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Iot Based Water Quality Monitoring System

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ABSTRACT
Our project presents an Internet of Things (IOT) based Water Quality Monitoring System designed to assess and display key water quality parameters in real time. The system employs sensors to measure pH, Turbidity, conductivity and temperature, with the collected data being presented on a Liquid Crystal Display (LCD). To enhance user awareness, the system integrates visual indicators, including green and red LEDs that signify normal and contaminated water conditions, respectively. In the event of high contamination, an alert is triggered through a buzzer, providing an audible indication of the issue. Further more, the project incorporates a cloud-based infrastructure for seamless data storage and accessibility. All monitored data is transmitted to a cloud server, enabling users to remotely monitor and analyze water quality trends over time. This cloud integration enhances the system's scalability andfacilitates long-term data management.

KEYWORDS: pH Sensor, Temperature Sensor, Turbidity Sensor, TDS Sensor, Arduino Uno, Node MCU, Display Module, Buzzer & Led.

I. INTRODUCTION

The critical nature of water quality across various sectors ranging from public health to industrial processes underscores the urgent need for precise and continuous monitoring systems. Recognizing this necessity, the chapter delves into the intricacies of a sophisticated Water Quality Monitoring System, meticulously designed to harness the advanced capabilities of Arduino and NodeMCU platforms.This system is not merely a technological marvel; it represents a concerted effort to provide a comprehensive solution for water quality analysis. Equipped with a suite of advanced sensors, the system is adept at conducting detailed assessments of key water quality parameters: turbidity, total dissolved solids (TDS), pH levels, and temperature. Each sensor plays a pivotal role in painting a complete picture of the water's condition, enabling stakeholders to make informed decisions based on accurate, real- time data. Turbidity sensors detect particulate matter in water, providing insights into its clarity and potential contamination. TDS sensors measure the concentration of dissolved substances, offering a gauge of water purity and suitability for various uses. pH sensors assess the acidity or alkalinity of the water, a critical factor for both ecological balance and industrial applications. Temperature sensors, meanwhile, provide data essential for understanding the water's chemical behavior and biological activity. This chapter not only introduces the components and functionalities of the Water Quality Monitoring System but also sets the stage for a deeper exploration of its potential to revolutionize the way water quality is managed and maintained. By integrating these sensors with the robust Arduino and NodeMCU platforms, the system offers a dynamic and adaptable approach to water quality monitoring, ensuring that the assessment is not only comprehensive but also precise and reliable. Through this advanced monitoring system, the objective is to safe guard water resources, ensure Public health and sustainable environmental practices, thereby addressing the critical need for an effective and efficient water quality monitoring system.

II. LITERATURE SURVEY

proposed a monitoring system which consists of a number of sensors used to measure several quality parameters like turbidity, pH value, water level in the tank, dampness of the adjoining environment and temperature of the water. The sensors are interfaced with the Microcontroller Unit (MCU) and additional processing is executed by the Personal Computer (PC). The acquired data will be directed to the cloud by means of Internet of Things (IOT) based application Blynk for monitoring the quality of the water under test. As a future directive, work should be extended for analyzing some other parameters such as nitrates, electrical conductivity, dissolved oxygen in the water and free residual chlorine.

A. Arduino Based Smart Water Quality Monitoring System

developed an IoT based Smart Water Quality Monitoring (SWQM) system which helps in incessant measurement of quality of water on the basis of four different parameters of water quality i.e., pH, temperature, turbidity and electric conductivity. Four different sensors are coupled to Arduino Uno in order to sense the quality parameters.

B. IOT Based Water Quality Assessment System With Multi-Sensors

developed a method for determining the quality of water using IoT and different sensor modules. This system uses different sensors for monitoring the water quality by determining pH, turbidity, conductivity and temperature. The Arduino controller used will access the sensor data. With the use of IoT, the collected data is analyzed and the pollution of water can be investigated by a stringent mechanism.

