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MARINE POLLUTION CONTROL SYSTEM AND EMERGENCY ALERT SYSTEM

[1] Raskar Rushikesh Arun, [2] Narawade Krushna Suresh, [3] Kolhe Yash Somnath,

[4]Rohokale Gaurav Rohidas, [5]Prof. Mr. Satpute A.S.

[1]Dept. Electronics and telecommunication Engineering, Samarth Polytechnic, Belhe, Pune, India.
[2] Dept. Electronics and telecommunication Engineering, Samarth Polytechnic, Belhe, Pune, India.
[3] Dept. Electronics and telecommunication Engineering, Samarth Polytechnic, Belhe, Pune, India.
[4]Dept. Electronics and telecommunication Engineering, Samarth Polytechnic, Belhe, Pune, India.
[5]Dept. Electronics and telecommunication Engineering, Samarth Polytechnic, Belhe, Pune, India.

Abstract: Marine pollution and navigational hazards pose critical threats to ecosystems and maritime safety, necessitating proactive and efficient solutions. This paper presents a Marine Pollution Control and Emergency Alert System designed to monitor environmental conditions, detect obstacles, and mitigate surface pollution in real time. The system employs advanced monitoring techniques and automated decision-making to enhance maritime safety and sustainability. Through remote connectivity and real-time data visualization, it enables users to assess environmental threats and take necessary actions efficiently. The scalable and adaptable design ensures flexibility for future enhancements, making it a cost-effective approach to addressing marine pollution and improving navigational security.

I. INTRODUCTION

Marine environments are increasingly threatened by pollution and hazardous obstacles, disrupting ecosystems, endangering marine life, and posing significant challenges to maritime operations. The accumulation of waste on the ocean's surface, along with floating debris and obstacles, necessitates innovative solutions that address these concerns efficiently. Traditional methods rely on manual interventions, which are time-consuming, resource-intensive, and reactive. The demand for automated, real-time systems for environmental threat detection and response is increasing.

This paper introduces a novel Marine Pollution Control and Emergency Alert System, integrating advanced sensing, communication, and decision-making technologies. The system employs an ultrasonic sensor for detecting obstacles such as icebergs and other floating debris, ensuring safe navigation. It features an ESP32-based control unit that processes sensor inputs, communicates with users via Wi-Fi, and provides real-time monitoring through an integrated camera module. The system incorporates an automated garbage collection mechanism, using gear motors to retrieve floating waste. A DHT11 sensor monitors environmental parameters such as temperature and humidity, while an IR sensor detects garbage tank levels, pausing collection when full. GPS tracking enables precise location monitoring, ensuring situational awareness and efficient operational management. The system's web-based interface allows users to control operations remotely, visualize real-time sensor data, and receive emergency alerts. The incorporation of solar panels and an external charging module ensures continuous operation, making it a sustainable and energy-efficient solution. The adaptable design allows future upgrades to integrate additional features or respond to evolving maritime challenges.

By combining environmental monitoring, obstacle detection, and automated alerting within a unified platform, this system provides a scalable, cost-effective approach to addressing marine pollution and enhancing maritime safety. The subsequent sections will detail the system's architecture, component integration, and performance analysis in simulated and real-world conditions.

II. DESCRIPTION OF THE BLOCK DIAGRAM

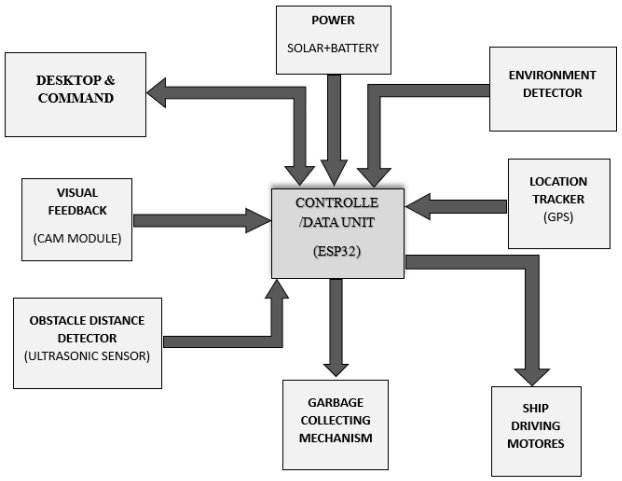


Fig: Block Diagram

Description:

The block diagram illustrates the system architecture of the Marine Pollution Control System And Emergency Alert System, highlighting the interaction between various functional modules. This modular design facilitates effective integration of sensor data, real-time monitoring, and user control for efficient marine waste management.

