P.E.S. COLLEGE OF ENGINEERING,

(An Autonomous Institute under Visvesvaraya Technological University, Belagavi)

MANDYA-571401

PROJECT REPORT ON

"AUTONOMOUS RIVER DEPTH PLOTTING AND CLEANING ROBOT"

Submitted in partial fulfilment of the requirement
for the award of the
BACHELOR OF ENGINEERING DEGREE

Submitted by

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2024-2025

P.E.S. COLLEGE OF ENGINEERING

(An Autonomous Institution Affiliated to VTU, Belagavi)

MANDYA-571401

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

This is to certify that,

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have successfully completed the project work entitled **"Autonomous River Depth Plotting and River Cleaning Robot"** in partial fulfillment towards the award of degree of **Bachelor of Engineering in Electronics and communication Engineering** of **P.E.S. college of Engineering, Mandya, VTU Belagavi** during the year **2024-2025**. It is certified that the report meets all the guidelines laid out by the department.

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P.E.S. COLLEGE OF ENGINEERING

(An Autonomous Institute under VTU, Belagavi)

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DECLARATION

We **SUHAS P, MANU H P, AKSHAY M, PAVAN R** students of 8th semester Bachelor of Engineering in Electronics and Communication Engineering, PESCE, Mandya, hereby declare that the project work **"Autonomous River Depth Plotting and Cleaning Robot"** being presented is an authentic record of the work that has been independently carried out by us and submitted towards partial fulfillment of the requirements for the award of degree in **Bachelor of Engineering in Electronics and Communication Engineering,** affiliated to **Visvesvaraya Technological University (VTU), Belagavi** during the year 2024- 2025.

Place: Mandya

Date: 22/05/2025

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We would like to express our humble thanks to all who have helped us directly or indirectly in the successful completion of this project work.

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ABSTRACT

This project introduces a novel approach to river monitoring and upkeep: the design and construction of an autonomous river depth plotting and cleaning robot. For real-time mapping and environmental analysis, the system combines hazard identification, sonar-based depth measurement, and a GPS-guided navigation platform. Autonomous waypoint navigation, Bluetooth data transfer, onboard data logging, and a mobile application interface for user engagement are some of the main features. Eco-friendly materials, optional solar power, and waterproofing all highlight sustainability. This is a flexible instrument for environmental monitoring and river maintenance chores because it improves safety through obstacle recognition and emergency recovery, which guarantees dependable performance.

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CHAPTER 1

INTRODUCTION

Rivers, lakes, and reservoirs are examples of natural water bodies that are essential to our ecosystems and are also important for leisure activities and the welfare of local communities. They serve as drinking water supplies, support a variety of recreational activities including swimming, boating, and fishing, and offer homes for a wide variety of plants and animals. But in spite of their significance, these areas also present serious safety hazards because of the erratic fluctuations in water depth, which can result in deadly mishaps. Drowning occurrences can occur from abrupt and unmarked dips in the riverbed, which are frequently brought on by sedimentation, soil erosion, and other natural causes. This is especially true in places where swimmers and boaters frequently visit. Users find it challenging to maneuver securely due to this lack of trustworthy depth information, which raises the possibility of accidents.

The lack of real-time monitoring and mapping of dangerous zones makes it more difficult to ensure safety in natural water bodies. Conventional techniques for measuring depth, such manual surveys, are frequently ineffective and don't give timely information on conditions that change. Therefore, there has never been a greater need for creative ways to improve water safety. By creating a transportable, sonar-equipped depth mapping robot that can continuously scan and map the riverbed, this project seeks to overcome these issues and give users vital information.

The suggested robot uses cutting-edge sonar technology to identify depth changes, enabling the production of precise and current riverbed maps. By highlighting possible dangers, these maps help users make wise choices when negotiating bodies of water. To guarantee that users have instant access to critical information, the robot uses Bluetooth to send real-time data to a smartphone application. With the help of this creative system, which is powered by STM32 microcontroller technology, users can effortlessly explore and keep an eye on the state of rivers thanks to its manual control capabilities. The concept offers a thorough method of improving water safety by fusing user-friendly technology with crucial safety measures.

This research tackles urgent environmental issues including plastic waste and pollution in our waterways, while simultaneously enhancing safety through depth mapping. Litter and trash are frequently transported from the land to the oceans via rivers. In addition to endangering aquatic life, the buildup of plastic waste also endangers the environment and public health. The robot has a collection net that is intended to catch floating debris when it is maneuvered close to waste materials in order to address this problem.

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1.1 Existing System

The majority of current river and waterway depth mapping techniques are manual or semi-automated, using human-driven boats fitted with sonar or echo-sounding equipment. Predetermined survey pathways are usually used to get depth measurements, which is a labor-intensive, time-consuming procedure that requires competent operators for navigation, data collecting, and processing. This raises related expenses in addition to making operations more complex.

Sonar-equipped autonomous surface vehicles (ASVs) are used in sophisticated configurations. Although these systems provide real-time depth measurement capabilities and improved automation, their cost is frequently prohibitive, and their operation and maintenance necessitate specific programming knowledge. Additionally, a lot of ASVs don't have built-in alert systems for abrupt depth anomalies, which lessens their usefulness for safety interventions and real-time hazard detection.

While some of the systems already in use allow data to be transmitted to stationary stations or mobile devices, they usually do not combine navigation, hazard detection, and data processing on one platform. Rather, these systems frequently depend on outside operators to interpret post-survey data and identify hazards, which causes delays in making decisions that may be put into action.

1.2 Proposed System

An advanced, real-time method for mapping river depths and identifying underwater hazards is presented by the proposed Autonomous GPS-Guided River Depth Plotting System. A fully autonomous boat platform with cutting-edge navigation and sensing technologies, such as a waterproof sonar sensor, a digital compass for directional orientation, and a high-accuracy GPS module, is integrated into this system. The system, which is microcontroller-controlled, can carry out autonomous tasks at user-provided waypoints via an intuitive mobile application, greatly minimizing the requirement for human intervention.

Using a Bluetooth-enabled interface, the user enters the desired waypoints into the navigation system at the beginning of each mission. After being configured, the system uses a compass module to guarantee precise directional alignment between waypoints and GPS for precise location tracking to navigate the designated path on its own. A real-time 2D bathymetric map of the studied area is produced by the sonar sensor's constant measurement of water depths.

The system's capacity to recognize and react to abrupt depth changes is one of its best features. The system instantly logs the relevant GPS coordinates and sends an alarm to the mobile application when it detects a severe underwater abnormality, like a steep drop or submerged hazard. In regions with unexplored or changing undersea environments, this real-time hazard identification capacity improves safety and permits prompt responses.

The suggested system is well-suited for a variety of applications, such as environmental monitoring, hydrographic surveying, and enhancing navigational safety, because it offers an effective, independent, and economical solution. By addressing the shortcomings of conventional and semi-automated techniques, its integrated, user-centric design sets a new standard for aquatic surveying technologies' operational effectiveness, accuracy, and accessibility.

CHAPTER 2

LITERATURE SURVEY

1. **“Design and Development of River Cleaning Robot Using IoT Technology,” - M. N. Mohammed, S. Al-Zubaidi, Siti Humairah Kamarul Bahrain, IEEE, 2020.**

   This paper proposes an IoT-based automated system for collecting garbage from rivers, emphasizing real-time monitoring and communication. It introduces a scalable solution for effectively cleaning various water bodies. It uses sensors and wireless modules to enable real-time waste monitoring. The robot reduces human labor while increasing cleaning efficiency. It supports scalable deployment in various water bodies. This system inspires the waste collection mechanism of our project.

2. **“An Efficient GPS Parameter Prediction Method Using GPS Ephemeris Patterns for Self-Assisted GPS” - Jongsun Ahn, Ha Yeong Song, Sangkyung Sung, Jin-Bok Kim, IEEE,2010**.

   This approach significantly benefits GPS-reliant autonomous systems. Improved tracking allows better waypoint alignment during navigation. The system adapts well to real-time applications in variable environments. GPS reliability is crucial for autonomous aquatic robots. The technique boosts location accuracy, even with limited signal strength. The proposed method is cost effective and suitable for embedded systems. It supports our robot’s precision navigation using GPS-coordinated paths.

3. **“Researches in Water Pollution: A Review,” - Anil K Dwivedi**

   This paper discusses the impact of industrial, agricultural, and domestic pollution on aquatic ecosystems. It provides a foundation for monitoring and mitigating water pollution through automated cleaning systems. This review explores sources and impacts of water pollution on aquatic ecosystems. It emphasizes the need for real-time monitoring and waste reduction. Manual methods are inadequate for modern pollution control. The paper recommends automation for sustainable water health. It supports our project's goal of autonomous water cleaning.

4. **"Design and Development of River Cleaning Robot Using IoT Technology," - M. Zaenudin, Muhammad Irsyad Abdullah, et al., IEEE**.

The paper presents the development of an innovative robotic system aimed at addressing the growing issue of water pollution in rivers. The research focuses on designing an autonomous river-cleaning robot equipped with Internet of Things (IoT) technology to monitor and collect waste from river surfaces efficiently. The system integrates various sensors and microcontrollers for navigation, waste detection, and collection. Real-time monitoring is enabled through IoT connectivity, allowing users to track the robot's location, waste collection status, and environmental data via a mobile or web interface. The paper highlights the robot's ability to operate independently in shallow waters, navigate using predefined paths, and avoid obstacles while collecting floating debris.

This study demonstrates a practical and sustainable approach to environmental conservation through automation and remote monitoring, providing valuable insights for developing similar smart environmental protection systems.

