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Autonomous River Depth Plotting and Cleaning Robot

Suhas P, Manu HP, Akshay M, Pavan R, Spoorthy M R

U.G. Student, Department of Electronics and Communication Engineering, P.E.S. College of Engineering, Mandya,
Karnataka, India

U.G. Student, Department of Electronics and Communication Engineering, P.E.S. College of Engineering, Mandya,
Karnataka, India

U.G. Student, Department of Electronics and Communication Engineering, P.E.S. College of Engineering, Mandya,
Karnataka, India

U.G. Student, Department of Electronics and Communication Engineering, P.E.S. College of Engineering, Mandya,
Karnataka, India

Assistant Professor, Department of Electronics and Communication Engineering, P.E.S. College of Engineering,
Mandya, Karnataka, India

ABSTRACT: Natural water bodies often pose safety and environmental risks due to sudden depth changes and floating debris. Current methods lack real-time monitoring and integration. This project addresses the gap by developing an autonomous robot equipped with sonar, GPS, and Bluetooth to map river depths and detect hazards in real-time. A mobile app displays alerts, while a waste collection unit removes surface debris. Initial results show effective depth detection and reliable wireless communication. The system offers a compact solution for water safety and environmental monitoring, contributing to smarter, safer aquatic resource management without excessive manual effort.

KEYWORDS: Autonomous Robot, River Depth Mapping, Floating Waste Collection, Sonar Sensor, GPS Navigation, Bluetooth Communication, STM32 Microcontroller, Environmental Monitoring, Real-Time Data Transmission, Smart Water Management.

I. INTRODUCTION

“Every year, more than 230,000 lives are lost to drowning worldwide—many of them in natural water bodies due to unknown underwater hazards.” Despite the crucial role rivers and lakes play in ecosystems, recreation, and daily human activities, their unpredictable nature pose significant safety threats. Meanwhile, the growing accumulation of plastic waste and debris further harms aquatic life and degrades water quality, creating dual challenges that demand innovative, real-time solutions.

Today, river monitoring largely depends on manual surveying methods that are not only time consuming and labor-intensive but also fail to provide continuous updates. While some automated systems exist, they are often expensive and designed for specific tasks like either depth measurement or pollution control—rarely both. Moreover, these systems usually lack real-time communication with users, delaying responses to potential hazards. The lack of integrated, low-cost technologies for depth mapping and surface cleaning limits the efficiency of water safety programs and environmental conservation efforts, especially in developing regions.

Our project aims to bridge this gap by developing an affordable, multifunctional autonomous robot that can both map riverbed depth and clean floating debris in real time. The robot is equipped with a sonar sensor for continuous depth monitoring, a GPS and compass module for accurate navigation, and a Bluetooth interface for live data transmission to a user-friendly mobile application. A built-in waste collection mechanism allows the robot to gather surface debris while performing its primary scanning task. Through this project, we propose a scalable and efficient solution to

enhance aquatic safety and environmental cleanliness by combining real-time hazard detection with autonomous waste collection in a single, integrated robotic platform.

II. LITERATURE SURVEY

An IoT-based river cleaning system with automated debris detection and removal was presented by Mohammed, Al-Zubaidi, and Kamarul Bahrain [1]. Their robot leverages sensors and wireless modules for real-time waste monitoring, reducing human labor while increasing cleaning efficiency and supporting scalable deployment in various water bodies. This system inspires the waste collection mechanism of our project. To enhance navigation, Ahn et al. [2] proposed a GPS parameter prediction method using ephemeris patterns, which improves tracking performance in autonomous systems by reducing positional errors and acquisition delays. Their predictive model is well-suited for real-time applications and embedded systems, supporting our robot's GPS-based precision navigation. Dwivedi [3] conducted a comprehensive review of water pollution, highlighting its sources and impact on aquatic ecosystems while advocating for real-time monitoring and automated waste reduction strategies. This aligns with our project's goal of autonomous water cleaning. Similarly, Zaenudin and Abdullah [4] developed an IoT-enabled river cleaning robot emphasizing real-time communication and mobile-based automation. Their system improves cleaning efficiency in flowing water environments, which informs our integrated control and cleaning approach. For smaller water bodies, Soumya, Preeti, and Gadgay [5] introduced a Bluetooth-controlled pond cleaning robot using IR sensors and motors for basic maneuverability. Despite being manually operated, its compact and functional design supports the mechanical layout of our waste collection system. GPS-based tracking applications were further discussed by Bajaj, Ranaweera, and Agrawal [6], who outlined techniques for signal correction and accurate real-time navigation, reinforcing the GPS module's role in our robot's safe operation across mapped zones. In terms of riverbed hazard detection, Huber, Anders, and Huggenberger [7] utilized Ground Penetrating Radar (GPR) to measure scour depth and detect subsurface anomalies with high resolution. Their non-invasive method for mapping underwater features parallels the sonar-based depth sensing employed in our project. Lastly, Fu and Hu [8] studied the influence of flow angle on local scour depth using fluid mechanics to model erosion patterns and hydraulic forces. Their predictive models contribute to safer waterway design and support our sonar system's real-time detection and hazard-mapping features.

