DEVELOPMENT AND CALIBRATION OF A PORTABLE SENSOR FOR MICRO PLASTIC DETECTION USING MACHINE LEARNING ALGORITHM

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ABSTARCT

Water pollution caused by micro plasticsand floating debris has become a serious environmental concern, requiring intelligent monitoring and detection systems for effective management. This project presents a smart water monitoring and micro plastic detection system using convolutional neural network, ESP32, sensors, and Internet of things technology. The system is designed withtwoseparatetankstosimulatereal-time water conditions and analysis. In Tank-1, convolutional neural network is utilized for image processing to detect micro plasticsand micro wood particles present on the water surface. Images captured using an ESP32-CAM module are processed to identify and analyze floating pollutants with improved accuracy. The project aims to utilize fine filtration methods for the effectiveremovalofmicroplastics.Tank-2 is dedicated to water quality monitoring, where an ultrasonic sensor continuously measures the water level distance to ensure safe and controlled operation. A pH sensoris employed to monitor the acidity or alkalinity of the water, providing crucial information about water quality variations.A water motor facilitates the controlled transfer and spraying of water from Tank-1 to Tank-2, enabling integrated analysis between pollutant detection and water quality assessment.

The ESP32 microcontroller acts as the central processing unit, managing sensor data acquisition, processing convolutional neural network generated detection outputs, and coordinating system operations. To enhance system responsiveness and accessibility, Internetofthingstechnologyis implementedtotransmitreal-timedataand

alert notifications wirelessly to authorized personnel. This enables timely decision-making and rapid response to pollution detection events. Overall, the proposed system offers a cost-effective, automated, and scalable solution for micro plastic detection and water quality monitoring, contributing to improved environmental safety and sustainable water resource management.

KEYWORDS:MicroplasticDetection, Convolutional Neural Network (CNN) Algorithm, Ultrasonic Sensor, Motor Driver, Water Motor.

INTRODUCTION

Water pollution caused by micro plastics is a major environmental challenge affecting rivers, lakes, and coastal regions. Large amounts of micro plasticwasterangingfromtiny plastic fragments to floating debris pose severe risks to aquatic life and human health. To address this issue, our Automated Micro plastic Detection and Collection Boat System is designed to identify, collect, and manage micro plastic wasteinwaterbodiesusingadvanced sensing, processing, and Internet of Thingstechnologies.Thesystem uses convolutional neural network-based image processing to detect microplasticparticlesfromcaptured images, enabling precise identificationbefore collection. Once detected, a servo-based mechanical lifting mechanism collects and deposits micro plastic into anonboard waste bin. A gear motor systemcontrols the boat's directional movement, while a motor driver regulates speed for stable navigation. An ultrasonic sensor continuously monitors the plastic fill level inside the garbage bin to avoid overflow. Internet of Things technologyenableswirelesscommunicationwith authorities, notifying them when the bin is full or when critical environmental updates are detected. The ESP32 controller serves as the central processing unit, integratingall sensors, motors and communication modules, and transmitting real-time data to a cloud platform. This technology-driven approach ensures continuous monitoring, systematic waste collection, and fast-response alerts. Unlike traditional manual waste collectionmethods,whicharelaborintensive and slow, our system provides an automated and environmentallysustainablesolution. The boat acts as a smart robotic unit, capable of navigating water surfaces autonomously and efficiently removing micro plastic pollutants.By combining image processing, embedded systems, and Internet of Things, this project helps reduce water pollution and supports long-term ecological conservation.

RELATED WORKS

In recent years, the integration of image processing, Internet of Things (Internet of things), and embedded systems has gained significant attention for water quality monitoring and environmental protection applications. Several studies have focusedondetectingwatercontaminants, monitoring physical and chemical parameters, and enabling real-time decision-making through smart sensing platforms.