5. **"Pond Cleaning Robot," - Soumya, H.M. Preeti, Baswaraj Gadgay, IEEE.**

This work introduces a Bluetooth-controlled robot for pond cleaning. It uses IR sensors and motors for basic movement and control. The robot collects floating debris from small water bodies. Although manually operated, it demonstrates compact and functional design. Its approach supports the mechanical design of our waste collector. This paper also explores the design and implementation of a robotic system specifically aimed at cleaning ponds by removing floating waste and debris from the water surface. The robot is designed to operate autonomously or semi-autonomously, using basic electronic components and sensors to detect and collect waste materials. It incorporates a conveyor mechanism or scooping system to gather trash and store it in an onboard container. The authors emphasize the low cost and simplicity of the design, making it suitable for rural or small-scale applications where manual cleaning is labor-intensive and inefficient. The project showcases how basic robotics can be utilized for environmental cleanup tasks, promoting cleaner water bodies through mechanized intervention.

This paper serves as a foundational reference for developing automated water cleaning systems using accessible technology.

6. **"GPS: Location-Tracking Technology," - R. Bajaj, S.L. Ranaweera, D.P. Agrawal, IEEE**.

This paper discusses GPS tracking applications in mobile systems. It outlines signal correction and position accuracy techniques. Real time navigation is essential for autonomous movement. GPS aids in safe and precise operation across mapped zones. This concept reinforces the navigation system in our robot. This paper also provides a comprehensive overview of Global Positioning System (GPS) technology and its application in location tracking systems. The authors discuss the fundamental principles of GPS, including satellite signal transmission, triangulation methods, and positioning accuracy. The paper explores how GPS has evolved to become a crucial component in various applications such as navigation, fleet management, personal tracking, and emergency response. It also addresses the challenges related to signal loss in urban or indoor environments and the integration of GPS with other technologies like wireless communication and sensor networks to enhance performance.

This study highlights the importance of GPS as a reliable and efficient tool for real-time location tracking, making it highly relevant for projects that require autonomous navigation and monitoring, such as river or pond cleaning robots.

7. **"Quantifying Scour Depth in a Straightened Gravel-Bed River with Ground-Penetrating Radar," -Emanuel Huber, Birte Anders, Peter Huggenberger, IEEE, 2018**.

This paper introduces ground-penetrating radar for measuring subsurface structures, enabling accurate quantification of scour depth in riverbeds. This paper investigates the use of GPR (Ground-Penetrating Radar) for measuring riverbed scour depth. It provides techniques to identify subsurface anomalies with high resolution. The method enables detection of sediment layers and erosion patterns. The study validates the data using physical measurements and radar simulation. It proposes a non-invasive way to map underwater river features. The technology enhances the safety and reliability of bathymetric surveys. Although radar-based, the findings parallel sonar-based depth sensing in your project.

The paper supports the need for hazard detection in riverbeds. It contributes to the research direction of river morphology and safe navigation.

8. "Influence of Flow Angle on Local Scour Depth in Steep Gravel River," - Xu-hui Fu, Jiang Hu, IEEE, 2011.

This research explores how water flow angles affect local scour depth. Fluid mechanics are used to model erosion near riverbanks. Scour patterns are linked to hydraulic forces and terrain. Flow dynamics cause rapid changes in riverbed depth. Predictive models are developed for safer waterway designs. The study aids in planning for aquatic infrastructure. Data is used to prevent structural damage and accidents. Our robot's sonar system supports real-time detection of such scours.

9. "Mismanaged Plastic Waste and River Pollution," - Fuchs, Yannic, et al., IEEE.

The paper addresses the growing concern of mismanaged plastic waste (MPW) as a major contributor to river pollution and, consequently, marine plastic contamination. Rivers act as primary pathways transporting plastic debris from land to oceans, with both floating and suspended particles posing removal challenges. The study proposes a novel river-cleaning system featuring self-cleaning, rotating screen drums designed to collect various plastic types, including 3D objects and fragments, under different flow conditions. Through 42 prototype-scale experiments using multiple plastic types and polymers, the system demonstrated an average efficiency of 82% for 3D plastics, though it was less effective for smaller fragments due to their complex behavior in water currents. The research highlights the system's adaptability and potential scalability for real-world application, making it a promising solution for reducing plastic pollution in freshwater bodies. This innovation supports broader environmental goals and can be integrated into localized river-cleaning initiatives, such as autonomous robotic systems for river maintenance.

10. "Geological Influences on Groundwater Exploration," - Amponsah, Theophilus Yaw, et al., IEEE.

The paper by Amponsah et al. examines how geological lineaments affect groundwater availability in Ghana's Voltaian Basin. The study focuses on areas with crystalline basement rocks. Using remote sensing and geospatial tools, lineaments like fractures and faults were mapped. A statistical analysis linked lineament density with groundwater depth in weathered zones. The findings help predict groundwater sources more accurately.

CHAPTER 3

PROBLEM FORMULATION

Problem Statement

Sudden and unmarked riverbed dips caused by soil erosion often led to drowning incidents in rivers and lakes. The lack of real-time monitoring and mapping of riverbed information prevents users from identifying areas affected by erosion. Additionally, cleaning the river surface at tourist locations involves high labor costs and significant human intervention, posing a challenge to efficient and cost-effective management.

CHAPTER 4

OBJECTIVES

1. Design and develop an autonomous robot and coordinate through the mobile app.
2. Detect river depths in real time using sonar sensors to identify hazards and mitigate risks, such as drowning, through precise mapping.
3. Interface Bluetooth communication for live depth data and alerts.
4. Record and transmit latitude and longitude coordinates of sudden dips in the riverbed to the mobile application for further analysis and monitoring.
5. Integrate a waste collection feature into the robot for debris removal and improved water quality.

CHAPTER 5

METHODOLOGY

5.1 BLOCK DIAGRAM

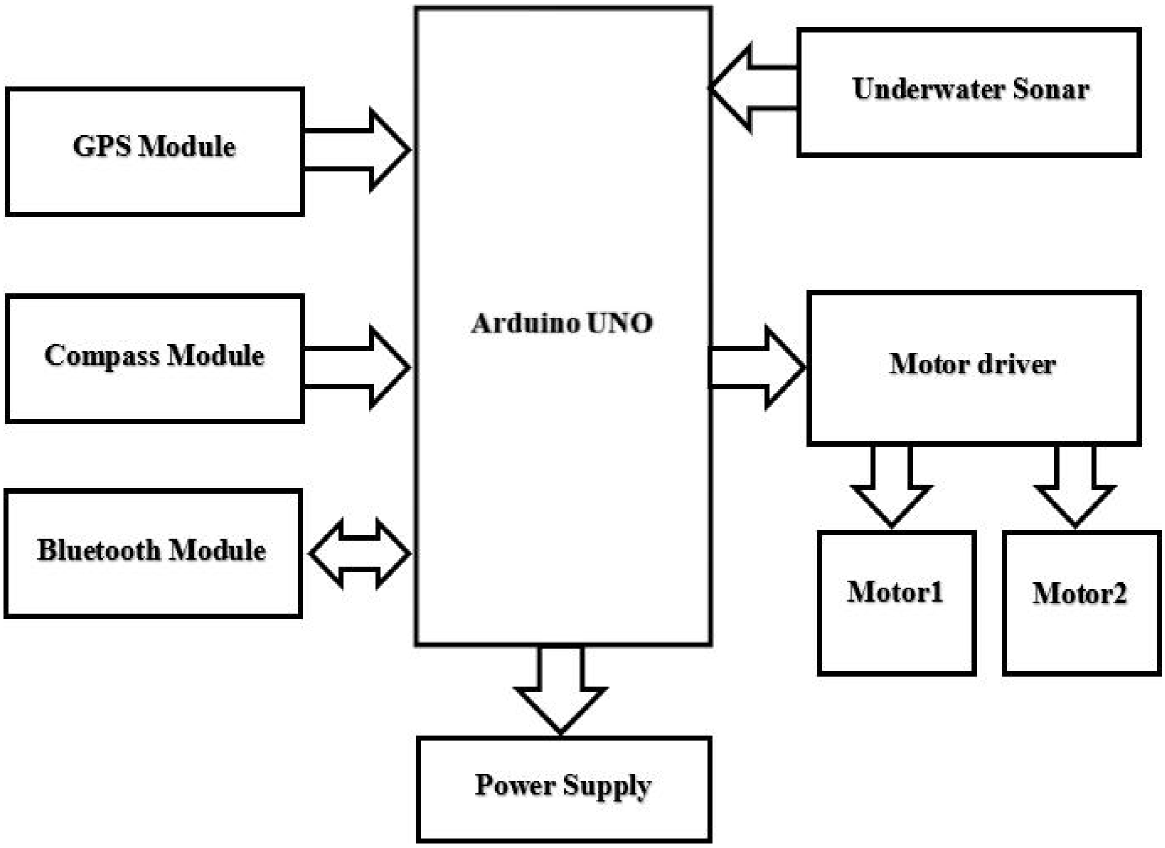

Figure 5.1: Block diagram of Autonomous River Depth Plotting and Cleaning Robot

The figure 5.1 illustrates the Block Diagram of the proposed system is an autonomous river depth plotting and cleaning robot designed to navigate water bodies and perform real-time depth measurement and surface cleaning without human intervention. At the core of the system is the Arduino UNO microcontroller, which serves as the central control unit. It interfaces with several key modules, including a GPS module for acquiring real-time geographic coordinates and a compass module for determining the robot's heading or direction of movement. This combination allows the robot to follow a predefined or dynamically generated path across the river. An underwater sonar sensor is connected to the Arduino to continuously measure the depth of the riverbed. A digital depth map of the region can be produced by recording the depth data and the associated GPS coordinates while moving.

