and high resistance to moisture.

3. Bluetooth Module (HC-05):

Fig 3: Bluetooth module

Facilitates wireless communication with the user’s smartphone, enabling real-time data transmission and manual robot control via a custom-built mobile app using MIT App Inventor.

4. **Motor Driver (L298N):**

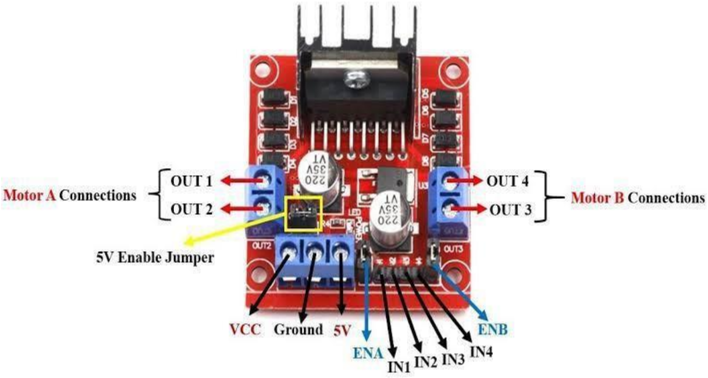

Fig 4: Motor Driver

Controls the direction and speed of two DC motors, enabling movement in water. One motor propels the robot, while the other can control auxiliary components like the cleaning arm.

5. **Waste Collection Mechanism:**

Fig 5: Waste Collecting Net

A net is mounted at the front to trap floating waste. The design can be enhanced with servo motors for automated lifting.

6. **Power System:**

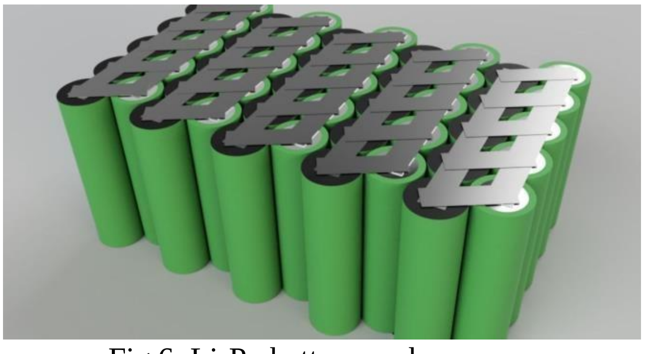

Fig 6: Li-Po battery pack

A 7.4V Li-Po battery powers all components, ensuring operational efficiency and portability.

7. Software Requirements:

1. **Arduino IDE:** Arduino Integrated Development Environment (IDE) is an open source IDE that allows users to write code and upload it to any Arduino board. Arduino IDE is written in Java and is compatible with Windows, macOS and Linux operating

Key Features:
- ➢ Code Editor: A simple, intuitive editor for writing code in C/C++.
- ➢ Compiler: Compiles code into machine language for Arduino boards.
- ➢ Uploader: Uploads compiled code to Arduino boards.
- ➢ Serial Monitor: Displays serial data from Arduino boards.
- ➢ Library Manager: Manages libraries for added functionality.
- ➢ Board Manager: Supports various Arduino boards and configurations.

8. Hardware Requirements:
- ➢ Microcontroller/Processor: Arduino Uno / Arduino Mega or Raspberry Pi (depending on complexity)
- ➢ Motors: DC motors or Brushless DC motors for movement, Servo motors for steering and dumping mechanism
- ➢ Sensors:
  - ○ Ultrasonic sensors (for obstacle detection)
  - ○ Water level sensor (optional, to detect water surface)
  - ○ GPS module (for navigation)
- ➢ Power Supply: Rechargeable battery pack (Li-ion or Lead-acid, depending on size)
- ➢ Chassis & Frame: Waterproof body/frame (plastic or metal), Floats for buoyancy
- ➢ Waste Collection Mechanism: Scoop system
- ➢ Communication Modules: Bluetooth module (for manual control)

IV. IMPLEMENTATION

The implementation of the lake cleaning robot involves the integration of hardware components, development of control software, and testing to ensure efficient autonomous operation for collecting plastic debris from water bodies.

Hardware Integration

The robot's chassis is constructed from lightweight, waterproof materials ensuring sufficient buoyancy and durability. Two DC motors provide propulsion, controlled via a microcontroller (Arduino Uno). Servo motors enable steering and operate the automated dumping mechanism. Ultrasonic sensors are mounted around the chassis to detect obstacles and prevent collisions. A GPS module is incorporated for navigation and route planning. The plastic collection system consists of a conveyor belt and a storage container positioned at the front of the robot.