Image-based detectiontechniques have been widely explored for identifying pollutants present on water surfaces. Researchers have utilized convolutional neural network for image processing due to its powerful toolboxesforfeatureextraction, segmentation, and pattern recognition. Prior works demonstrate the effectiveness of convolutional neural network based algorithms in detecting floating impurities such as plastics, debris, and organic matterin controlled water bodies. The use of camera modules combined with image processing has proven to be a cost-effective and accurate method for visual monitoringof water contamination.

Embedded vision systems using low-power microcontrollers havealso been investigated for real-time monitoring. The ESP32-CAM module has been employed in multiple studies for on-site image capture and wireless transmission due to its compactsize, integrated camera, and Wi-Fi capability. Existing systems highlight the ability of ESP32-CAM to support real-time visual data acquisition and preliminary processing,makingitsuitableforcontinuous environmental surveillance applications.

Water level monitoring and chemical analysis are essential components of intelligent water management systems. Ultrasonic sensors are commonly used in related works to measure water level distance accurately and non-invasively. Similarly, pH sensors have been extensively adoptedtoassesswateracidityoralkalinity, serving as a key indicator of water quality. Previous research confirms that combining physicalparameterssuch aswater levelwith chemical parameters like pH enhances the reliability of water quality assessment.

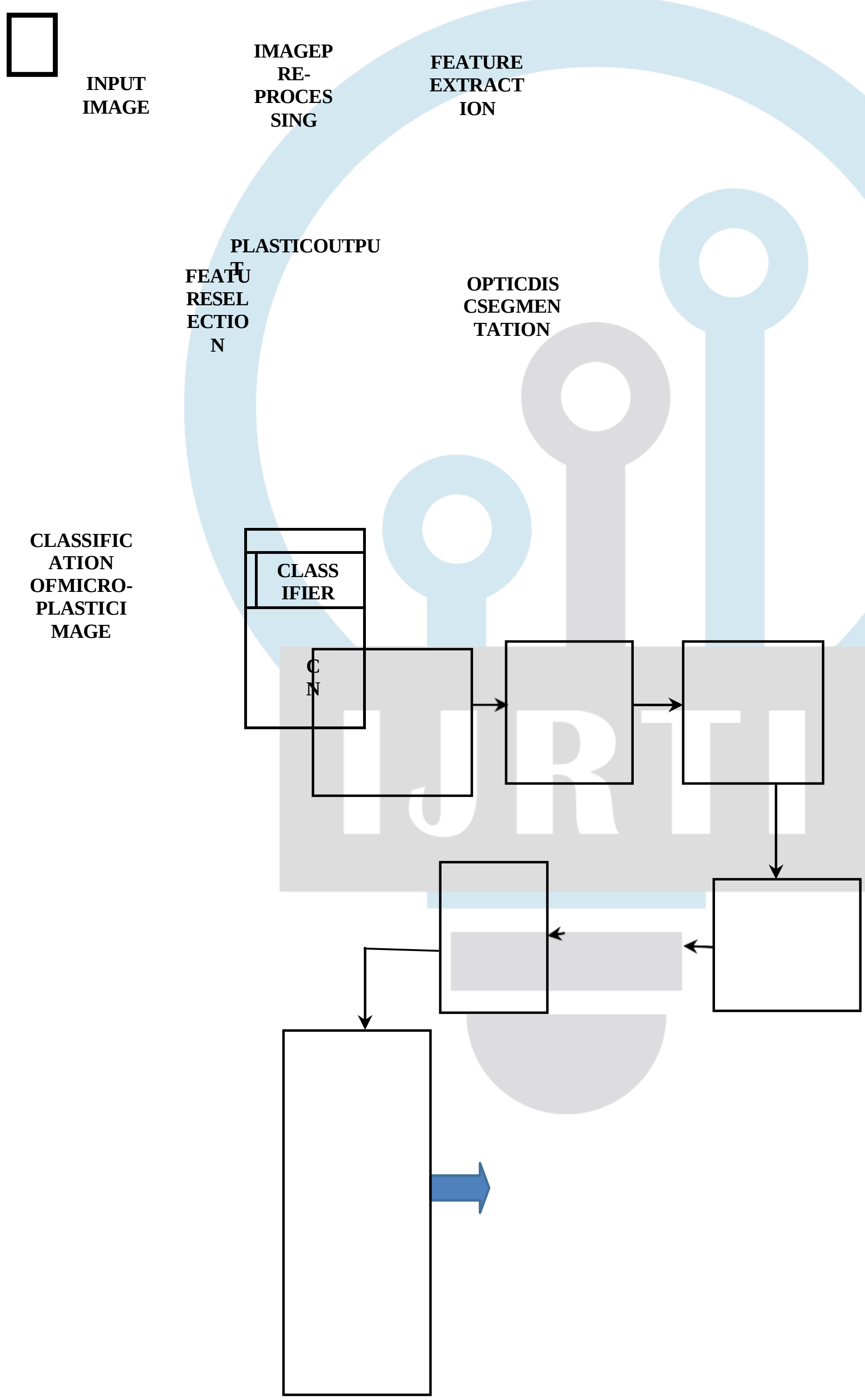
System integration using microcontrollers such as ESP32 has been a major focus in recent Internet of things-based monitoring solutions. Researchers have demonstrated successful integration of multiple sensors and external processing platforms, enabling centralized control of actuators such aswater pumps and motors. Automated water transferandsprayingmechanismscontrolled by sensor feedback have been reported to improve operational efficiency and reduce humanintervention.Furthermore,Internetof things-based communication frameworks play a crucial role in remote monitoring and alert systems. Related studies emphasize the use of wireless data transmission to cloud platforms or authorized personnel for real-time notifications and decision support. Internet of things-enabled monitoring systems provide scalability, continuous access to data, and timely response to abnormal conditions, making them highly effective for smart water management applications.

