

IoT and Autonomous RC Boats for Water Quality Assessment: Trends, Challenges, and Future Prospects

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Abstract

Nowadays the application of Internet of things (IoT) is increasing in many applications like drone, remote control vehicles, electrical vehicle, etc. In this study, we proposed a way to check quality of water present in vast water bodies by Remote Controlled (RC) Boat. This RC environmental monitor boat collects water quality data and sends it online via the Internet of Things, so that can maintain the cleanliness of water by using the received data. It has a DC motor for propulsion attached with rudder, and as per commands received from RC receiver, controller operates the DC motor which rotates the propeller. Three sensors are being used here: temperature, turbidity, and pH sensors. pH sensors detect the potential of Hydrogen value, turbidity sensors measure the liquid effluent and temperature sensors measure the water temperature. We developed a RC boat prototype hardware model, and it was successfully tested for water pollution monitoring. By enabling real-time data collecting, cost-effectiveness, and accessibility to hard-to-reach water bodies, the combination of the Internet of Things (IoT) with autonomous remotely controlled (RC) boats has completely changed the evaluation of water quality. This review examines current developments in the subject, emphasising developments in autonomous navigation systems, sensor technologies, and data analytics powered by artificial intelligence (AI). It also talks about the main issues, such as environmental adaptability, data security, and energy efficiency. The review ends with a prediction for the future, highlighting how AI, edge computing, and better materials can help IoT-driven autonomous boats become more capable of thorough water quality monitoring.

Keywords: Internet of Things (IoT), Remote Control (RC), pH sensor, turbidity sensor, temperature sensor, Arduino

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INTRODUCTION

The quality of the water has a major effect on the health of both humans and animals. Lakes, reservoirs, and canals are some of the primary sources of drinking water. The first step in reducing water contamination is, being able to monitor its actual levels. The physical labour required to navigate a boat through a lake or reservoir each time to keep an eye on pollution levels across the body of water is the issue with water pollution monitoring. The motorised propeller system provides forward propulsion, while the servo motor arrangement provides steering via a rudder. This system is controlled and operated remotely by an RC remote, which allows it to be manoeuvred appropriately.

Three sensors: a dissolved oxygen sensor, a turbidity sensor, and a pH sensor, are used to assess the quality of the water. These sensors will detect the presence of any particles that are suspended in the water. Additionally, we have a GSM module that will log sensor data and send it online via IoT at specific intervals. Therefore, it is easy to utilise the water quality by monitoring RC boats to check the water quality in lakes and reservoirs.

LITERATURE SURVEY

Pasika and Gandla developed a water quality monitoring system using sensors for turbidity, pH, water level, environmental dampness, and temperature, interfaced with an MCU and processed via PC [1]. IoT-based ThinkSpeak is used to transmit the data to the cloud for real-time monitoring. Measurements will be extended to nitrates, electrical conductivity, oxygen that is dissolved, and free residual chlorine in future research. Mukta et al. developed an Internet of Things (IoT)-based Smart Water Quality Monitoring (SWQM) system that evaluates the overall condition of water using devices for pH, humidity, temperature, and electrical conductivity [2]. A.NET desktop program receives the data from these sensors and compares it with predetermined values. The SWQM model uses a fast forest binary classifier to determine if the water is potable.

Konde and Deosarkar developed an IoT-based Smart Water Quality Monitoring (SWQM) system using a reconfigurable sensor interface with an FPGA board and Zigbee module, monitoring six parameters, including turbidity, pH, and CO₂ levels, in real-time [3]. This system aims to protect water bodies and reduce the cost and time of water quality assessment. Future work includes expanding coverage with a larger Wireless Sensor Network (WSN). A solar-powered environmental surveillance system that uses an underwater wireless sensor network (UWSN) with ZigBee for continuous assessment was proposed by Amruta and Satish [4].