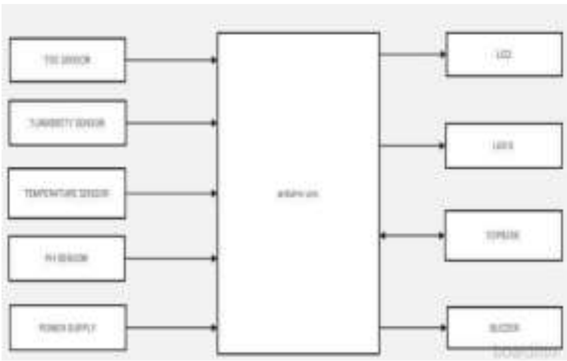
C. Cloud Integration and Deep Learning Proposed a Smart Water Quality Monitoring System based on IoT using Cloud and Deep Learning methods for monitoring the water quality of various water resources. In traditional methods the procedure of monitoring implicates collecting the sample of water manually from different water resources, trailed by testing and analysis in the laboratory. This process is usually ineffectual since this process is strenuous and consumes more time and it will not give results in realtime. There should be continuous monitoring of quality of water for ensuring safe supply of water to the end users from any water resources or water bodies. Hence forth, designing And developing a cost effective system for real- time monitoring water quality using the IoT is a requisite. Monitoring quality of water in water resources using IoT aids for combating issues related to environment and improves the wellbeing and standard of living of all living beings. The developed system helps in monitoring the water quality persistently by using IoT devices and Node-MCU. The built-in Wi-Fi module associated with Node- MCU facilitates connectivity of internet, and transmits the data measured from the sensor to the Cloud. Various sensors are utilized for measuring different parameters for assessing the water quality from water resources. The obtained results are stowed in the Cloud and deep learning techniques are employed for predicting if the water under test is potable or not.

II. EXISTED METHOD

Traditional water quality monitoring methods have historically relied on manual sampling and subsequent lab-based analyses. This approach, while providing accurate snapshots of water quality at specific points in time, inherently suffers from significant delays between sample collection and resultavailability. Such delays can be critical when immediate action is required to address contamination or sudden changes in water quality. Moreover, these traditional methods offer only a piecemeal view of water quality, lacking the capability to deliver continuous and real- time data This episodic nature of characteristics, which can be influenced by various factors like weather events,industrial discharges, or agricultural runoff. The absence of continuous monitoring means that potentially hazardous changes in water quality could go undetected between sampling times, leading to situations where corrective actions might be delayed or ineffective. This gap in continuous monitoring and real-time data analysis is where modern technology, with its ability to provide constant and immediate feedback on water quality, can make a substantial impact. The advent of IoT-based water quality monitoring systems, which leverage sensors for real-time data collection and cloud platforms for instant analysis, presents a transformative solution. These systems not only facilitate immediate detection of water quality issues but also enable a proactive approach to water management. By integrating advanced sensors and real-time data processing capabilities, modern monitoring systems can fill the critical gap left by traditional methods, offering a comprehensive and dynamic understanding of water quality trends and anomalies.

IV. PROPOSED METHOD

The proposed system represents a significant advancement in water quality monitoring, Introducing an automated t real- time framework that leverages the robust capabilities of Arduino and NodeMCU boards. These microcontroller platforms are at the heart of the system, orchestrating the seamless integration and operation of specialized sensors that continuously measure water's turbidity, total dissolved solids (TDS), levels, and temperature. Each sensor is carefully chosen for its precision and reliability, ensuring that the system can accurately monitor the various aspects of water quality. The turbidity sensor, for example, plays a crucial role in detecting suspended particles in water, providing essential data for assessing water clarity and potential pollution. The TDS sensor, on the other hand, measures the concentration of dissolved particles, offering insights into the water's overall solute content and salinity, which are important indicators of water quality and suitability for various uses.The pH sensor within the system measures the acidity or alkalinity of the water, a critical parameter that affects both aquatic life and industrial processes. Meanwhile, the temperature sensor provides data on the thermal state of the water, which influences not only the chemical reactions but also the biological activities within the aquatic environment.



V. Software

The Arduino IDE, or Integrate development Environment, is a software tool used for programming Arduino microcontrollers. It provides a simple interface for writing, compiling, and uploading code to Arduino boards. The IDE includes a text editor, compiler, and uploader. It supports a simplified version of C++ programming language, making it accessible for beginners. Users can easily install libraries to extend the functionality of their projects. The IDE also features a serial monitor for debugging an testing. It's open-source software, fostering a vibrant community of developers and resources. Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of the window displays the configured board and serial port. The tool barbuttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor. NB: Versions of the Arduino Software (IDE) prior to 1.0 saved sketches with the extension.It is possible to open these files with version 1.0, you will be prompted to save the sketch with the .into extension on save.