Components and Functional Blocks:

1. Power Source:
   - The system is powered by a combination of solar panels and rechargeable batteries, ensuring a sustainable and uninterrupted power supply for marine operations.
2. Control Unit (ESP32):
   - At the core of the system is the ESP32 microcontroller, which acts as the central processing unit. It coordinates data collection, processing, and communication between modules.
3. Location Tracker (GPS):
   - A GPS module is integrated to provide real-time location tracking of the system, enabling users to monitor its precise position in marine environments.
4. Obstacle Distance Detector (Ultrasonic Sensor):
   - This module uses an ultrasonic sensor to detect obstacles in the system's path, ensuring safe navigation and collision avoidance.
5. Garbage Collecting Mechanism:
   - A dedicated garbage collection mechanism is designed to collect marine debris. The mechanism halts automatically when the garbage tank is full, as detected by an IR sensor.
6. Ship Driving Motors:
   - The system is equipped with driving motors to facilitate autonomous movement and navigation across the water surface. These motors can also be controlled remotely by the user.

7. Environment Detector:
   - The environment detector, comprising sensors like DHT11, monitors environmental parameters such as temperature and humidity to assess marine conditions.
8. Visual Feedback (CAM Module):
   - A camera module (ESP32-CAM) provides a live video feed, enabling the user to visually assess the system's surroundings and make decisions in real-time.
9. Desktop & Command Interface:
   - A web-based desktop interface allows the user to:
     - Visualize real-time sensor data and GPS location.
     - Control the system remotely, including garbage collection and navigation.

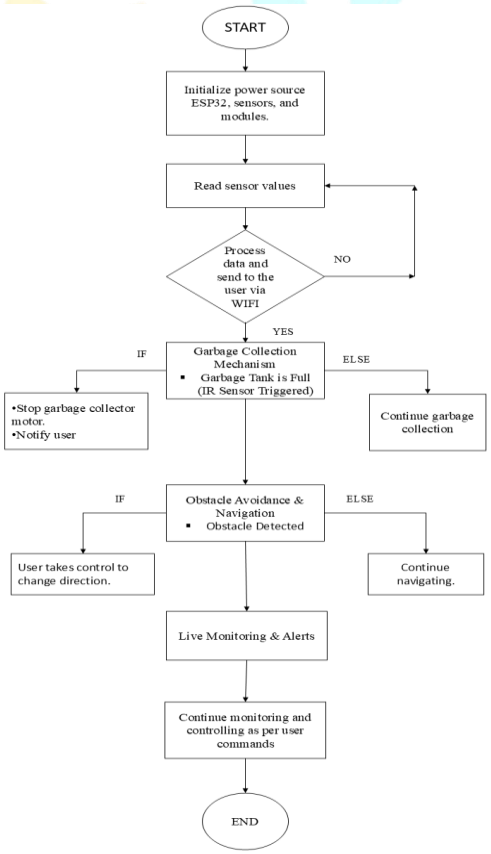
System Workflow:

- The ESP32 microcontroller collects data from all sensors and modules, processes it, and transmits it to the desktop interface via Wi-Fi.
- The user can analyse live data and video feedback to make decisions about navigation and garbage collection.
- The system operates autonomously for garbage collection and obstacle avoidance but allows manual intervention when necessary.

Key Features:

- Sustainability: The hybrid power source (solar + battery) supports eco-friendly and continuous operations.
- Automation and Control: Combines autonomous operations with user control for flexibility in marine environments.
- Real-Time Feedback: Provides live updates via sensor data and video feed, ensuring informed decision-making.
- Safety and Efficiency: Integrated obstacle detection and environmental monitoring enhance operational safety and effectiveness.

III. DESCRIPTION OF FLOWCHART:



DESCRIPTION OF FLOWCHART:

- Start:
  - The system initializes by activating the ESP32 microcontroller, sensors, and modules.
  - It verifies the power source, which could be one of the following: battery, solar, or external charging module.
- Data Acquisition:
  - Once initialized, the system reads environmental and operational data from the connected sensors:
    - DHT11: Measures temperature and humidity to assess environmental conditions.
    - GPS Module: Tracks the precise location of the system.
    - Ultrasonic Sensor: Detects nearby obstacles and measures distance to prevent collisions.
    - IR Sensor: Monitors the garbage tank's fill level to determine whether it is full.
- User Decision-Making:
  - The acquired data is processed and sent to the user via a Wi-Fi-enabled interface.
  - A live video feed from the ESP32-CAM module is displayed to assist the user in making decisions based on real-time environmental conditions and obstacle detection.
  - If necessary, the user can intervene to adjust the system's operations.