The system includes a base station and solar-powered sensor nodes to collect data on turbidity, oxygen, and pH, transmitting it wirelessly for analysis. This model offers benefits like low power consumption, zero carbon emissions, and flexibility for deployment across locations. Sughapriya et al. created an Internet of Things (IoT)-based water quality monitoring system that includes sensors to assess temperature, conductivity, turbidity, and pH. An Arduino controller accesses the data [5]. The system analyses pollution levels and sends alerts to authorities, requiring minimal training for operation. This model is accurate, cost-effective, and easy to install near water sources for real-time monitoring and action. Unnikrishna et al. proposed a Wireless Sensor Network (WSN) for continuous, remote monitoring of river water quality, focusing on pH as a key parameter [6]. The system transmits data to a base station via a sensor node equipped with Zigbee-based wireless interaction modules, processing, signal conditioning, and power. This design offers a low-cost, low-power solution for water quality monitoring. Utilising IoT and remote sensing, Prasad et al. created a smart water quality tracking device in Fiji that measures conductivity, temperature, turbidity, pH, ORP, and other characteristics [7].

The system demonstrated precise real-time monitoring across four water sources, with data validated over 12-hour intervals. GSM alerts are sent based on reference parameters, and Neural Network Analysis is applied for automated water quality analysis. Jerom et al. introduced a Smart Water Quality Monitoring System that uses deep learning, cloud computing, and the Internet of Things to allow for real-time water quality measurement [8].

Unlike traditional methods, this system offers continuous monitoring through IoT devices and Node-MCU, sending sensor data to the cloud for storage and analysis. In order to ensure a healthy water supply and solve environmental concerns, deep learning approaches forecast potability. Geetha and Gouthami developed a low-power, IoT-based water quality monitoring system for in-pipe water that is cost-effective and simple to implement [9]. The system uses sensors to measure parameters like turbidity, conductivity, and pH, with data uploaded online for analysis and user alerts on quality deviations. Future enhancements include integrating algorithms for detecting water quality anomalies.

Sengupta et al. proposed a cost-effective IoT-based water quality monitoring and control system using sensors and a Raspberry Pi to automate water flow [10].

A solenoid valve controls water from the overhead tank, operating automatically based on real-time data without human intervention. This system is efficient, low-cost, and ensures water quality within desired parameters. All the above literature survey focused on control of water quality using different sensors and monitoring using IoT devices but there have not focused on remote areas covered under water bodies. So, we proposed a prototype model of RC boat to monitor the water pollution using IoT devices.

PROPOSED METHOD

Figure 1 shows the block diagram representing the hardware model and it describes how we are monitoring water pollution using different sensors using Arduino UNO. Figure 2 shows representation of remote-control unit of proposed model.

Arduino UNO

The Arduino Uno microcontroller circuit board was created by Arduino LLC and is based on the ATmega328P microcontroller. It is a popular and widely used board in the Arduino family, which is designed for creating interactive objects and environments. Figure 3 represents the sematic representation of Arduino board. The board features a USB port, a power jack, six analogue inputs, 14 digital input/output pins, and a 16 MHz quartz crystal. The Arduino Software (IDE), a cross-platform Integrated Development Environment (IDE) that enables users to write, upload, and execute code on the Board, is compatible with this open-source hardware ecosystem. The Arduino UNO can be programmed in C and C++ programming languages, making it accessible to both beginners and advanced users. It is a versatile and affordable board that can be used in various projects, including robotics, home automation, and IoT applications. Its price, adaptability, and simplicity of use make it a popular choice among professionals, students, and enthusiasts.

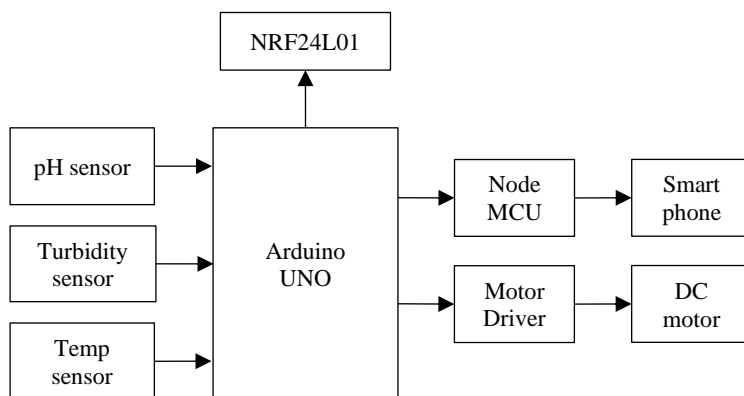


Figure 1. Block diagram of proposed model boat.