Verify: Checks your code for errors compiling it.

Upload: Compiles your code and uploads it to the configured board. See uploading below for details.

Note: If you are using an external programmer with your board, you can hold down the "shift" key on your computer when using this icon. The text will change to "Upload using Programmer"

New: Creates a new sketch.

Open

Allows to load a sketch file browsing through the computer drives and folders.

Open Recent

Provides a short list of the most recent sketches, ready to be opened.

Sketchbook

Shows the current sketches within the sketchbook folder structure; clicking on any name opens the corresponding sketch in a new editor instance.

Examples

Any example provided by the Arduino Software (IDE) or library shows up in this menu item. All the examples are structured in a tree that allows easy access by topic or library.

Close

Closes the instance ofthe Arduino Software from which it is clicked.

Save

Saves the sketch with the current name. Ifthe file hasn't been named before, a name will be provided in a "Save as." window.

Save as...

Allows to save the current sketch with a different name.

Page Setup

It shows the Page Setup window for printing.

Print

Sends the current sketch to the printer according to the settings defined in Page Setup.

Preferences

Opens the Preferences window where some settings of the IDE may be customized, as the language of the IDE interface.

Quit

Closes all IDE windows. The same sketches open when Quit was chosen will be automatically reopened the next time you start the IDE.

Since version 1.0.1, the Arduino Software (IDE) has been translated into 30+ different languages. Bydefault, the IDE loads in the language selected by your operating system. (Note: on Windows and possibly Linux, this is determined by the locale setting which controls currency and date formats, not by the language the operating system is displayed in.) If you would like to change the language manually, start the Arduino Software (IDE) and open the Preferences window. Next to the Editor Language there is a dropdown menu of currently supported languages. Select your preferred language from the menu, and restart the software to use the selected language. If your operating system language is not supported, the Arduino Software (IDE) will default to English. You can return the software to its default setting of selecting its language based on your operating system by selecting System Default from the Editor Language dropdown. This setting will take effect when you restart the Arduino Software (IDE). Similarly, after changing your operating system's settings, you must restart the Arduino Software (IDE) to update it to the new default language.

VI. HARDWARE COMPONENT ARDUINO UNO

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and reset button. It contains everything needed to support the microcontroller; connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDIUSB-to- serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to- serial converter. "Uno" means one in Italian and is named to mark the upcoming release of Arduino.

Fig. Arduino uno

The Arduino Uno is a popular microcontroller board based on the ATmega328P microcontroller. Here are its key specifications:

Microcontroller

- Microcontroller: ATmega328P
- Operating Voltage: 5V
- Input Voltage (recommended): 7- 12V
- Input Voltage (limit): 6-20V

Digital I/O Pins

- Number of Digital I/O Pins: 14 (of which 6 can provide PWM output)
- PWM Digital I/O Pins: 6 (pins 3, 5,

6, 9, 10, 11)

Analog Input Pins

- Number of Analog Input Pins: 6 (A0 to A5)

Current

- DC Current per I/O Pin: 20 mA
- DC Current for 3.3V Pin: 50 mA

Memory

- Flash Memory: 32 KB (ATmega328P) of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328P)
- EEPROM: 1 KB (ATmega328P)

Clock Speed

- Clock Speed: 16 MHz

Communication

- UART: 1
- SPI: 1
- I2C: 1

Other Features

- LED_BUILTIN: 13
- USB Connection: Type-B
- Power Jack: Yes
- ICSP Header: Yes
- Reset Button: Yes

The Arduino Uno is a versatile board widely used for prototyping and educational purposes. It offers a good balance between simplicity and functionality, making it suitable for beginners and experienced users alike.

