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Smart Autonomous Surface Vehicle for Water Quality Analysis

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KEYWORDS

Embedded C, Arduino IDE, NodeMCU, Water Quality monitoring, Internet of Things, Surface Vehicle

ABSTRACT

The Smart Autonomous Surface Vehicle for Water Quality Analysis is to assesswaterqualitythroughtheuseofasurfacevehicle.Waterpollutionreferstothecontamination ofwaterbodiesbyharmfulsubstancesthatmakethewaterunsuitablefordrinking,cooking,cleaning, swimming,andvariousotherpurposes.Pollutantsincludechemicals,waste,bacteria,andparasites. Traditional monitoring methods entail manually collecting water samples from various water resources,followedbytestingandanalysis inthelaboratory.Thisprocedureisfrequentlyineffective because it is time-consuming and does not produce results in real time. Water quality should be continuously monitored to ensure a safe supplyof water to end users from any water resources or waterbodies.Designing and creating acost-effective systemforreal-time monitoring ofwaterquality utilisingtheInternetofThingsisnowrequired.Awatervehicleisemployedheretohousethewater quality monitoring system. The vehicle is self-contained for measuring water quality. Using IoT devicesandaWi-Fimodule,theproposedsystemaidsinthecontinuousmonitoringofwaterquality. The Wi-Fi module enables internet connectivity and sends sensor data to the Cloud. Turbidity, temperatureandgassensorsareusedtomeasurevariousfactorstoassessthewaterqualityofwater resources.

1. INTRODUCTION

Water quality monitoring is crucial for ensuring environmental sustainability, safeguarding public health, and conserving aquatic ecosystems. The rising rates of water pollution from industrial effluent discharge, agricultural runoff, and urbanization are major threats to water resources. Conventional water quality monitoring techniques involve manual sampling and laboratory analysis, which are time-consuming and unable to deliver real-time information. These shortcomings make it imperative to create sophisticated, automated systems for effective and continuous monitoring.

The Smart Autonomous Surface Vehicle (SASV) for Water Quality Analysis is a new technology that combines autonomous vehicle navigation, Internet of Things (IoT), and high-sensitivity sensors for real-time observation of water bodies. The system is programmed to detect important parameters like pH, temperature, dissolved oxygen, turbidity, and levels of contaminants without any external intervention. By facilitating automatic, real-time water quality measurement, the SASV eliminates the shortcomings of the old methods and gives a better water quality evaluation solution.

The SASV has the ability to move through varied water environments of lakes, rivers, reservoirs, and marine coasts. Autonomous capability permits its use in remote and hard-to-reach locations, providing thorough water quality testing. In addition, the use of artificial intelligence (AI) and machine learning (ML) provides greater flexibility to the system to adapt with mixed environmental situations, enhancing the accuracy and reliability of data as time progresses.

Water pollution is increasingly a global issue, and innovative and scalable solutions are urgently needed. The SASV is an evolutionary leap in automated water quality analysis, providing a more cost-effective and intelligent solution compared to conventional methods. This study investigates the development, application, and potential uses of the SASV with the aim of enhancing water resource management, contamination detection, and environmental sustainability. Through real-time monitoring, on-site detection of contamination, and decision-making based on data, the SASV is a key component in the protection of water bodies and safe water supply for different uses.

II. LITERATURE REVIEW

A real-time water quality monitoring system based on IoT was established through a range of sensors, such as pH, turbidity, dissolved oxygen, and temperature sensors. The system runs in real time, collecting data continuously and uploading it to a cloud platform for storage and processing. Utilizing cloud computing, the method allows for remote monitoring and real-time notifications, making it possible for authorities to identify water contamination at an early stage. This technology is especially useful for managing water resources in urban and rural areas to provide safe and clean drinking water.[1]

A low-cost and effective IoT water quality monitoring system was established with the integration of microcontrollers and wireless communication units like GSM or Wi-Fi. The system monitors major water quality parameters in real time and enables remote access through a mobile application. The technology is very useful for smart water management applications such as agriculture, industrial wastewater management, and municipal water supply systems. The study focuses on the accessibility and affordability of this system and how it could be a viable option for locations with minimal infrastructure.[2]

An IoT system in the cloud was established to integrate machine learning-based anomaly detection algorithms in water quality data. The system continuously monitors multiple environmental factors and uses AI-based methods for forecasting contamination patterns. A web-based dashboard is also provided for visualizing the data, permitting users to investigate long-term variations in water quality. The paper discusses the significance of predictive analytics for improving water management practices so that proactive actions against possible pollution events can be ensured.[3]

III. EXISTING SYSTEM

Water quality testing is traditionally done with conventional techniques that involve laboratory, field, and Internet of Things (IoT) node applications. While laboratory testing is more accurate, it is criticized to be time and money consuming. The process involves multiple steps including sample collection, transportation to labs, testing, and statistical computations. This multi-step methodology can lead to substantial delays in receiving results, which is highly undesirable in crisis situations where an immediate response needs to be initiated to treat water contamination issues.