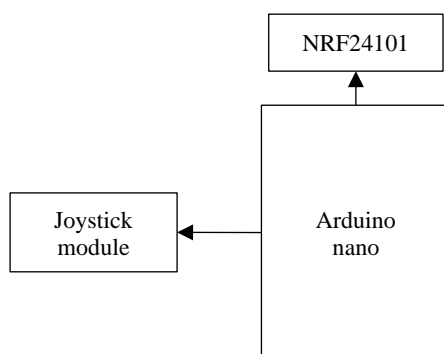


Figure 2. Block diagram of remote-control unit.

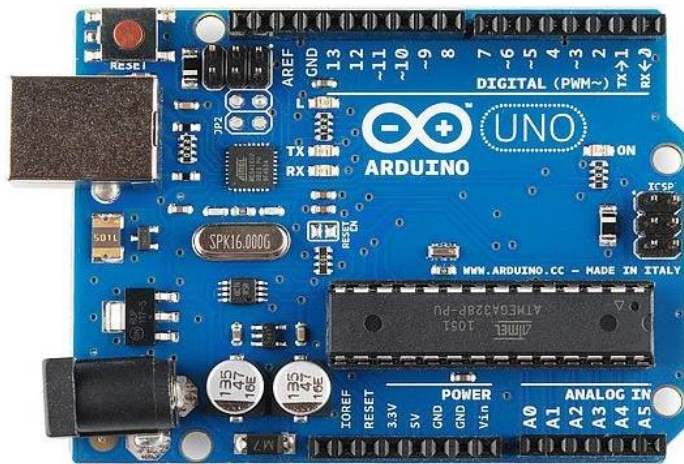


Figure 3. Schematic representation of Arduino board.

HARWARE COMPONENTS

pH Sensor

The pH of a liquid is commonly tested with this pH sensor, which measures the hydrogen-ion activity in water-based solutions. When required, the chemical, pharmaceutical, dye, and scientific research industries all make extensive use of acidity and alkalinity testing. This kit's drive board is suitable for 9 V systems. Additionally, working with Arduino and Raspberry Pi is made exceedingly easy by Grove connection and the standard BNC probe interface. A power indicator LED, a BNC connector, and a pH2.0 sensor interface are all included. Simply connect the pH sensor to the BND connection and plug the pH2.0 interface into the analogue input port of any Arduino controller to get started. You may easily obtain the pH value if you are pre-programmed; it comes with foams for improved mobile storage in a small plastic box. The concentration of hydrogen ions in the body is measured by the power of hydrogen, or pH. The standard pH level of the human body is 7.4, which is necessary for proper bodily function. The body will want to return to its neutral state if its composition ever becomes too acidic or alkaline.

Turbidity Sensor

The degree to which suspended materials like silt, clay, organic matter, plankton, and microorganisms in the water generate turbidity, is referred to as the turbidity of water. The cost of designing electronic goods is too high, and industrial-grade turbidity sensors and meters are costly. The light transmittance and scattering rate in the solution are used by the sensor to determine the turbidity in a comprehensive manner using optical principles. An infrared tube is located inside the sensor. The degree of dirtiness of the water determines how much light is transmitted when it passes through a given volume of water. Water transmits less light, the dirtier it is.

The transmitted light's intensity is converted to the appropriate current size at the receiving end. Both the current and the amount of light transferred are greater. Conversely, there is less light transmitted and less current flowing. The turbidity sensor module uses a single-chip microcontroller to process AD conversion data and transform the current signal it receives from the sensor into a voltage signal. Both digital and analogue output interfaces are available on the re-modelling module. To determine the present level of water contamination, the single-chip A/D converter can sample and process the analogue quantity. The sensors utilized are presented in Figure 4.

Temperature Sensor-DS18B20

This 1-m long, waterproof, sealed, and pre-wired digital temperature sensor probe is based on the DS18B20 sensor. It is quite useful when you need to measure anything that is far away or in a wet environment. Since they are digital, there is no signal degradation even for long distances. These 1-wire digital temperature sensors are reasonably precise ($\pm 0.5^{\circ}\text{C}$ over a wide section of the range) and can provide up to 12 bits of precision with an on-board digital-to-analogue converter. Each one has a unique



Figure 4. Sensors utilized: (a) pH sensor, (b) turbidity sensor, (c) temperature sensor.



Figure 5. NEO-6M GSM Module.

64-bit ID burned in the factory to distinguish it from the others, and they function well with any microcontroller when connected to a single digital pin. It is also possible to connect many to the same pin. 3.0–5.0 V systems can use it.