NodeMCU ESP8266

Fig. NodeMCU ESP Module NodeMCU is an open-source IoT platform that integrates a microcontroller with Wi-Fi capabilities. The most commonly used version is based on the ESP8266 Wi-Fi module. Here are the key specifications of the NodeMCU:

Microcontroller Microcontroller: ESP8266 Operating Voltage: 3.3V
Input Voltage: 4.5V-10V (Vin), 5V (USB)

Digital I/O Pins
Number of Digital I/O Pins: 17 (GPIO0 to GPIO16)

Analog Input Pins
Number of Analog Input Pins: 1 (A0)
ADC Range: 0-1V

Current
DC Current per I/O Pin: 12 mA

Power Consumption:
Deep Sleep: 10 µA Light Sleep: 1 mA Modem Sleep: 15 mA Active: 70-200 mA **Memory**
Flash Memory: 4 MB (32 Mb)
SRAM: 160 KB (64 KB available for user applications)

Clock Speed
Clock Speed: 80 MHz (default) / 160 MHz (overclock)

Wi-Fi
Standard: IEEE 802.11 b/g/n Frequency: 2.4 GHz Encryption: WPA/WPA2 **Interfaces**
UART: 1
SPI: 1
I2C: 1 I2S: Yes
PWM: Yes

Other Features
USB Connection: Micro USB Integrated TCP/IP Protocol Stack
GPIO Pins: Can be configured to perform various functions like UART, I2C, SPI, PWM, etc.
LED_BUILTIN: Connected to GPIO2
Development
Programming Language: Lua, Arduino C/C++
Development Environments: Arduino IDE, NodeMCU IDE, Plat form IO.

NodeMCU is particularly popular for IoT projects due to its built-in Wi-Fi and relatively easy programming interface, making it suitable for projects that require wireless connectivity and remote control.

Fig. Ph sensor Module

When discussing small specifications in pH sensors, several key parameters and characteristics are typically considered to ensure accurate and reliable measurements. Here are the main specifications to look for:

1. Measurement Range Typical Range: pH 0 to 14 Some sensors might have a narrower or slightly extended range depending on the application.
2. Accuracy Typical Accuracy: ±0.01 to ±0.1 pH units High-precision sensors offer better accuracy, often essential for scientific and industrial applications.
3. Resolution Typical Resolution:0.01 pH units Determines the smallest change in pH that the sensor can detect.
4. Response Time Typical Response Time:1 to 60 seconds The time it takes for the sensor to reach 95% of the final value after a step change in pH.
5. Temperature Compensation Automatic Temperature Compensation (ATC): Adjusts the pH reading based on the temperature to ensure accuracy. Temperature Range: Commonly 0 to 100°C, depending on the sensor model.

TDS Sensor

Fig TDS Sensor

- The tdsPin constant defines the analog pin connected to the TDS sensor module.
- In the setup function, Serial begin(9600) initializes serial communication for debugging.
- In The Loop Function, analog Read (tdsPin) reads the sensor value, which is then converted to voltage.
- Connect the TDS sensor probe to the TDS sensor module.
- The TDS sensor module typically has three pins: VCC, GND, and AOUT.
- Connect the VCC pin of the TDS sensor module to the 5V pin on the Arduino.
- Connect the GND pin of the TDS sensor module to a GND pin on the Arduino.
- Connect the AOUT pin of the TDS sensor module to an analog input pin on the Arduino (e.g., A0)

Turbidity Sensor

Fig. Turbidity Sensor

- The turbidity Pin constant defines the analog pin connected to the turbidity sensor.
- In the setup function, Serial.begin (9600)initializes. the serial water communication for debugging. The turbidity sensor typically has three pins: VCC, GND, and A0.Connect the VCC pin of the turbidity sensor to the 5V pin on the Arduino.
- Connect the GND pin of the turbidity sensor to a GND pin on the Arduino.
- Connect the A0 pin of the turbidity sensor to an analog input pin on the Arduino (e.g., A0).

Temperature Sensor

Fig. Temperature Sensor

- The DS18B20 sensor has three pins: GND, VCC, and DATA.
- Connect the GND pin of the DS18B20 to a GND pin on the Arduino.
- Connect the VCC pin of the DS18B20 to the 5V pin on the Arduino.
- Connect the DATA pin of the DS18B20 to a digital pin on the Arduino (e.g., pin 2).
- Place a 4.7k ohm pull-up resistor between the DATA pin and the 5V pin to ensure proper communication.

LCD

Fig. 16X2 LCD

- The LCD has 16 pins (1 to 16), but the essential ones are:
- VSS (Pin 1) to GND
- VDD (Pin 2) to 5V
- VO (Pin 3) to the wiper (middle pin) of the potentiometer, with the other two pins of the potentiometer connected to 5V and GND respectively
- RS (Pin 4) to digital pin 12 on the Arduino
- RW (Pin 5) to GND (for write mode)

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- E (Pin 6) to digital pin 11 on the Arduino
- D4 (Pin 11) to digital pin 5 on the Arduino
- D5 (Pin 12) to digital pin 4 on the Arduino
- D6 (Pin 13) to digital pin 3 on the Arduino
- D7 (Pin 14) to digital pin 2 on the Arduino
- A (Pin 15) to 5V (through a current- limiting resistor, e.g., 220 ohms)
- K (Pin 16) to GND.