The robot moves and propels itself using two motors connected by a motor driver, which the Arduino controls according to navigational needs.To keep the motors on the intended path, the motor driver decodes the control signals and modifies the motors' speed and direction accordingly. To enable wireless connection between the robot and a distant device, like a computer or smartphone, a Bluetooth module is also included. This enables users to give manual commands, monitor data in real time, and, if needed, override the autonomous processes. A specialized power source powers the entire system, guaranteeing steady functioning throughout the mission. Through the integration of these elements, the robot can independently assess the depth of rivers and wipe their surfaces, assisting with environmental monitoring and canal upkeep.

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Advantages

1. Manual navigation is less necessary when an activity is fully automated.
2. Instantaneous insights into riverbed conditions are provided by real-time depth mapping.
3. Accurate navigation over predetermined routes is ensured by GPS and compass components.
4. Quick waypoint setup from a mobile device is made possible via Bluetooth communication.
5. Users are immediately warned of any dangers by automated depth anomaly detection.
6. Less expensive than conventional survey techniques.
7. Minimizes human risk by being safe for usage in isolated or dangerous aquatic regions.
8. Excellent effectiveness at gathering vast amounts of data over extended distances.
9. Transportable and adjustable to different settings and bodies of water.
10. Less human oversight is required, enabling more regular surveys.

CHAPTER 6

SYSTEM DESIGN AND IMPLEMENTATION

6.1 DESIGN ASPECTS

In order to guarantee effective navigation, depth mapping, debris removal, and environmental sustainability, the autonomous river depth plotting and cleaning robot is designed with a number of mechanisms.

The main features of the design are highlighted in the sections that follow:

1. **System Architecture**

The lightweight, weather-resistant chassis of the autonomous boat platform offers stability in a range of water conditions. To guard against environmental exposure-induced damage, the electronic components are contained within a small, tightly sealed enclosure. All parts of the power supply system are powered by a rechargeable battery, and for longer operation, a solar panel add-on is offered. In order to guarantee continuous operation, a power management system keeps an eye on and controls battery levels..

2. **Navigation System**

In order to guarantee precise navigation, the system incorporates:
• **GPS Module:** Real-time location tracking and waypoint integration are made possible by a high-accuracy GPS module, which uses Bluetooth to send waypoints from a mobile application.
• **Compass Module:** To keep on the right path to the desired waypoints, a digital compass helps with direction alignment. To ensure accurate navigation, an algorithm corrects for irregularities brought on by outside influences or water currents.

3. **Depth Measurement System**

The following components make up the depth measurement system:

• **Sonar Sensor:** A waterproof sonar sensor installed on the boat's underside continuously gathers depth data and sends it in real time to the microcontroller on board.

• **Hazard Detection:** For user awareness, the system records dangerous dips with GPS coordinates when it detects abrupt depth changes in real-time.

4. **Data Communication**

The communication system makes it easier for the human and robot to interact:
• **Bluetooth Module:** During prolonged operations, a low-energy Bluetooth module allows the robot to broadcast depth data to a mobile application and receive waypoints while using less power.
• **Mobile Application:** The application offers an easy-to-use interface for waypoint entry, hazard alerts, and the display of depth maps and GPS coordinates of dangers that have been discovered.

5. **Control System**

The control centre is a centralized microprocessor that integrates Bluetooth, GPS, compass, and sonar modules. It follows waypoints and adjusts to ambient disturbances using an autonomous navigation system. In addition to a servo motor for accurate orientation corrections based on compass data, the propulsion system consists of dual motors for speed and direction control.

6. **Data Storage and Processing**

For post-mission analysis, depth information and matching GPS coordinates are stored on an SD card module. In the event of communication failures, a backup system guarantees data protection and saves important data for later analysis.

7. **Safety Features**

Safety features are incorporated into the robot to improve operating reliability:
• **Obstacle Detection:** LIDAR or ultrasonic sensors may identify and steer clear of obstructions in water.
• **Emergency Recovery:** In the event of a communication breakdown or extremely low power levels, a fail-safe mechanism makes sure the boat returns to its starting position.

8. **Environmental Considerations**

The design incorporates the following features to guarantee sustainability and durability:
• **Waterproofing:** All electronic parts are enclosed in waterproof enclosures with eco-friendly materials, buoyancy aids, and the option of solar charging for longer missions.

9. User Interaction

A smooth user experience is offered via the mobile application, which enables waypoint input, real-time updates, and hazard notifications. It provides information on the depth profile and dangers of the river by displaying a graphical depth map of the studied area.

10. Testing and Calibration

The robot undergoes rigorous testing and calibration to ensure accurate performance:

- **Calibration Procedures:** GPS, compass, and sonar sensors are initially calibrated for accuracy. Periodic testing in controlled water bodies helps refine navigation and depth-mapping algorithms.
- **Field Testing:** The robot is deployed in real river environments to evaluate its performance under diverse conditions, such as strong currents and shallow waters.

This integrated design ensures that the robot effectively meets its objectives of river depth plotting and cleaning while maintaining operational safety and environmental sustainability.

6.1.2 FLOWCHART

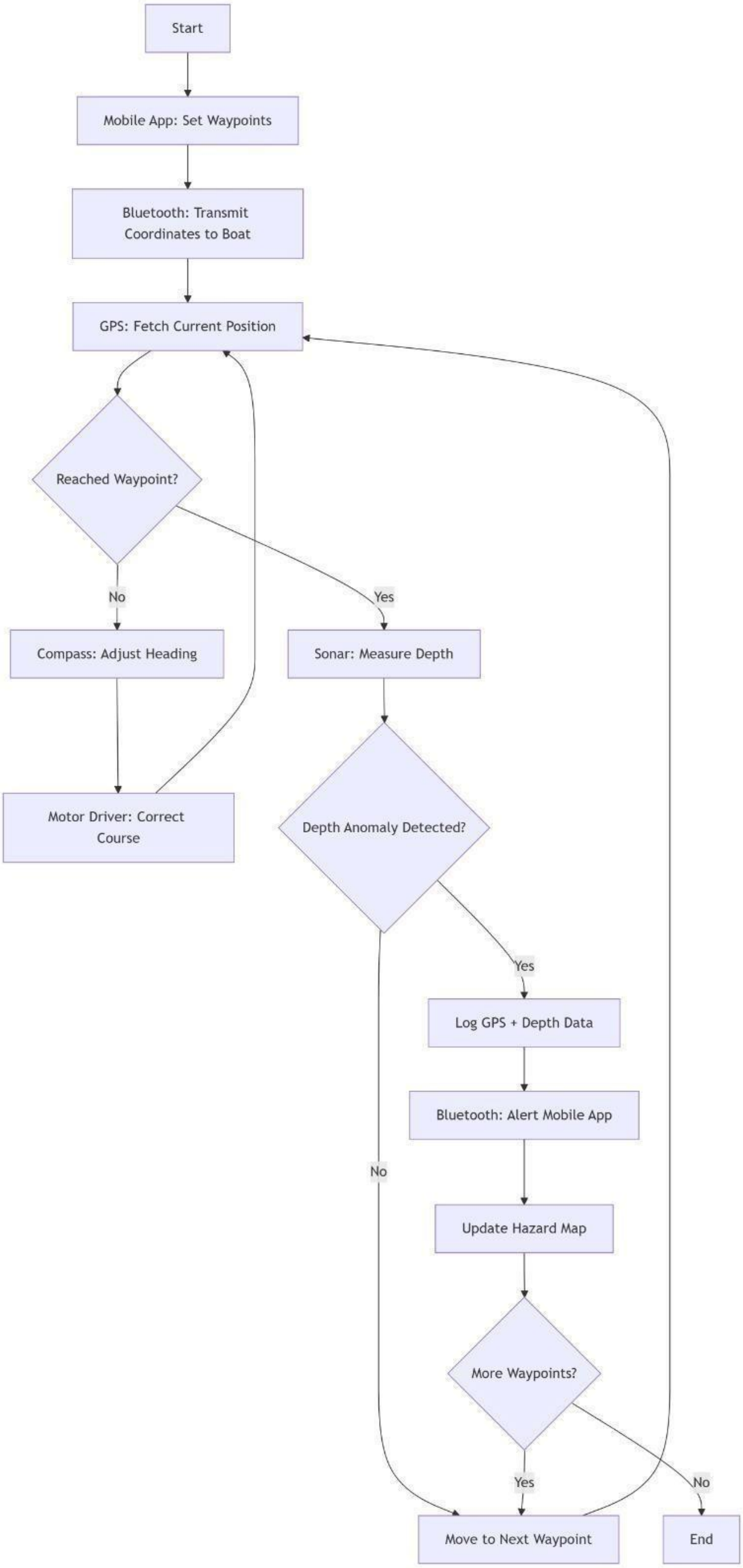

Figure 6.1.2: Flow chart of the proposed system

Figure 6.1.2 illustrates the flowchart step-by-step operational flow of the autonomous river depth plotting and cleaning robot, integrating navigation, depth measurement, and hazard reporting functionalities.

The process begins with the initial setup, where the user defines a series of waypoints using a mobile application. These waypoints represent the target locations the robot must visit on the river. Once the waypoints are set, they are transmitted to the robot via Bluetooth communication.

Upon receiving the coordinates, the robot uses its GPS module to fetch its current location and compare it with the waypoint coordinates. It checks whether it has reached the current waypoint. If not, it uses the compass module to determine the correct heading, and the motor driver adjusts the movement of the motors to correct the robot's course and steer it toward the waypoint.
When the robot arrives at a waypoint, it activates the underwater sonar sensor to measure the depth of the water at that location. The system then checks for any depth anomalies, which could indicate hazards like sudden drop-offs, shallow regions, or submerged obstacles.

If an anomaly is detected, the robot logs the GPS coordinates along with the depth data, transmits an alert back to the mobile app via Bluetooth, and updates the internal hazard map for the river. This enables the system to store and report potentially dangerous or unusual depth readings for further analysis or future navigation.

Next, the robot checks whether there are more waypoints to visit. If there are, it moves on to the next waypoint and repeats the process. If all waypoints have been visited, the mission ends.