- Garbage Collection Mechanism:
  - The system checks the garbage tank status:
    - If the IR Sensor detects that the tank is full:
      - The garbage collector motor stops to prevent overflow.
      - The system sends a notification to the user for further action.
    - If the tank is not full, garbage collection continues uninterrupted.
- Obstacle Avoidance and Navigation:
  - The Ultrasonic Sensor continuously monitors for obstacles:
    - If an obstacle is detected, the user is notified and can manually control the system to avoid the obstacle.
    - If no obstacle is detected, the system continues navigating autonomously.
- Live Monitoring and Alerts:
  - The system provides real-time updates via a web interface, including:
    - Visualizations of sensor data (e.g., environmental parameters).
    - Real-time GPS tracking for location awareness.
    - Remote control capabilities, allowing the user to manage navigation and garbage collection tasks via Wi-Fi.
- End/Repeat:
  - The system continues to monitor and operate as per the user's commands until it is stopped.
  - This ensures continuous operation in dynamic marine environments.

Key Features of the System:

- Automation: The flowchart emphasizes a highly automated garbage collection and navigation process, reducing the need for constant user intervention.
- Real-Time Monitoring: Incorporates live video and sensor data visualization for effective remote management.
- Environmental Awareness: Integrates multiple sensors (DHT11, IR, Ultrasonic) to monitor marine conditions and ensure safe and efficient operation.
- User Control: Provides decision points where the user can intervene, making the system adaptable to various scenarios.