Overall, existing literature supports the feasibility of combining image processing, sensor-based monitoring, embedded control, andInternetofthingscommunication.These related works form the foundation for developing an integrated system that detects surface pollutants, monitors water quality parameters, controls water flow operations, and provides real-time notifications for effective environmental monitoring.

PROPOSEDMETHODOLOGY

The proposed system introduces an automated, intelligent boat-based micro plastic collection mechanism designed to enhance the efficiency of water surface cleaning operations.The system integrates multiple electromechanical components and smart technologies to ensure accurate detection, efficient collection, and real-time monitoring of micro plastic waste. A **gear motor** is employed to drive the boat in the requireddirection, enabling smooth navigation across water bodies. The movement and speed of the gear motor are precisely controlled using a motor driver, ensuring stable motion even in varying water conditions. To facilitate thecollectionprocess,aservomotor is used to operate a lifting mechanism that picks up micro plastic waste and drops it into the onboard garbage bin. To prevent overflow, an **ultrasonic sensor** is installed inside the bin to continuously measure the waste level andprovidetimelyalertswhenthebin nears full capacity. For accurate identification of micro plastics, convolutional neural network is utilized to perform image processing and color-based conversion of micro plastic images captured during operation. This enhances the system's detectionaccuracyand supports better classification of collected particles. The entire system is controlled by an **ESP32 microcontroller**, which processes sensor inputs, coordinates actuator functions, and ensures seamless integration between hardware components. The ESP32 also enables **Internet of things connectivity**, allowing collected data and alert notifications to be transmitted wirelessly to authorized personnel through a cloud platform. This real-time notification system ensures timely waste disposal, continuous monitoring, and efficient operationalmanagement.Overall,the proposed system provides a smart, automated, and scalable solution for micro plastic collection in aquatic environments.