CHAPTER 7

HARDWARE AND SOFTWARE REQUIREMENTS

7.1 HARDWARE REQUIREMENTS

1. Microcontroller (Arduino Uno)
2. GPS and Compass Module (NEO-7M)
3. Bluetooth Module (HC-06)
4. Sonar Depth Sensor
5. DC Motors
6. Motor Driver (L298N 2A)
7. Power Supply
8. Mobile Device (with Bluetooth capability)

7.1.1 Arduino UNO: It is a popular open-source microcontroller board based on the ATmega328P microcontroller. It is widely used in embedded systems and robotics projects due to its simplicity, reliability, and ease of programming. The board provides a user-friendly platform for interfacing sensors, actuators, and communication modules, making it ideal for real-time monitoring and control applications.

Figure 7.1.1: Arduino UNO

Specifications

Specifications: Microcontroller: ATmega328P

Operating Voltage: 5V

Input Voltage (recommended): 7–12V

Digital I/O Pins: 14 (of which 6 provide PWM output)

Analog Input Pins: 6

Clock Speed: 16 MHz

Flash Memory: 32 KB (ATmega328P) of which 0.5 KB used by bootloader

SRAM: 2 KB

EEPROM: 1 KB

USB Interface: For programming and serial communication Protocols: UART, SPI, I2C

This combination of features makes the Arduino UNO suitable for controlling and managing the functions of the underground water channel robot.

7.1.2 GPS and Compass Module: Often found in robotics, autonomous vehicles, and drones, the NEO-7M GPS with Compass module is a high-precision positioning and navigation tool. It has the u-blocks NEO-7M GPS receiver, which uses little power and acquires satellites quickly to offer precise location data. It provides heading and orientation data necessary for steady and independent navigation when combined with an electronic compass (magnetometer), often the HMC5883L or a comparable model.

This module provides essential information for GPS-based flying modes, waypoint navigation, and return-to-home operations. It is specifically made to work with flight controllers such as APM 2.6/2.8 and Pixhawk 2.4.6/2.4.8. Drones, ground vehicles, and mapping systems all make extensive use of it.

Figure 7.1.2: GPS and Compass Module

Specifications

Type of Module: HMC5883L GPS Module with Integrated Digital Compass

GPS Chipset: NEO-7M u-blocks

Channels: high sensitivity receiver with 56 channels

Update Rate: Position updates at 10 Hz Voltage

range for operation: 3.3V to 5V DC

Interface for communication: I²C for compass, UART (by default, 38400 baud).

Antenna: An active ceramic patch antenna for receiving signals with strength and precision

Backup Battery: Hot start rechargeable backup battery

Memory: Configuration settings are stored in an onboard I²C EEPROM.

Enclosure: Molded plastic container to keep out moisture and dust

Connectivity:

- 4-pin I/C compass connector
- 6-pin GPS module connector

Applications

• Drone and UAV navigation: Offers accurate heading and GPS positioning data for self-piloted flight.

• Waypoint and Mission Planning: Allows robots and drones to geofence and follow routes automatically.

• Accurate Heading and Orientation: Improves stability and directional control by combining GPS and compass data.

• Autonomous Vehicle Guidance: Used for path tracking and navigation in maritime vehicles and ground rovers.

• Mapping and Surveying: Gathers GPS data for terrain mapping and geographic information systems (GIS).

7.1.3 Bluetooth Module: Using Bluetooth 2.0 technology, the HC-05 Bluetooth module is a wireless communication device intended for short-range serial data transmission. Although it runs on a 3.3V logic level, inbuilt regulators frequently provide 5V power. The module can only receive connections from a master (such as a computer or smartphone) because it is set up as a slave-only device. It is frequently used in conjunction with microcontrollers such as Arduino and communicates via UART (TX/RX). For projects including Bluetooth-controlled robotics, home automation, and sensor monitoring, the HC-06 is perfect for wireless control and data transmission. It is well-liked in do-it-yourself electronics due to its affordability and ease of use.

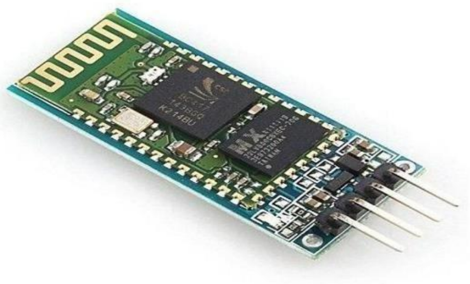

Figure 7.1.3: The HC-05 Bluetooth module

Specifications

Bluetooth Serial Communication Module (Slave Only) is the type of module.

Chipset: CSR BC4

Bluetooth V2.0 + EDR (Enhanced Data Rate) is the current version.

3.3V is the operating voltage (with an internal 3.3V voltage regulator).

Interface for communication: UART (breakout pins for TXD, RXD, VCC, and GND)

The default baud rate is 9600 bps, however AT commands can be used to change it. AT Instructions:

- Module name, baud rate, and pairing password are set using this feature, which is only accessible while Bluetooth is not connected.

Compatibility and Pairing:

- Compatible with Bluetooth-enabled devices, including Android smartphones, PDAs, PSPs, and other Bluetooth masters; computers (as Bluetooth masters); and Note: No slave-to-slave connectivity is possible with another HC-06.

Applications

- Wireless Communication with Arduino: Allows Android devices and Arduino to communicate serially.
- Remote Control of Robots: Used in mobile-controlled robots and vehicles via smartphone apps.
- Home Automation Projects: Controls lights, fans, and appliances wirelessly using Bluetooth.
- Data Logging and Monitoring: Sends sensor data (e.g., temperature, humidity) wirelessly to a phone or PC.

7.1.4 Sonar Depth Sensor (Ultrasonic obstacle sensor that is waterproof and has a separate probe for reversing radar)**:** Ultrasonic obstacle sensor that is waterproof and has a separate probe for reversing radar is a durable distance-measuring sensor designed for use in outdoor or harsh environments. It emits ultrasonic waves through its waterproof probe and calculates the distance to an object by measuring the time it takes for the echo to return. This sensor is commonly used in reversing radar systems for vehicles, robotic obstacle avoidance, parking assistance, and level detection in tanks. Its waterproof design allows it to function reliably in wet or dusty conditions. With high sensitivity and a separate probe design, it offers flexible installation and accurate measurement over short to medium ranges.

Figure 7.1.4: Ultrasonic obstacle sensor that is waterproof and has a separate probe for reversing radar

Specifications

Sensor Type: Waterproof Ultrasonic Distance and Obstacle Sensor

Construction: Two separate parts

- Transducer (sensing element)
- Control board (processing unit)

Distance Range: 250 mm to 4500 mm (0.25 m to 4.5 m)

Operating Voltage: Typically, 5V DC

Output: Pulse width based on estimated distance

Interface: Compatible with different microcontrollers, including Arduino.

Working Principle: Calculates distance by sending ultrasonic pulses and timing the echo back.

Applications

- Vehicle Parking Assistance: This feature helps with safe parking by acting as a reverse radar to identify impediments.
- Robot Obstacle Detection: Assists mobile robots in identifying and avoiding obstacles in a variety of settings.
- Home Automation Security: Recognizes movement or presence close to doors or other restricted spaces.
- Underwater Robotics and Applications: Because of its waterproof construction, it can be used to measure distance underwater.

7.1.5 DC Motors: Often utilized in portable and transportable applications, DC BO (Battery Operated) motors are small, compact electric motors that run on batteries. Toys, robots, and small appliances can move thanks to their ability to transform electrical energy into mechanical rotation. Usually running at low voltages (3V to 12V), these motors offer variable speeds based on the voltage applied. DC BO motors are perfect for robotics, hobby electronics, and educational applications because of their lightweight and straightforward construction. They are popular for do-it-yourself projects that call for effective, battery-powered motion because they are simple to control using motor drivers or microcontrollers.

Figure 7.1.5: DC BO Motor

Specifications

Motor Type: DC Geared Motor (BO Series – L-Shape, Plastic Gear)

Speed: 60 RPM (at optimal voltage)

Operating Voltage: 3V to 12V DC Optimal Voltage Range: 6V to 12V

Good torque is produced at lower operating voltages.

Shaft Type: Compact shaft that can be mounted on wheels or encoders

Shaft Diameter: 6 mm (typically D-shaped)

Design: L-shape configuration for space-saving and compact applications

Mechanical Features:

Mounting: Inbuilt mounting holes allow for secure and simple positioning. Weight: Lightweight, perfect for mobile designs and in-circuit installation

Compatible Wheels:

- 69mm Diameter Wheel for Plastic Gear Motors
- 87mm Diameter Multipurpose Wheel for Plastic Gear Motors

Applications

- Robotics Projects: Used to drive wheels in small robots and mobile platforms.
- Line Following Robots: Powers the movement mechanism in line-tracking robotic systems.
- Obstacle Avoidance Robots: Helps in navigation and mobility by driving wheels or treads.
- Mini Conveyor Belts: Used in small-scale material handling systems and educational demos.

7.1.6 L298N 2A Motor Driver: This multipurpose dual H-Bridge driver module regulates the direction and speed of one stepper motor or two DC motors. It usually runs from 5V and 35V and can manage up to 2 amps of continuous current per channel. By using logic inputs to activate the forward, reverse, and brake operations, the driver permits bidirectional control. Robotics, automation, and motor control projects frequently use the L298N, which is compatible with microcontrollers such as Arduino and Raspberry Pi and enables PWM speed control. It is perfect for prototyping and instruction because of its sturdy build.