Field testing provides a quicker option but is still not without great difficulties. It is time-consuming and usually involves the use of trained personnel to take samples, which can be costly as well. Field testing also usually yields localized information that may not represent the overall water quality of large bodies of water. This is a limitation that becomes especially clear with the use of IoT nodes, which, though they can do real-time monitoring, are point data only. These data can be inadequate to make thorough assessments of large water bodies since they can miss fluctuations in water quality at different sites.

Moreover, deploying sensors in challenging terrain can be challenging, and health hazards from waterborne bacteria create additional challenges for sample collectors. Such current methods show the necessity for an efficient and effective means of water quality measurement that can be solved by creating superior technologies like the Smart Autonomous Surface Vehicle (SASV). The SASV is designed to combine multiple sensors and autonomous navigation functions to enable continuous, real-time monitoring of water quality over extensive regions, thus eliminating the drawbacks of conventional methods.

IV. PROPOSED SYSTEM

Keeping in view the drawbacks and limitations of the above techniques, this research combines IoT sensors with an unmanned surface vehicle (USV) designed and developed to monitor and classify the water quality of an entire water body in real time.Under this scenario, individual sensors measure temperature, turbidity, and water pollution levels. These values from the sensors can be remotely accessed from the Thing Speak website.

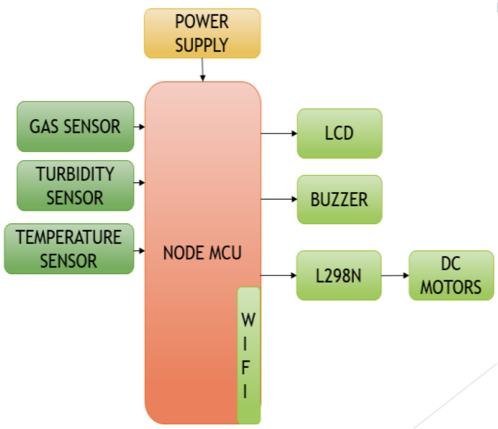

Fig. 1: Block Diagramof Smart Autonomous Surface Vehicle for Water Quality Analysis

A.NODEMCU (ESP-8266 12E) Wi-Fi Module

The NodeMCU (ESP-8266 12E) is a Wi-Fi module that is suitable for IoT applications. It has an onboard ESP8266 chip, which is a cost-effective solution for connecting devices to the internet. The module is compatible with the Lua script interpreter, making it convenient to program and prototype quickly. With its GPIO pins, NodeMCU can be connected to different sensors and actuators, making it suitable for applications like home automation and environmental monitoring. Its small size and integrated Wi-Fi features allow for easy communication and data exchange, making it easy to develop smart applications in many areas.

B. LCD (Liquid Cristal Display)

A liquid crystal display or LCD borrows its definition from its own name. It is a blend of two forms of matter, the liquid and the solid. LCD employs a liquid crystal in order to display a visible image. Liquid crystal displays are very thin technology display screen that are commonly applied to laptop computer screen, television sets, cell phones and handheld video games. LCD's technology enables screens to be very slim compared to the cathode ray tube technology. Liquid crystal display consists of various layers including two polarized panel filters and electrodes.

C. DC MOTOR

A DC motor is an electromechanical device used to transform direct current electrical energy into mechanical energy. It works on the principle of electromagnetism, where a magnetic field is produced by an electric current-carrying conductor that interacts with an external magnetic field and results in rotational motion. DC motors are extensively applied in most modern applications such as robotics, automotive systems, and domestic appliances because of their ease of control and simplicity. They are either battery- or power supply-powered and provide adjustable torque and speed through variable voltage or current. Their compact design and reliability make them a popular choice for both industrial and consumer products.

D. MQ2 GAS SENSOR

MQ2 gas sensor is a type of electronic sensor used for detecting the concentration of gases in air like LPG, propane, methane, hydrogen, alcohol, smoke and carbon monoxide. MQ2 gas sensor is also referred to as Chemiresistor. It has a sensing material whose resistance changes when exposed to the gas. The change in the resistance value is utilized for the detection of gas.

E. DS18B20 TEMPERATURE SENSOR

The DS18B20 is a digital temperature sensor that finds broad application across many applications owing to its precision and the convenience of integration. The sensor works on a 1-Wire communication protocol, which enables multiple sensors to be addressed by a single data line, easy wiring, and low cost. The range of the sensor is -55°C to +125°C with an accuracy of ±0.5°C, suitable for both indoor and outdoor conditions. Its small size and waterproof capabilities also make it perfectly suited for HVAC system applications, weather stations, and water monitoring. The DS18B20 is preferred because of its durability and ease of interfacing with microcontrollers.