BLOCKDIAGRAM

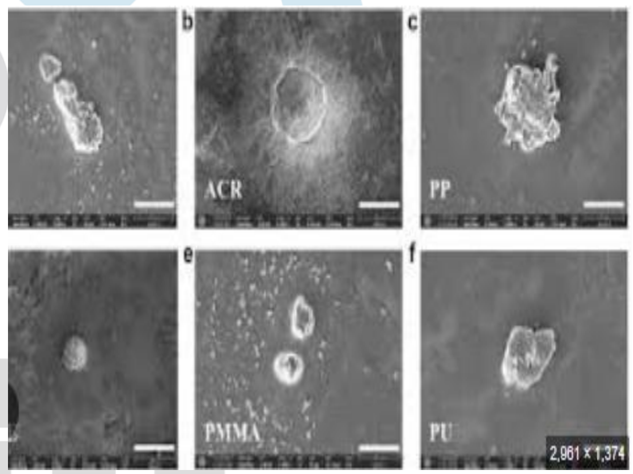


RESULT

The proposed system was successfully implemented and tested under controlled conditions to evaluate its performance in detecting surface pollutants, monitoring water quality parameters, and enabling automated water transfer with real-time communication. The experimental results demonstrate the effectiveness of integrating image processing, sensor-based monitoring, embedded control, and Internet of things technology.

Convolutional neural network-based image processingaccuratelyidentifiedthepresence of micro plastics and micro wood particles on the water surface in Tank-1. Images captured using the ESP32-CAM were transmitted and processed in real time, allowingclear visualdifferentiationbetween floating contaminants and clean water regions. The system achieved reliable detection performance under varyinglighting conditions, confirming thesuitability of convolutional neural network algorithms for real-time environmental monitoring applications.

The ultrasonic sensor installed in Tank-2 continuously measured the water level distancewithstableandconsistentreadings. The recorded data enabled precise monitoring of water availability, preventing overflow and dry-run conditions. Simultaneously, the pH sensor effectively measured the acidity or alkalinity of the water, providing real-time insights intowater qualitystatus.The pH values obtained during testing were within expected ranges, validating the accuracy and responsiveness of the sensing unit.



CONCLUSION

This project successfully demonstrates an integrated smart water monitoring and management system by combining image processing, embedded control, and Internet ofthings technologies. Convolutional neural network-based image processing plays avital role in identifying micro plastics and micro wood particles present on the water surface in Tank-1, while the ESP32-CAM enables real-time visual data acquisition and analysis. This approach provides aneffective method for early detection of surface-level pollutants and supports informed decision-making.

The system also incorporates ultrasonic and pH sensors to continuously monitor water level distance and chemical characteristicsin Tank-2. The ultrasonic sensor ensures accurate and non-contact measurement of water levels, while the pH sensor provides essential information on water acidity or alkalinity, offering a reliable assessment of overall water quality. Together, these sensing components enhance the accuracy and completeness ofthe monitoring process.

An ESP32 controller serves as the central processing unit, integrating sensor readings and convolutional neural network outputs to automate system operations. Based on the analyzed data, the controller efficiently manages the water motor to spray and transferwaterbetweentanks,reducingthe need for manual intervention and improving operational efficiency. This closed-loop control mechanism ensures timely and precise system responses under varying conditions.

FUTURESCOPE

The proposed system can be further enhanced by incorporating advanced image processing and machine learning techniques to improve the accuracy of microplastic and micro-wood detection on the water surface. Deep learning modelssuchasConvolutional Neural Networks (CNNs) can be integrated with convolutional neural network or edge-based frameworks to enable automatic classification and quantification of different types of surface pollutants under varying lighting and environmental conditions.

In future developments, additional water quality parameters such as turbidity, dissolved oxygen, conductivity, and temperature sensors can be integrated to provide a more comprehensive assessmentof water health. This multi-parameter monitoring approach would enhance decision-making for water treatment and environmental conservation applications.

The system can also be expanded by implementing edge computing directly on the ESP32ormore powerfuledge devices to reduce dependency on external processing and minimize latency. Optimizing real-time data processing at the edge will improve system responsiveness and reliability, especially in remote or large-scale deployments.

Further improvements may include the automation of pollutant removal mechanisms,suchassmartfiltrationor

skimming systems, controlled based onreal- time image analysis and sensor feedback. This would transform the system from a monitoring solution into a fully autonomous water purification and managementplatform.

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