III. METHODOLOGY

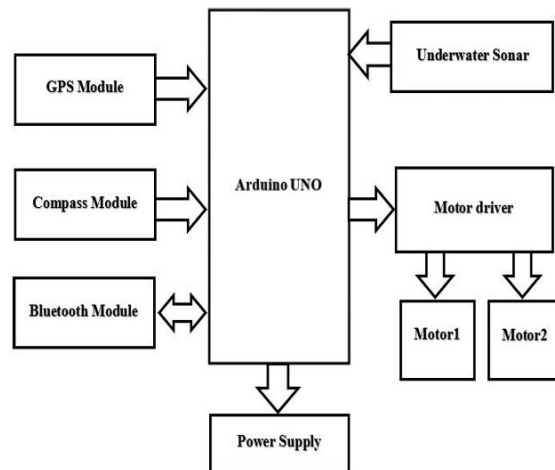
The proposed system is an autonomous, multifunctional robot designed for simultaneous river cleaning and depth mapping. The robot is mechanically built as a waterproof, buoyant platform capable of floating and navigating on river surfaces. Its internal architecture is centred around an STM32 microcontroller, which governs all major operations including sensor integration, movement control, and wireless communication. In the system design phase, modules such as GPS, a digital compass, a sonar depth sensor, and a Bluetooth transceiver are integrated to ensure seamless real-time navigation and environmental monitoring.

The operation begins by establishing a Bluetooth connection between the robot and a dedicated mobile application. Through this interface, users can input GPS waypoints to define a specific navigation path. Upon receiving these inputs, the robot uses its GPS module to determine its real-time position and the digital compass to obtain its current heading. This ensures accurate alignment and directional control as the robot begins to autonomously follow the predefined path.

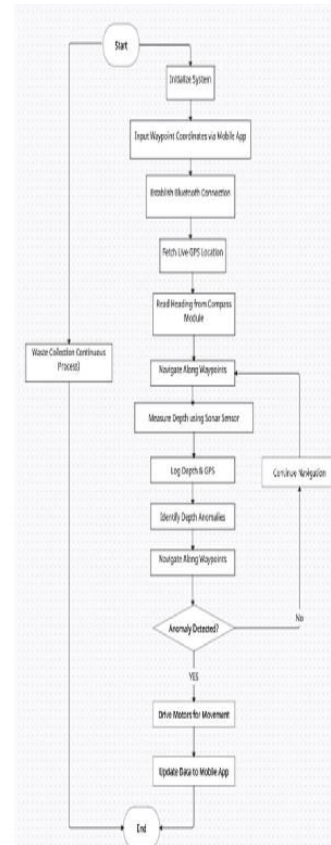
As the robot moves along these waypoints, it employs an underwater sonar sensor to continuously measure riverbed depth. These measurements are processed in real time by the microcontroller. When sudden drops or hazardous anomalies are detected in the riverbed, the system flags them by logging the GPS coordinates and depth readings. These hazard alerts are then transmitted to the mobile application instantly, allowing the user to visualize dangerous or unstable river sections. All sensor data, including river depth and flagged anomalies, is also optionally saved to an on-board SD card for post-analysis and record-keeping.

Simultaneously, a waste collection system mounted on the robot continuously operates during navigation. This system consists of a mechanically fixed net designed to capture floating debris as the robot moves through the water. The entire propulsion mechanism is driven by two DC motors controlled via a motor driver circuit, providing both linear

and directional motion. A servo motor maintains heading stability, while power for the entire system is supplied by a rechargeable lithium-polymer (Li-Po) battery pack, ensuring sufficient energy for extended autonomous operation.



(a)



(b)

Fig. 1 (a) Block diagram of system design approach. (b) Flow chart of proposed workflow

The robot's design emphasizes a modular, low-power, and cost-efficient architecture. Its block diagram Figure 1 (a) shows the integration of all essential components: GPS for positioning, a compass for directional alignment, a sonar sensor for depth measurement, a Bluetooth module for communication, and motor drivers for actuation. Figure 1 (b) outlines the operational workflow, highlighting the sequence from initial setup and navigation to real-time depth logging and waste collection. The system has been tested in both controlled laboratory conditions and real-world environments to evaluate the accuracy of navigation, reliability of Bluetooth connectivity, depth anomaly detection efficiency, and effectiveness in floating debris removal.