Figure 7.1.6: L298N 2A Motor Driver

Specifications

Driver IC: L298N Dual H-Bridge Motor Driver IC

Operating Voltage: 5V to 35V DC

Logic Voltage: 5V (onboard 5V regulator can supply external components)

Maximum Current: Up to 2A per channel

Motor Control Capability:

- Controls up to 4 DC motors (unidirectional)
- Controls 2 DC motors (bidirectional) with speed (PWM) and direction control
- Supports stepper motor control

Onboard Features:

- 5V voltage regulator
- Heat sink for better thermal performance

Power and status LEDs

Applications

- DC Motor Control: Used to control speed and direction of one or two DC motors.
- Robotics Projects: Powers motors in robots for mobility and maneuverability.
- Bidirectional Motor Driving: Enables forward and reverse movement of motors using H-Bridge design.

7.1.7 Lithium-ion battery (LG INR18650 M26 2600mAh) power supply: A premium rechargeable lithium-ion battery with a 2600mAh nominal capacity is the LG INR18650 M26. It provides dependable power for a variety of electronic devices, such as power tools, robotics, flashlights, and battery packs, and is designed in the 18650 cylindrical styles.

Figure 7.1.7: Power supply (LG INR18650 M26 2600mAh Lithium-Ion Battery)

Specifications:

High Capacity: 2600mAh for extended run time

Stable Voltage Output: 3.6V nominal

Rechargeable: Can be charged hundreds of times

Flat Top Design: Ideal for battery pack assembly

Lithium Nickel Manganese Cobalt Oxide (NMC): Balances energy density and safety

Specifications:

Model: LG INR18650 M26

Battery Type: Lithium-ion (Li-ion), INR (NMC chemistry)

Capacity: 2600mAh

Nominal Voltage: 3.6V

Charging Voltage: 4.2V max

Discharge Cut-off Voltage: 2.5V

Max Continuous Discharge Current: 5A

Cell Dimensions: 18.4mm (D) x 65.0mm (L)

Weight: ~45g

Cycle Life: ~300–500 charge cycles

Applications:

- Battery packs for robotics, RC vehicles, and drones
- Power banks and portable devices
- Flashlights and torches
- DIY electronics and energy storage system

7.1.8 Mobile Device: A portable controller, like a smartphone or tablet, that is used to remotely monitor, control, or receive real-time data and video feeds from an underground water channel inspection robot is referred to as a mobile device.

Figure 7.1.8: Mobile Device

Specifications:

Wireless Connectivity: Communicates via Bluetooth, Wi-Fi, or cellular network with the robot Real-Time Monitoring: Displays live sensor data or video feed

User Interface: Touchscreen controls for navigation and function commands Portability: Easy to carry and operate from above ground

Compatibility: Works with robot's control app or custom software

Specifications (Typical):

OS: Android or iOS

Connectivity: Wi-Fi, Bluetooth, USB-OTG

Battery: 3000mAh or higher for field use

Display: 5–7-inch touchscreen

App Support: Custom or standard apps for robot control.

SOFTWARE REQUIREMENTS

1. Arduino IDE
2. Bluetooth Serial Terminal App
3. Motor Control Libraries
4. Bluetooth Communication Library

7.1.5 Arduino IDE: Arduino software, also known as the Arduino Integrated Development Environment (IDE), is a platform used for writing and uploading code to Arduino-compatible boards. It includes a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions, and a series of menus. It connects to the Arduino hardware via a USB cable and communicates using a simple protocol. The Arduino IDE supports programming in C/C++ and provides a standard API called "Arduino language,"simplifying the programming process. Users write code in the IDE, which is then compiled and uploaded to the Arduino board. The board executes the uploaded code, which can interact with sensors, motors, and other electronic components to create a wide range of projects, from simple LED blinking to complex robotics. The IDE's simplicity and the extensive online community make it accessible for beginners and powerful for advanced users.

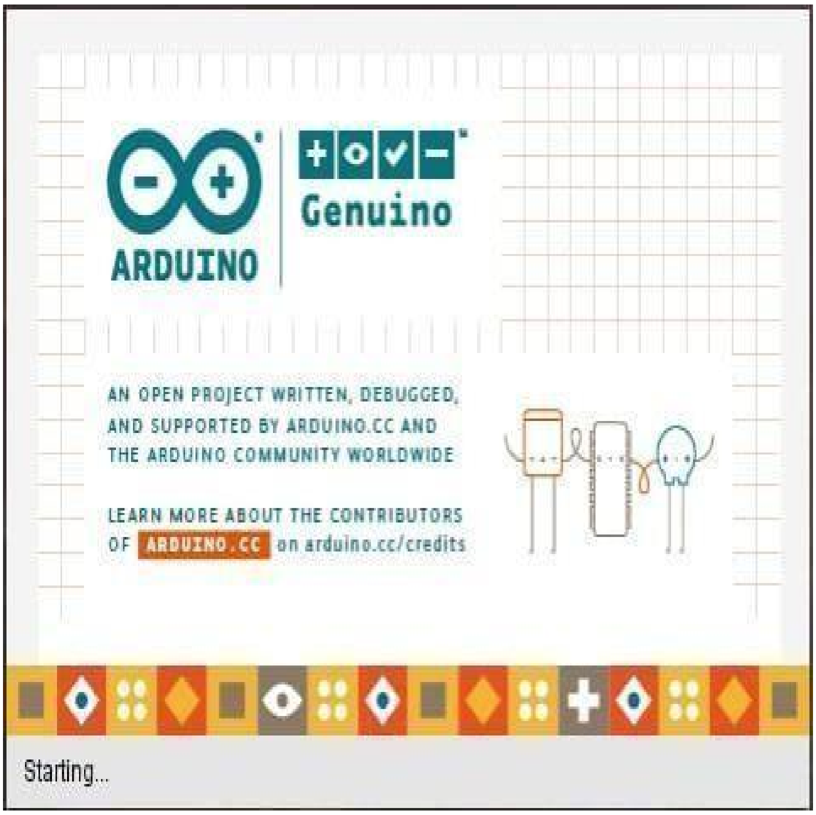

Figure 7.2.1: Arduino Integrated Development Environment (IDE)

1. Connect Your Arduino

Plug your Arduino board into your computer via USB.

Wait for your computer to detect it (drivers may install automatically).

2. Open Arduino IDE

Launch the Arduino IDE on your computer.

3. Select the Board

Go to Tools > Board and select the correct board (e.g., Arduino Uno, Mega, Nano, etc.).

4. Select the Port

Go to Tools > Port and choose the COM port associated with your Arduino (e.g., COM3, COM4, etc.).

If you're unsure which one, unplug the Arduino and plug it back in to see which port disappears/reappears.

5. Open or Paste Your Code

Either write your code in the editor or paste code into a new sketch window.

6. Verify the Code

Click the checkmark icon (top-left) or go to Sketch > Verify/Compile to compile your code and check for errors.

7. Upload the Code

Click the right-arrow icon (next to the checkmark) or go to Sketch > Upload.

Wait for the upload to complete (you'll see "Done uploading" at the bottom if successful).

7.1.5 Bluetooth Serial Terminal App: The Bluetooth Serial Terminal app is a handy tool for wireless communication with Bluetooth-enabled devices. It connects to modules like HC-05 or HC-06 using the Serial Port Profile (SPP). This app is widely used by developers working on embedded systems and IoT projects. Users can send and receive serial data in real-time from their smartphones. It supports both ASCII and HEX formats for flexible communication. The app also offers features like command history, auto-reconnect, and line-ending settings. It's an essential utility for testing, debugging, and monitoring Bluetooth serial communication.

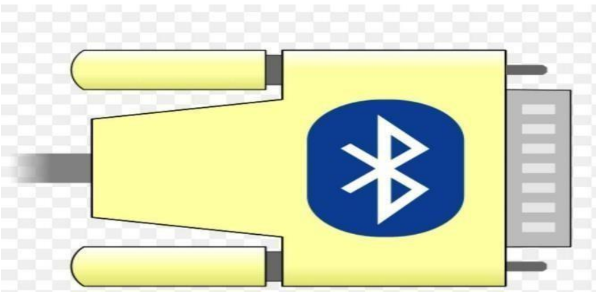

Figure 7.2.2: Bluetooth Serial Terminal App

7.1.5 Motor Control Libraries: These libraries facilitate the control of DC motors via the motor driver. Examples include the L298N motor driver library.

7.1.5 Bluetooth Communication Library: The Software Serial library in stm32o, used to handle Bluetooth communication between the robot and the mobile app.

CHAPTER 8

OBJECTIVES ACCOMPLISHED

Objectives:

1. Design and develop an autonomous robot and coordinate through the mobile app: Successfully designed and developed an autonomous robot capable of navigating water bodies without manual intervention. The robot's operations can be monitored and coordinated remotely via a custom-built mobile application.

2. Detect river depths in real time using sonar sensors to identify hazards and mitigate risks, such as drowning, through precise mapping: Integrated sonar sensors into the robotic system to enable real-time detection and analysis of riverbed depth. This allows for precise topographical mapping and helps identify sudden dips or hazardous zones that may pose risks such as drowning.

3. Interface Bluetooth communication for live depth data and alerts: Implemented Bluetooth communication between the robot and the mobile app to transmit live depth data and alert users immediately upon detection of abnormal depth readings.

4. Record and transmit latitude and longitude coordinates of sudden dips in the riverbed to the mobile application for further analysis and monitoring: Enabled the robot to capture and transmit GPS coordinates (latitude and longitude) of critical points, especially sudden dips in the riverbed. These coordinates are logged and displayed in the mobile application for further analysis and long-term monitoring.

5. Integrate a waste collection feature into the robot for debris removal and improved water quality: Added a mechanical waste collection system to the robot, allowing it to gather floating debris during its autonomous operations. This feature contributes significantly to improving water quality and supporting environmental cleanliness.