IV. DESCRIPTION OF CIRCUIT DIAGRAM

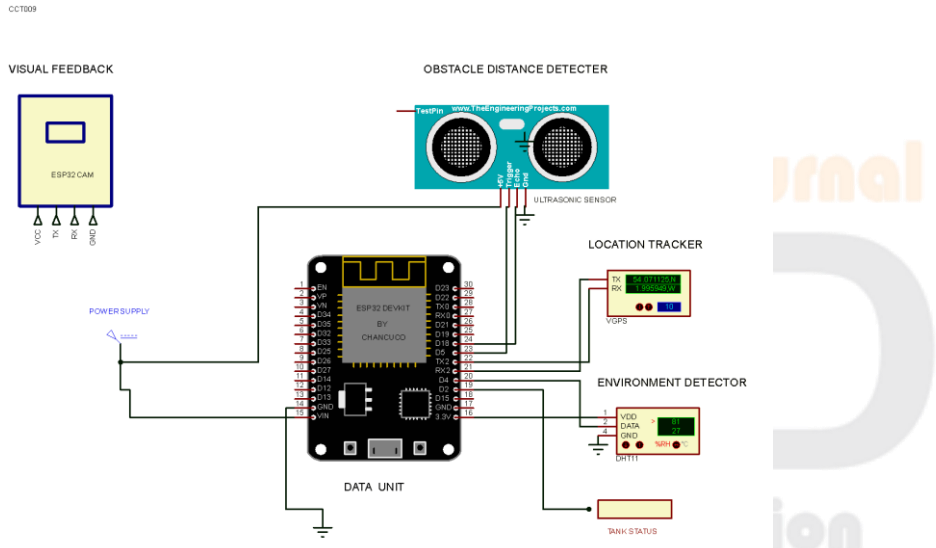


Fig: Circuit Diagram DATA UNIT

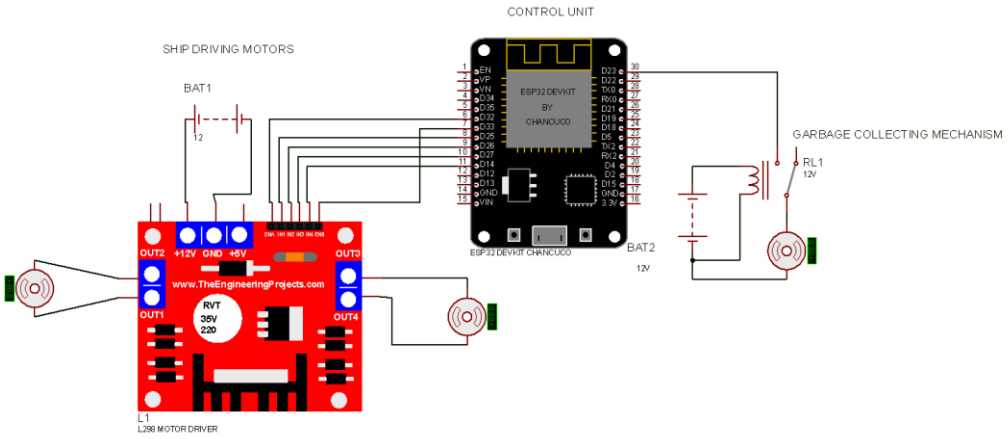


Fig: Circuit Diagram CONTROL UNIT

DESCRIPTION OF CIRCUIT DIAGRAM

1. Data Unit (Sensor & Data Monitoring System)

- **ESP32 (Data Unit Controller):**
  - Handles all sensor data processing and communication with the Control Unit.
  - Collects and transmits data via Wi-Fi or another communication protocol.
- **ESP32-CAM (Visual Feedback):**
  - Provides real-time visual monitoring.
  - Captures images or video to detect pollution levels.
- **Ultrasonic Sensor (Obstacle Distance Detector):**
  - Detects obstacles in the ship's path and measures distances.
  - Helps avoid collisions by sending alerts to the Control Unit.
- **GPS Module (Location Tracker):**
  - Provides real-time GPS coordinates.
  - Logs the location of detected pollution or obstacles.
- **DHT Sensor (Environment Detector):**
  - Measures **temperature and humidity** to assess environmental conditions.
- **IR Sensor (Garbage Tank Status Monitoring):**
  - Detects whether the garbage tank is full or empty.
  - Sends a signal to the ESP32 when the garbage tank reaches its maximum capacity.
  - Helps in scheduling garbage disposal efficiently.
- **Power Supply:**
  - Powers the ESP32 and all connected sensors.

2. Control Unit (Motor Control & Garbage Collection)

The **Control Unit** is responsible for moving the system and operating the garbage collection mechanism:

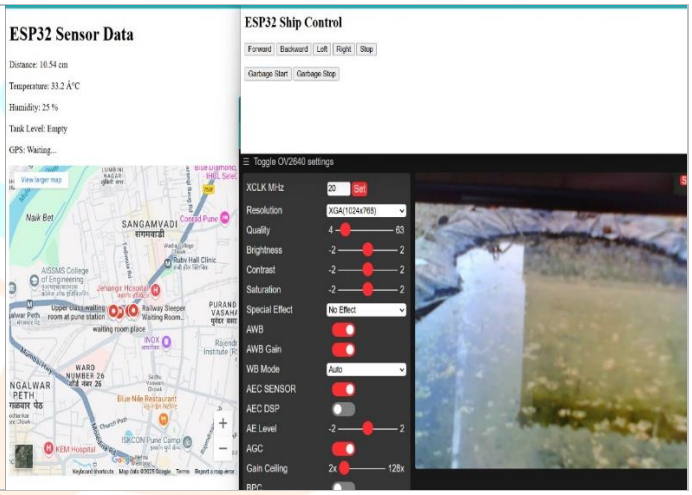
- **ESP32 (Control Unit Controller):**
  - Controls the motors for ship movement.
  - Receives sensor data from the Data Unit and takes necessary actions.
- **Motor Driver (L298N):**
  - Drives the ship's motors.
  - Adjusts speed and direction for navigation.
- **Relay Module (Garbage Collecting Mechanism):**
  - Activates the garbage collection system when pollution is detected.
  - Works in coordination with the Data Unit.
- **Power Supply (12V Batteries BAT1 & BAT2):**
  - Provides power to the motors, relay module, and control unit.

System Working:

1. The IR Sensor continuously monitors the garbage tank status and sends updates to the Data Unit.
2. If the garbage tank is full, the system logs an alert and notifies the operator for disposal.
3. The Data Unit transmits this information to the Control Unit.
4. The Control Unit can pause further garbage collection until the tank is emptied.
5. Meanwhile, other sensors continue monitoring environmental conditions and obstacles.
6. The ship navigates automatically while collecting garbage and avoiding obstacles.
7. In case of an emergency, the ESP32-CAM and GPS send location and image feedback to the operator.

V. SYSTEM TESTING AND VALIDATION

ACTUAL MODEUL



DESKSTOP AND CONTROL

TESTING VIDEO SCANNER

VI. ACKNOWLEDGMENT:

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BIOGRAPHIES:

Mr. Raskar Rushikesh Arun
student of Dept. Electronics and Telecommunication Engineering, Samarth Polytechnic, Belhe

Mr. Narawade Krushna Suresh
student of Dept. Electronics and Telecommunication Engineering, Samarth Polytechnic, Belhe

Mr. Kolhe Yash Somnath
student of Dept. Electronics and Telecommunication Engineering, Samarth Polytechnic, Belhe

Mr. Rohokale Gaurav Rohidas
student of Dept. Electronics and Telecommunication Engineering, Samarth Polytechnic, Belhe

Prof. Mr. Satpute A.S.
(ME in Embedded system and VLSI)
HOD OF Dept. Electronics and Telecommunication Engineering, Samarth Polytechnic, Belhe