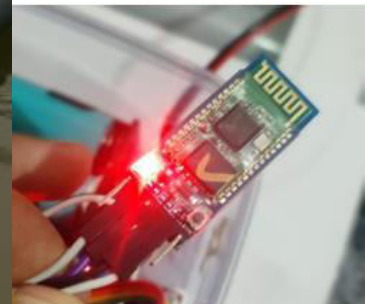
This unified methodology and working principle enable the robot to serve as an intelligent solution for environmental monitoring and autonomous waterway cleaning, providing real-time data and contributing to sustainable aquatic ecosystem management.

IV. EXPERIMENTAL RESULTS

Figure (a) displays serial terminal logs where real time riverbed depth is reported as "Depth: 24: Normal," validating sonar accuracy and anomaly detection. These logs confirm smooth data acquisition and continuous tracking of water level changes. Figure (b) presents the debris collection mechanism in action, where the net-mounted system effectively captures plastic and floating waste without obstructing the robot's mobility.

Figure (c) illustrates the active state of the Bluetooth module (HC-05) with successful pairing, enabling two-way communication with the mobile application. This confirms stable data transmission across various distances, essential for remote monitoring and control. Figures (d) and (e) further affirm system integration and field-level testing. Figure (d) presents the compass and motor response logs, demonstrating accurate heading data and waypoint tracking through terminal commands. Figure (e) provides a top view of the complete robot assembly, featuring the integration of the sonar sensor, motor drivers, battery unit, and mechanical chassis. Collectively, these results confirm that the robot can navigate predefined GPS-based paths, detect depth variations, log sensor data, and collect surface debris in real time. The prototype functions reliably in both controlled and outdoor environments, validating the system's effectiveness in dual purpose environmental applications driver to actuate the wheelchair's motors. The hardware setup includes the Arduino, EMG sensors, and motor driver.

```
19:27:20.303 0.00.77
19:27:20.303 Depth:24 :Normal
19:27:20.303 .....
19:27:20.303 fL
19:27:20.303 0.00.77
19:27:20.303 Depth:24 :Normal
19:27:20.303 .....
19:27:20.303 fL
19:27:20.303 0.00.77
19:27:20.303 Depth:24 :Normal
19:27:20.303 .....
19:27:20.303 fL
19:27:20.303 0.00.77
19:27:20.303 Depth:24 :Normal
19:27:20.303 .....
19:27:20.303 fL
19:27:20.303 0.00.77
19:27:20.303 Depth:24 :Normal
19:27:20.303 .....
19:27:20.562 fL
19:27:20.562 0.00.77
19:27:20.562 Depth:24 :Normal
19:27:20.562 .....
19:27:20.562 fL
19:27:20.562 0.00.77
19:27:20.562 Depth:24 :Normal
19:27:20.562 .....
19:27:20.562 fL
```

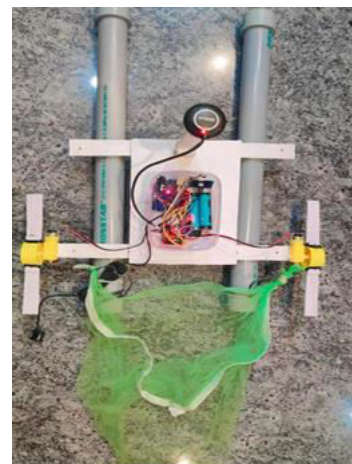


(a)

(b)

(c)

```
Terminal
117 Connection failed, read failed, socket
send, read, not-1
113 Connecting to HC-05 ...
505 Connected
518 Initialize HMC5883L
518 1
518 2
518 3
518 press 1 to calibrate, press 2 if done
738 1
552 ueff: 0
552 ueff: 0
552 ueff: 0
552 heading: 0.00
552 ---
792 ueff: 14
792 ueff: 511
792 ueff: 86
792 heading: 92.08
792 ---
M2 M3 M4 M5 M6
30PM point
3 4 5 6 7 8 9
```



(d)

(e)

Fig. 2 (a) Live mobile application interface. (b) Classification report of the model. (c) Bluetooth module. (d) Bluetooth communication of model. (e) Top view of complete robot.

V. CONCLUSION

In conclusion, this project demonstrates an effective approach to enhancing river safety and environmental cleanliness through a multifunctional autonomous robot. By integrating GPS-guided navigation, sonar based depth detection, and Bluetooth-enabled communication, the system successfully performs real time riverbed mapping and floating waste collection. Field results confirm accurate anomaly detection and reliable mobile communication.

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