CHAPTER 9

RESULTS AND DISCUSSION

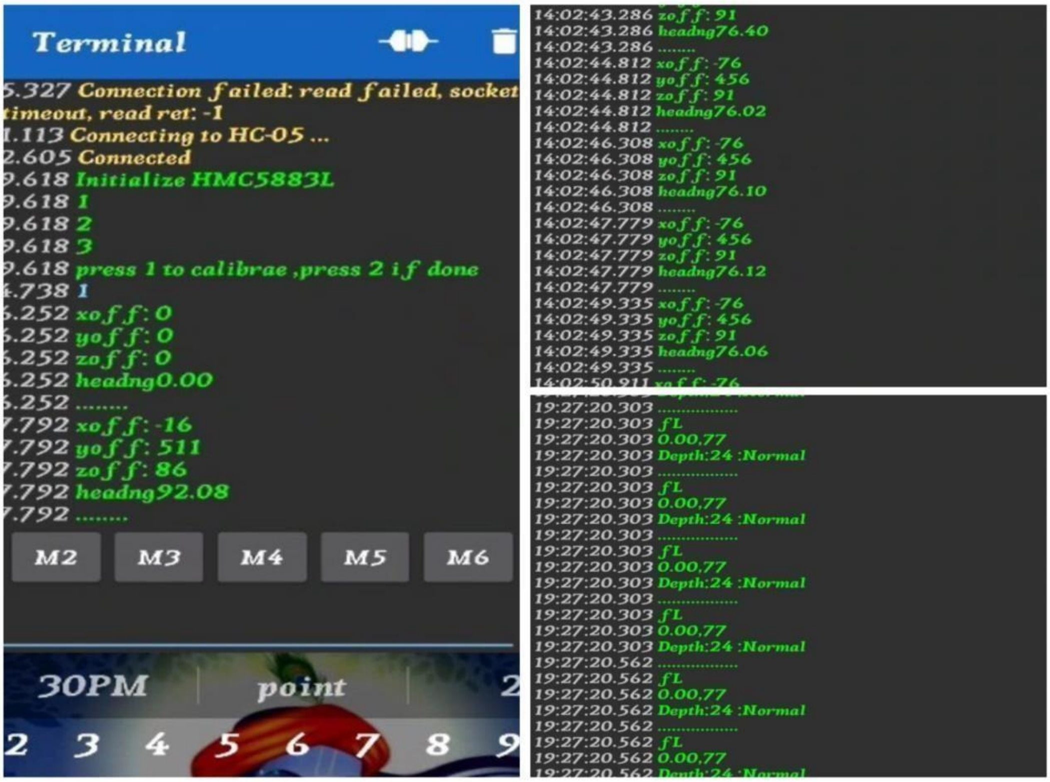

Figure 9.1: Live mobile application interface

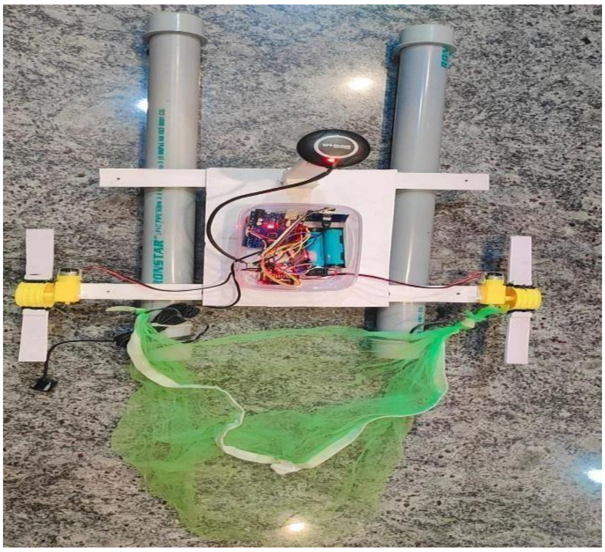

Figure 9.2: Top view of the Robot

Figure 9.3: Collection of debris on the surface of river

In accordance with the established goals, the autonomous river depth charting and cleaning robot was successfully designed, developed, and tested. Real-time coordination and user control were made possible by the robot's interaction with a smartphone application. The first goal of efficient coordination using a mobile interface was achieved by this program, which enabled users to specify waypoints, examine real-time changes, and get hazard alerts. The sonar sensor system continuously detected abrupt dips and fluctuations in the riverbed, correctly detecting and quantifying river depths in real time. This achieved the second goal by guaranteeing accurate depth mapping and assisting in reducing hazards like drowning.

Reliable Bluetooth connectivity between the robot and the smartphone app allowed for the smooth transfer of real-time alarms and live depth data. The third goal was accomplished when the microcontroller correctly processed and communicated this information to the user. The fourth goal, which was to document and communicate the location of dangerous dips, was accomplished successfully. Accurate latitude and longitude data were recorded by the GPS module and shown in the mobile app for tracking and additional analysis.

The robot's rubbish collection system performed well in addition to recording river depths. The fifth goal was accomplished when the debris net effectively caught floating trash while navigating the river, improving water quality and protecting the ecosystem. Because the chassis was designed using lightweight and waterproof materials, the system also demonstrated strong stability and buoyancy. Operational reliability was further improved by safety features like obstacle detection and an emergency return function. All things considered, the robot demonstrated trustworthy data communication, effective navigation, and accurate hazard recognition in real-world scenarios. These outcomes attest to the integrated system's viability and efficacy in boosting ecological sustainability and river safety.