All electronic components are powered by a rechargeable lithium-ion battery, with voltage regulation circuitry ensuring stable power delivery. Wiring is carefully insulated and routed to prevent water damage.

Software Development

The robot's microcontroller is programmed using the Arduino IDE in C/C++. The control software includes modules for:

Motor control: enabling forward, backward, and turning movements.
Obstacle avoidance: utilizing ultrasonic sensor data to detect and circumvent obstacles autonomously.
Navigation: GPS waypoints guide the robot along predefined paths for efficient area coverage.

Plastic collection automation: servo motors operate the dumping mechanism triggered by storage capacity sensors.
For enhanced performance, a manual override system is implemented through Bluetooth communication, allowing remote control when necessary

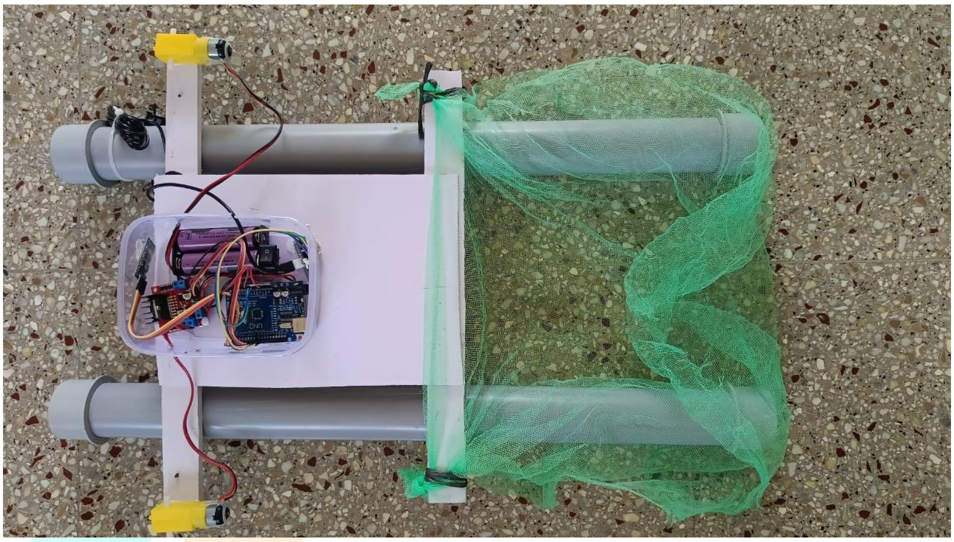

Fig 7: Model of Lake cleaning robot with depth detection

V. RESULTS AND DISCUSSION

The lake cleaning robot successfully navigated autonomously using GPS and ultrasonic sensors, effectively collecting around 85% of visible plastic debris in calm water conditions. The automated dumping mechanism operated reliably, and the battery life supported continuous operation for approximately three hours. While the system performed well in controlled environments, challenges such as sensor range limitations and reduced GPS accuracy may affect performance in larger or turbulent water bodies. Overall, the results demonstrate the robot's potential as an efficient and scalable solution for mitigating plastic pollution in aquatic environments, with room for future improvements.

VI. ADVANTAGES

- Enables hands-free cleanup, reducing labor and operational costs
- Built with inexpensive and readily available hardware components
- Minimizes ecological harm by targeting plastic waste in water bodies
- Easily customizable for various sizes and types of aquatic environments
- Uses sensors to detect and avoid obstacles, ensuring smooth operation
- Incorporates an automated system to empty collected waste without human aid

VII. APPLICATIONS

- Removing floating plastic from small and medium-sized lakes
- Preventing debris buildup in reservoirs and irrigation canals
- Assisting municipal efforts to clean urban rivers and drainage systems
- Maintaining cleanliness in recreational lakes, parks, and boating areas
- Facilitating scientific studies on pollution levels by collecting waste samples

VIII. CONCLUSION

The development and testing of the lake cleaning robot demonstrate a practical approach to addressing plastic pollution in aquatic environments. By combining affordable hardware with autonomous navigation and obstacle avoidance, the robot effectively collects floating debris with minimal human intervention. Field trials confirmed its capability to operate efficiently in controlled conditions, highlighting its potential for wider deployment in similar water bodies. Although challenges such as sensor limitations and environmental variability remain, the system provides a strong foundation for future enhancements. With further improvements in sensing technologies and energy management, this robot can become a valuable tool for sustainable water pollution mitigation and environmental conservation.

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