GSM Module

Figure 5 illustrates the whole GPS module, which is based on the NEO-6M. This gadget uses the most recent technology to deliver the best positional data possible and features a larger integrated 25×25 mm active GPS antenna with a UART TTL connector. A battery is also included so that you can obtain a GPS lock faster. This GPS module has been upgraded and is compatible with the Arduino Mega V2. With the best position data provided by this GPS module, your Ardupilot or any multirotor control platform will operate more effectively. The four pins on the GPS module are TX, RX, VCC, and GND. It also includes a serial TTL output.

NRF24L01 Transceiver

The newest RF component is the NRF24L01 (Figure 6a). Nordic Semiconductor's NRF24L01+ 2.4 GHz transceiver is used in this module. This transceiver IC includes a lot of new capabilities and uses the 2.4 GHz frequency. For optimal RF range, this board has a reverse polarised SMA connector. Additionally, the external antenna can reach a greater distance than the one without the PA and LNA circuits. This module has a 2.4G antenna (2DB), which can communicate over 800–1000K meters at a 250 kbps transmission rate outside.

Joy Stick Module

As seen in Figure 6(b), this is a high-quality, dual-axis joystick module. It is capable of sensing two axes of movement. Additionally, it features a built-in switch that can be turned on by pressing the stick. Two potentiometers, one for each axis, are all that are needed for directional movements. Pots cost about \$ 10,000 each. This Joystick Module allows you to move the “hat” to measure location coordinates on the X and Y axes. Additionally, it has a switch that may be pressed by pressing the “hat” down, like the controller for XBOX.



Figure 6. (a) NRF24L01 transceiver, (b) joystick module.

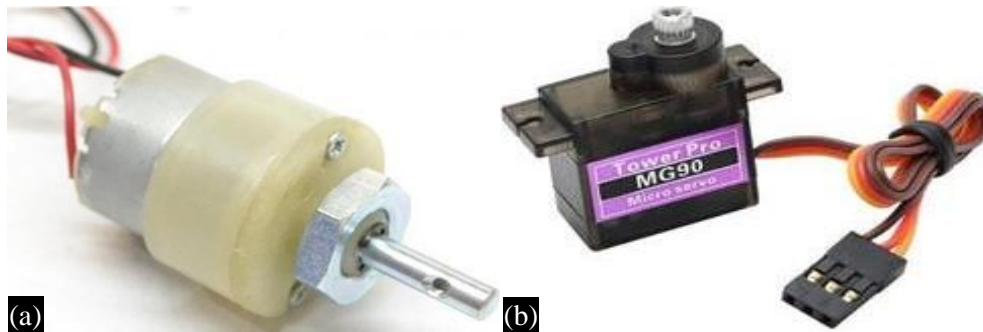


Figure 7. (a) DC motor, (b) MG 90S servomotor.

DC Motor

Simple DC motors with a gearbox attached are typically 1000 rpm, 12 V geared turbines shown in Figure 7(a). Numerous robotic applications, including all-terrain robots, can make use of this. The 3 mm threaded drill hole in the centre of the shaft makes it simple to connect these electric motors to wheels or any other mechanical assembly. The most popular L298N H-bridge component with on-board voltage regulator motor driver can be used with this motor, which has a voltage between 5 and 35 V DC. Alternatively, depending on your specific requirements, you can choose the most precise motor driver module from the vast range of options in the Motor Drivers category.

MG90 Servo Motor

The MG90S Tower Pro Mini Digital Servo rotates 180°. This digital servo motor processes and receives PWM signals more quickly and effectively. It has advanced internal circuitry that responds to external pressures more quickly and produces good torque and holding power. Our servos are the preferred option for many RC enthusiasts due to their excellent optimised performance and dependability. They come in a tight, durable plastic box that keeps them dry and clean, which is a great feature for RC boats, aeroplanes, and monster trucks, among other vehicles (Figure 7b).

Propeller

A propeller, also known as an airscrew on an aeroplane or a screw on a ship, is a machine that rotates and produces linear thrust on a working fluid, like air or water, by means of radiating blades positioned at a pitch to form a helical spiral. Propellers are used to generate push to move an aeroplane shown in Figure 8(a) through the air or a boat over water, or to pump fluid through a pipe or duct. The blades are formed specifically so that Bernoulli's principle, which applies force to the fluid, creates a pressure differential between the blade's two sides as it rotates through the fluid. Most marine propellers are screw propellers with helical blades that move on a propeller shaft that has an axis that is about horizontal.