CHAPTER 10

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APPENDIX

```
// line 7 change value according to number  of points,  from line 317 add lat and log for each
point
#include <Wire.h>
#include <SoftwareSerial.h>
#include <TinyGPS++.h>
#include <Wire.h>
#include <HMC5883L.h>



int number_of_points = 2;
const int trigPin = 8;
const int echoPin = 9;
// int buz = 13;

int z = 0;
int GPS_Course;
int Number_of_SATS;
TinyGPSPlus gps;

int16_t mx, my, mz;
int desired_heading;
int compass_heading;
int compass_dev = 5;

int  Heading_A;
int  Heading_B;
int pass = 0;
unsigned long Distance_To_Home;

int ac = 0;
int wpCount = 0;
double Home_LATarray[50];
double Home_LONarray[50];
```

```
int increment = 0;

SoftwareSerial serial2(10, 11);
const int HighL =4;  // LEFT SIDE MOTOR
const int LowL = 5;

HMC5883L compass;
const int HighR = 6;  //RIGHT SIDE MOTOR
const int LowR = 7;
float headingDegrees = 0;
//*8
int minX = 0;
int maxX = 0;
int minY = 0;
int maxY = 0;
int minZ = 0;
int maxZ = 0;
int offX = 0;
int offY = 0;
int offZ = 0;
int caliberror = 0;
unsigned long pt = 0;
void setup() {
  // pinMode(buz, OUTPUT);
  // digitalWrite(buz, LOW);
  serial2.begin(9600);
  Serial.begin(9600);
  pinMode(HighL, OUTPUT);
  pinMode(LowL, OUTPUT);
  // pinMode(8, OUTPUT);
  // pinMode(D5, OUTPUT);
  // pinMode(D6, OUTPUT);
  pinMode(HighR, OUTPUT);
  pinMode(LowR, OUTPUT);
  pinMode(trigPin, OUTPUT);
```

```
  pinMode(echoPin, INPUT);
  Serial.println("Initialize HMC5883L");
  while(!compass.begin()) {
    Serial.println("Could not find a valid HMC5883L sensor, check wiring!");
    delay(500);
  }
  Serial.println("1");
  // Set measurement range
  compass.setRange(HMC5883L_RANGE_1_3GA);

  // Set measurement mode
  compass.setMeasurementMode(HMC5883L_CONTINOUS);

  // Set data rate
  compass.setDataRate(HMC5883L_DATARATE_30HZ);

  // Set number of samples averaged
  compass.setSamples(HMC5883L_SAMPLES_8);

  // Set calibration offset. See HMC5883L_calibration.ino

  Serial.println("2");
  Startup();
}

void loop() {
  Vector norm = compass.readNormalize();

  // Calculate heading
  float heading = atan2(norm.YAxis, norm.XAxis);

  // Set declination angle on your location and fix heading
  // You can find your declination on: http://magnetic-declination.com/
  // (+) Positive or (-) for negative
  // For Bytom / Poland declination angle is 4'26E (positive)
  // Formula: (deg + (min / 60.0)) / (180 / M_PI);
```

```
float declinationAngle = 0;
heading += declinationAngle;
// Correct for heading < 0deg and heading > 360deg
if (heading < 0) {
  heading += 2 * PI;
}

if (heading > 2 * PI)
  { heading -= 2 * PI;
}

// Convert to degrees
headingDegrees = heading * 180 / M_PI;
int z = headingDegrees;
z = 360 - z;
z = z - 360 + caliberror;
if (z > 0) {
  if (z > 360 && z < 720)
    { z = z - 360;
  }
  if (z > 720 && z < 1080)
    { z = z - 720;
  }
  if (z > 1080 && z < 1440)
    { z = z - 1080;
  }
  if (z > 1440 && z < 1800)
    { z = z - 1440;
  }
  if (z > 1800 && z < 2160)
    { z = z - 1800;
  }
  if (z > 2160 && z < 2520)
    { z = z - 2160;
  }
} else {
```

```
    if (z < -360 && z > -720)
     { z = z + 360;
    }
    if (z < -720 && z > -1080)
     { z = z + 720;
    }
    if (z < -1080 && z > -1440)
     { z = z + 1080;
    }
    if (z < -1440 && z > -1800)
     { z = z + 1440;
    }
    if (z < -1800 && z > -2160)
     { z = z + 1800;
    }
    if (z < -2160 && z > -2520)
     { z = z + 2160;
    }
    z = 360 + z;
  }

  headingDegrees = z;

  car();
}
void car()
  { gpsInfo()
  ;
  if (ac < number_of_points) {  // Start of Go_Home procedure
                              //(1000);

    //Serial.println("on way");
    // Update Compass heading
    getGPS();  // Tiny GPS function that retrieves GPS data - update GPS location// delay time
changed from 100 to 10
```

```
   Distance_To_Home = TinyGPSPlus::distanceBetween(gps.location.lat(), gps.location.lng(),
Home_LATarray[ac], Home_LONarray[ac]);  //Query Tiny GPS for Distance to Destination
   GPS_Course = TinyGPSPlus::courseTo(gps.location.lat(), gps.location.lng(),
Home_LATarray[ac], Home_LONarray[ac]);              //Query Tiny GPS for Course to
Destination

//GPS_Course=90;

   if (Distance_To_Home < 10)  // If the Vehicle has reached it's Destination, then Stop
   {
     stopboat();  // Stop the robot after each waypoint is reached
              // Serial.println("arrived!");                    // Print to Bluetooth device - "You have
arrived"
     ac++;        // increment counter for next waypoint
              // Break from Go_Home procedure and send control back to the Void Loop
     // go to next waypoint
   }


   if (abs(GPS_Course - headingDegrees) <= 10)  // If GPS Course and the Compass Heading are
within x degrees of each other then go Forward
   // otherwise find the shortest turn radius and turn left or right
   {
     Forward();
     // analogWrite(D5, 255);
     // analogWrite(D6, 255); // Go Forward
     Serial.println("F");

   } else {

     if ((GPS_Course - headingDegrees) >= -2)  // if z is less than 180 and not a negative value
then turn left otherwise turn right
     {

       if (GPS_Course - headingDegrees < 10) {
```

```
          Serial.println("sR");
         SlowRightTurn();
          // analogWrite(D5, 130);  // pin 9 is pwm / power pin of right motor   0-255
          // analogWrite(D6, 255);  // pin 3 is pwm / power pin of left  motor

        } else
          { Serial.println("fR
          ");
          SlowRightTurn();
          // analogWrite(D5, 255);
          // analogWrite(D6, 255);
        }
      } else {
        if ((GPS_Course - headingDegrees) > -10) {

          SlowLeftTurn();
          // analogWrite(D5, 255);
          // analogWrite(D6, 130);
          Serial.println("sL");
        } else
           { SlowLeftTurn
           ();
          // analogWrite(D5, 255);
          // analogWrite(D6, 255);
          Serial.println("fL");
        }
      }
    }
     Serial.print(gps.location.lat());
     Serial.print(",");
     Serial.println(GPS_Course);
 int dis=us();
Serial.print("Depth:");
Serial.print(dis);
Serial.print(" :");
if(dis>152){ Serial.println("
```

```
Dangerous");
}
```

```
else{
  Serial.println("Normal");
}
 Serial.println("................. ");
  } else
    { stopboat
    ();
  }
}
void Startup() {



  // while (Number_of_SATS <= 3)                         // Wait until x number of satellites are
acquired before starting main loop
  // {
  //   //Serial.println("3    ");
  //   getGPS();                                         // Update gps data
  //   Number_of_SATS = (int)(gps.satellites.value());   // Query Tiny GPS for the number of
Satellites Acquired

  //                                     // Check to see if there are any bluetooth commands being received
  // }
  // setWaypoint();                                      // set intial waypoint to current location
  Serial.println("3");
  Serial.println("press 1 to calibrae ,press 2 if done");
  int c = takeip().toInt();
  if (c == 1)
    { while (true)
    {
      Vector mag = compass.readRaw();

      // Determine Min / Max values
      if (mag.XAxis < minX) minX = mag.XAxis;
      if (mag.XAxis > maxX) maxX = mag.XAxis;
      if (mag.YAxis < minY) minY = mag.YAxis;
      if (mag.YAxis > maxY) maxY = mag.YAxis;
```

```
if (mag.ZAxis < minZ) minZ = mag.ZAxis;
if (mag.ZAxis > maxZ) maxZ = mag.ZAxis;
```

```
// Calculate offsets
offX = (maxX + minX) / 2;
offY = (maxY + minY) / 2;
offZ = (maxZ + minZ) / 2;
Vector norm = compass.readNormalize();
float heading = atan2(norm.YAxis, norm.XAxis);

// Set declination angle on your location and fix heading
// You can find your declination on: http://magnetic-declination.com/
// (+) Positive or (-) for negative
// For Bytom / Poland declination angle is 4'26E (positive)
// Formula: (deg + (min / 60.0)) / (180 / M_PI);
float declinationAngle = 0;
heading += declinationAngle;
// Correct for heading < 0deg and heading > 360deg
if (heading < 0) {
  heading += 2 * PI;
}

if (heading > 2 * PI)
  { heading -= 2 * PI;
}

// Convert to degrees
headingDegrees = heading * 180 / M_PI;
if (millis() - pt > 1500)
{ Serial.print("xoff: ");
Serial.println(offX);
  Serial.print("yoff: ");
  Serial.println(offY);
  Serial.print("zoff: ");
  Serial.println(offZ);
  Serial.print("headng");
  Serial.println(headingDegrees);
  Serial.println("........ ");
```

```
      pt = millis();
    }
  }
}
Serial.println("enter xoffset");
offX = takeip().toInt();
Serial.println("enter yoffset");
offY = takeip().toInt();
Serial.println("enter Zoffset");
offZ = takeip().toInt();
//compass.setOffset(-6,290,-70);
compass.setOffset(offX, offY, offZ);
for (int k = 0; k < 10; k++) {
  Vector norm = compass.readNormalize();
  float heading = atan2(norm.YAxis, norm.XAxis);
  float declinationAngle = 0;
  heading += declinationAngle;
  // Correct for heading < 0deg and heading > 360deg
  if (heading < 0) {
    heading += 2 * PI;
  }

  if (heading > 2 * PI)
    { heading -= 2 * PI;
  }

  // Convert to degrees
  headingDegrees = heading * 180 / M_PI;



  Serial.println("heading");
  Serial.println(headingDegrees);
  delay(100);
}
Serial.println("enter calib Error");
caliberror = takeip().toInt();
```

```
for (int l = 0; l < 10; l++) {
  Vector norm = compass.readNormalize();
  float heading = atan2(norm.YAxis, norm.XAxis);
  float declinationAngle = 0;
  heading += declinationAngle;
  // Correct for heading < 0deg and heading > 360deg
  if (heading < 0) {
    heading += 2 * PI;
  }

  if (heading > 2 * PI)
    { heading -= 2 * PI;
  }

  // Convert to degrees
  headingDegrees = heading * 180 / M_PI;
  int z = headingDegrees;
  z = 360 - z;
  z = z - 360 + caliberror;
  if (z > 0) {
    if (z > 360 && z < 720)
      { z = z - 360;
    }
    if (z > 720 && z < 1080)
      { z = z - 720;
    }
    if (z > 1080 && z < 1440)
      { z = z - 1080;
    }
    if (z > 1440 && z < 1800)
      { z = z - 1440;
    }
    if (z > 1800 && z < 2160)
      { z = z - 1800;
    }
    if (z > 2160 && z < 2520) {
```

```
      z = z - 2160;
    }
  } else {
    if (z < -360 && z > -720)
      { z = z + 360;
    }
    if (z < -720 && z > -1080)
      { z = z + 720;
    }
    if (z < -1080 && z > -1440)
      { z = z + 1080;
    }
    if (z < -1440 && z > -1800)
      { z = z + 1440;
    }
    if (z < -1800 && z > -2160)
      { z = z + 1800;
    }
    if (z < -2160 && z > -2520)
      { z = z + 2160;
    }
    z = 360 + z;
  }



  headingDegrees = z;
  Serial.println("heading");
  Serial.println(headingDegrees);
  delay(100);
}
Serial.println("enter number of way points");
number_of_points = takeip().toInt();
Serial.println("number of waypoints entered");
Serial.println(number_of_points);
for (int l = 0; l < number_of_points; l++) {
```

```
    Serial.print("enter lat of ");
    Serial.print(l);
    Serial.print(" waypoint");
    Home_LATarray[l] = atof(takeipcordinate().c_str());
    Serial.println(Home_LATarray[0], 7);
    Serial.print("enter long of ");
    Serial.print(l);
    Serial.print(" waypoint");
    Home_LONarray[l] = atof(takeipcordinate().c_str());
    Serial.println(Home_LATarray[0], 7);
  }

  ac = 0;  // zero array counter
  //   Serial.print(Number_of_SATS);
  //   Serial.print(" Satellites Acquired");
}
void getGPS()  // Get Latest GPS coordinates
{

  while (serial2.available() > 0)
    gps.encode(serial2.read());
}
void gpsInfo()  // displays Satellite data to user
{
  Number_of_SATS = (int)(gps.satellites.value());
//Query Tiny GPS for the number of Satellites Acquired
  Distance_To_Home = TinyGPSPlus::distanceBetween(gps.location.lat(), gps.location.lng(),
Home_LATarray[ac], Home_LONarray[ac]);  //Query Tiny GPS for Distance to Destination

  //Serial.print("Distance to Home ");
  //  Serial.println(Distance_To_Home);
}
void Forward()
  { digitalWrite(HighL,
  HIGH); digitalWrite(LowL,
  LOW); digitalWrite(HighR,
```

```
HIGH);
```

```
  digitalWrite(LowR, LOW);
  // Serial.println("forward ");
}
void SlowRightTurn()
  { digitalWrite(HighL,
  LOW); digitalWrite(LowL,
  HIGH); digitalWrite(HighR,
  HIGH); digitalWrite(LowR,
  LOW);
  // Serial.println("Right");
}
void SlowLeftTurn() {

  digitalWrite(HighL, HIGH);
  digitalWrite(LowL, LOW);
  digitalWrite(HighR, LOW);
  digitalWrite(LowR, HIGH);
  // Serial.println("LEFT");
}
void stopboat()
  { digitalWrite(HighL,
  LOW); digitalWrite(LowL,
  LOW); digitalWrite(HighR,
  LOW); digitalWrite(LowR,
  LOW);
  //Serial.println("STOP ");
}
void backward()
  { digitalWrite(HighL,
  HIGH); digitalWrite(LowL,
  LOW); digitalWrite(HighR,
  LOW); digitalWrite(LowR,
  HIGH);
  // Serial.println("forward ");
}
```

```
long microsecondsToInches(long microseconds)
 { return microseconds / 74 / 2;
```

```
}

long microsecondsToCentimeters(long microseconds)
  { return microseconds / 29 / 2;
}
String    takeip()
  {  String  ip  =
  ""; while (true)
  {
    if (Serial.available() > 0)
      { ip = Serial.readString();
      break;
    }
  }
  return ip;
}

String takeipcordinate()
  { String ip = "";
  while (true) {
    if (Serial.available() > 0)
      { ip = Serial.readString();
      break;
    }
  }
  return ip;
}
 int us(){
     long duration;

  // Clear the trigPin
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);

  // Set the trigPin HIGH for 10 microseconds to send the pulse
  digitalWrite(trigPin, HIGH);
```

```
delayMicroseconds(10);
```

```
digitalWrite(trigPin, LOW);

// Read the echoPin, which returns the pulse width in microseconds duration =
pulseIn(echoPin, HIGH);

// Calculate the distance: speed of sound is 34300 cm/s int distance =
duration * 0.034 / 2;
return distance ;
}
```