F. L298N MOTOR DRIVER MODULE

The L298N Motor Driver module consists of an L298 Motor Driver IC, 78M05 Voltage Regulator, resistors, capacitor, Power LED, 5V jumper in an integrated circuit. This L298N Motor Driver Module is a high-power motor driver module for the driving of DC and Stepper Motors. This module contains an L298 motor driver IC and a 78M05 5V regulator. L298N Module is able to control a maximum of 4 DC motors, or 2 DC motors with direction and speed control.

G. TURBIDITY SENSOR

A turbidity sensor is a key instrument that measures water clarity through detection of suspended sediments and particles. It works on the principle of transmitting infrared light through a water sample, detecting how much of this light gets scattered by suspended particles. The turbidity sensor delivers real-time measurements of turbidity levels, an important aspect for determining water quality in diverse applications such as environmental monitoring, wastewater treatment, and aquaculture. By measuring total suspended solids (TSS) accurately, turbidity sensors ensure safe water conditions and effective management of water resources and ecosystems.

H. BUZZER

The electric buzzer was developed by Joseph Henry in 1831. A buzzer is an electronic signaling device that generates sound upon activation. Widely applied in alarms, notifications, and alerts, it functions on multiple voltage levels and may be active or passive. Buzzers are key elements in electronic projects, delivering audible feedback and facilitating user interaction in devices.

V. RESULTS

This project aims to continuously monitor water quality using IoT devices like NodeMCU ESP8266.Sensors such as temperature, turbidity, and gas sensors are used to identify real-time water conditions and transfer data to the microcontroller. The system is composed of two stations: the Monitoring Station and the Control Station. The Monitoring Station combines sensors and a battery, gathering data and sending it to the Control Station through IoT. The Control Station, which is loaded with NodeMCU, an LCD screen, and a buzzer, calculates the received data and shows real-time readings. When pollutant levels are higher than safe limits, the buzzer sends out an alert, facilitating timely intervention.

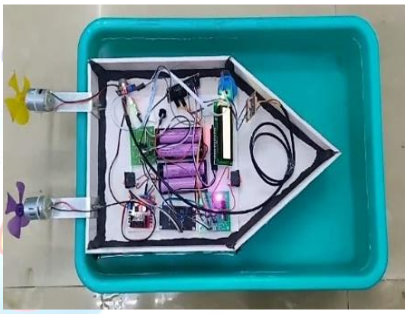

Fig. 2: Overall view of the project

Here, the Blynk is used to display sensors data such as Water Turbidity, Water Temperature, Air Pollution.

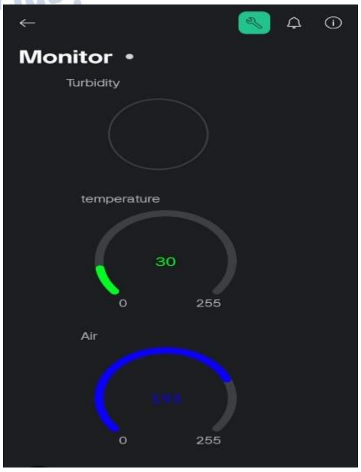

Fig. 3: Output of water quality monitoring system

VI. CONCLUSION

The potential to develop a smart Autonomous Surface Vehicle (ASV) for water quality analysis is emphasized in this project. This innovative system can assist various governmental and environmental agencies in monitoring water bodies, providing safer and healthier aquatic ecosystems. The proposed model has been tested and is functioning as intended, continuously analyzing key water quality parameters. It can promptly detect pollutants and other hazardous changes, enabling authorities to take immediate action. It also makes it easier to manage water quality and supports environmental preservation.In conclusion, this project will assist communities in making well-informed decisions and taking proactive steps to protect water resources.

VII. FUTURE SCOPE

Autonomous Fleet Management: Several SASVs can be used in a networked fleet, which coordinates with one another to patrol vast water bodies cost-effectively and exchange real-time information for efficient water resource planning.

Solar-Powered Mode: Equipping SASVs with solar panels will guarantee energy-saving, long-time autonomous operations with infrequent recharging, rendering them more eco-friendly.

Satellite and Cloud Integration: Real-time data gathered by SASVs may be transmitted to satellite networks or cloud platforms so that global monitoring and remote access by researchers, government agencies, and environmental NGOs are facilitated.

Disaster Response and Emergency Alerts: SASVs can be employed for post-disaster water quality testing, providing safe drinking water supply after floods, hurricanes, or industrial disasters.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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