Rudder

A ship, boat, submarine, hovercraft, aeroplane, or other vehicle moving through a fluid medium, usually air or water, is guided by its rudder, which is its main control surface. The rudder of an aeroplane



Figure 8. (a). propeller (b) rudder.

is not the main control used to steer the aircraft; rather, it is employed mainly to counteract undesirable yaw and p-factor as shown in Figure 8(b). A rudder gives a craft a turning or yawing motion by rerouting the fluid past the fuselage or hull (in the case of a watercraft). In essence, a rudder is a flat surface or sheet of materials that is attached to the ship's stern, tail, or after end by hinges.

WORKING OF PROTOTYPE MODEL

The IoT-based water pollution monitoring RC (Remote Controlled) boat is a project that aims to monitor water pollution levels in bodies of water using an Arduino-based system integrated with IoT (Internet of Things) technology. The proposed work involves designing and building a remote-controlled boat that can navigate through water bodies while collecting and analysing water samples for pollution levels. The collected data is then transmitted to a cloud-based server through an IoT module for further analysis and visualization. The core components of the system include an Arduino micro controller, various sensors for measuring water parameters such as temperature, pH, dissolved oxygen, and turbidity, a GPS module for location tracking, a wireless communication module (such as Wi-Fi or GSM) for transmitting data, and a remote-control system for controlling the boat's movement. The boat is equipped with a water sampling mechanism that collects water samples at regular intervals for analysis. The boat's Arduino micro controller serves as the brain of the system, collecting data from the various sensors and controlling the boat's movement based on remote control inputs.

Important markers of water quality, including temperature, pH, turbidity, and dissolved oxygen, are measured by the sensors. The GPS module provides location information for tracking the boat's

movement and mapping pollution data to specific locations. Users can regulate the boat's movement, including changing direction, speed, and stopping, with the use of remote-control technology. Users can also initiate water sampling through the remote control system.

This model has several potential applications, including water quality monitoring in lakes, rivers, and other bodies of water, pollution detection in industrial and agricultural areas, and support for environmental research and conservation.

HARDWARE PROTOTYPE MODEL

The hardware model has two modules as shown in Figures 9 and 10, the first module is a remote controller. Module 2 is controlled by this remote controller. Two joystick modules, an Arduino Nano, and an NRF24L01 are included in Module 1. All the components are controlled by an Arduino Nano microcontroller. The next part is a transceiver module, NRF24L01, which transmits and receives signals from Module 2. Two joysticks can be utilised to regulate the RC boat's mobility.



Figure 9. Hardware Prototype Model (module 2).

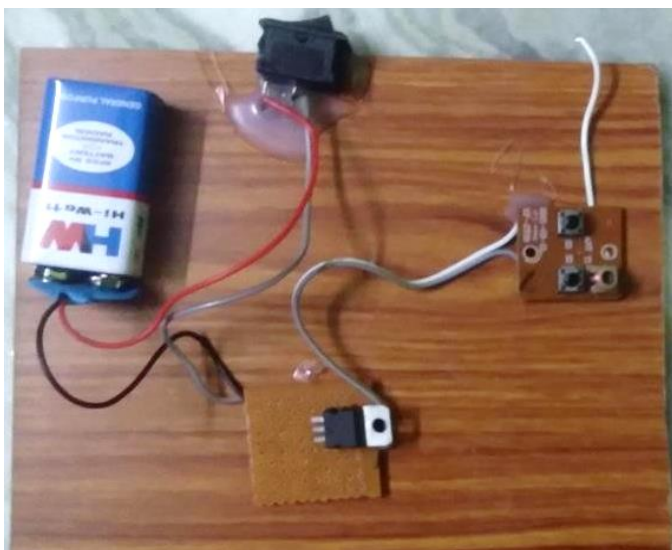


Figure 10. Hardware Prototype Model (module 1).

CONCLUSION

The proposed system automatically monitors water quality parameters like turbidity, pH, and temperature using water detection sensors and the existing GSM network. It offers quick, easy, and affordable testing, is inexpensive, and does not require human involvement. The system is flexible and can be expanded to monitor other environmental factors such as air pollution and industrial processes, offering widespread application and the potential for smart environmental monitoring. Data is collected by sensors and analysed, with results accessible to users via Wi-Fi.

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