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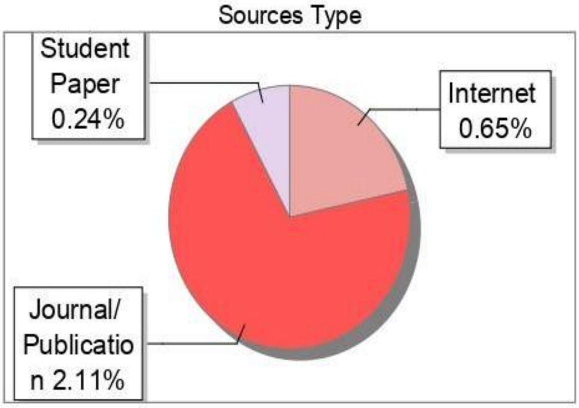

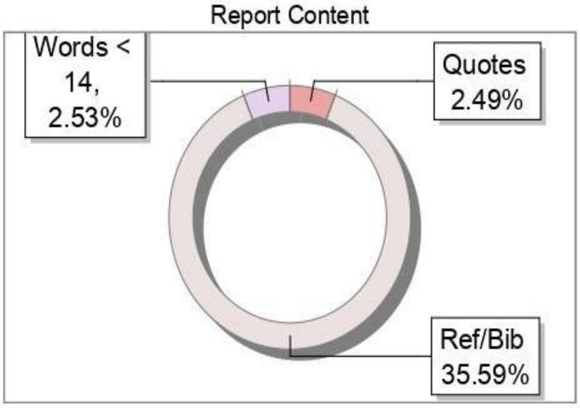

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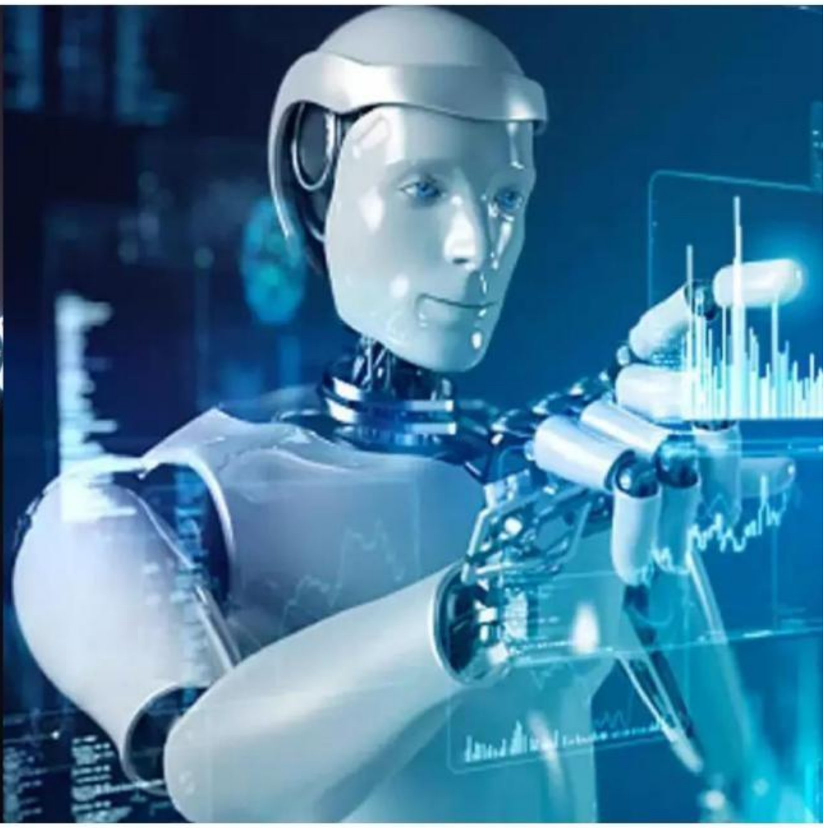

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Autonomous River Depth Plotting and Cleaning Robot

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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

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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

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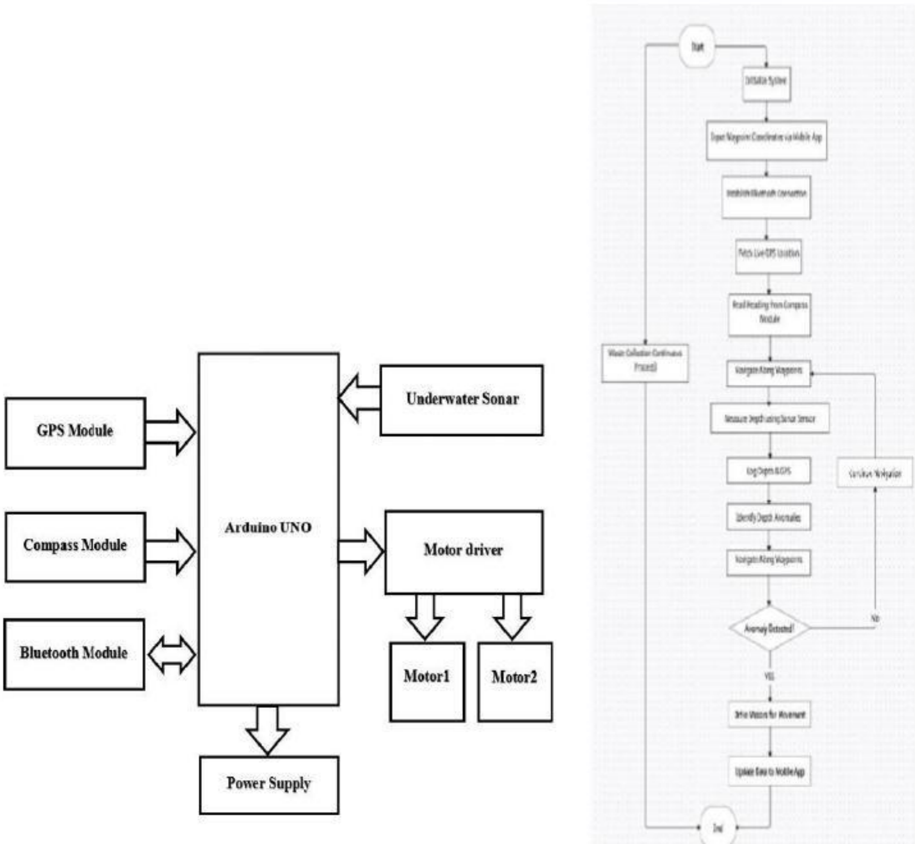
and directional motion. A servo motor maintains heading stability, while power for the entire system is supplied by a rechargeable lithium-polymer (Li-Po) battery pack, ensuring sufficient energy for extended autonomous operation.



(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.

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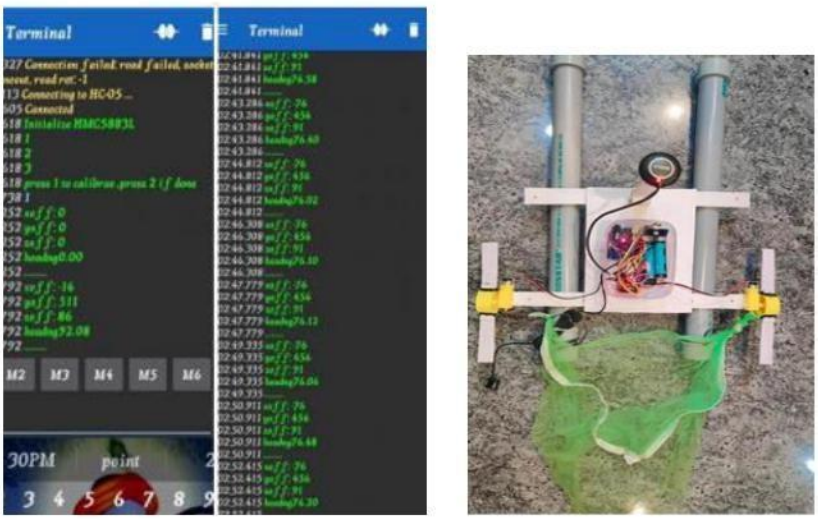
Figure (c) illustrates the active state of the Bluetooth module (HC-05) with successful pairing, enabling two-way communication with the mobile application. This confirms stable data transmission across various distances, essential for remote monitoring and control. Figures (d) and (e) further affirm 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.

(a) (b) (c)



(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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