Buzzer

Fig. Buzzer

Active Buzzer:

- Connect the positive lead of the active buzzer to a digital pin on the Arduino (e.g., pin 8).
- Connect the negative lead of the active buzzer to a GND pin on the Arduino

Passive Buzzer:

- Connect the positive lead of the passive buzzer to a digital pin on the Arduino (e.g., pin 8).
- Connect the negative lead of the passive buzzer to a GND pin on the Arduino.

LED's

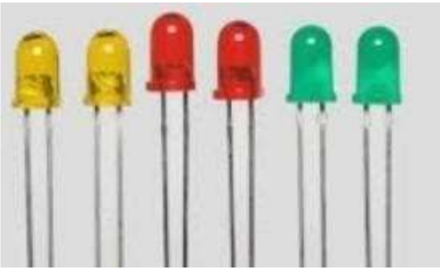

Fig. LED

- Connect the anodes of each LED to different digital pins on the Arduino (e.g., pins 9, 10, and 11).
- Connect the cathodes of each LED to one end of individual 220-ohm resistors.
- Connect the other end of each resistor to a common ground rail on the breadboard.
- Connect the ground rail to a GND pin on the Arduino.

Advantages

- Enhanced in The Environmental Protection.
- Accurate and Comprehensive Monitoring.
- Remote Monitoring and Control.
- GPS Integration for Geotagging.
- Easy Installation and Scalability.

- Cost-Effective Solution**.**

Application

- Municipal Water Supply Monitoring
- Environmental Research and Protection
- Industrial Water Usage
- Agriculture and Hydroponics
- Aquaculture

EXPERIMENTAL RESULT

The IoT-based Water Quality Monitoring System offers real-time assessment and display of crucial water quality parameters. It utilizes sensors to measure pH, turbidity, conductivity, and temperature. The collected data is showcased on an LCD screen, providing immediate insights to users. Enhancing user awareness, the system integrates visual indicators such as green and red LEDs, denoting normal and contaminated water conditions respectively. In cases of high contamination, an alert is activated through

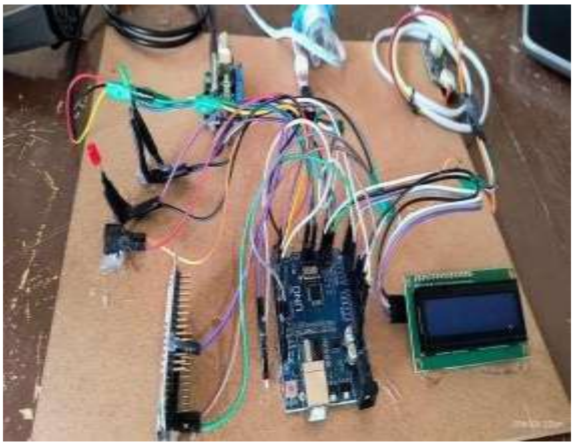

Fig. Project kit

a buzzer, providing audible indication. Furthermore, the project incorporates a cloud-based infrastructure for seamless data storage and accessibility. Monitored data is transmitted to a cloud server, enabling remote monitoring and analysis of water quality trends over time. This cloud integration not only enhances scalability but also facilitates long-term data management.

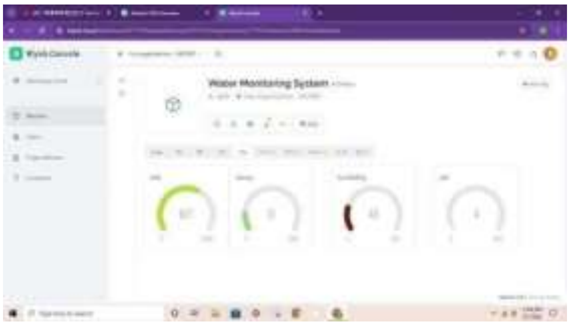

Fig. Cloud Server Output

Conclusion

In conclusion, the Water Quality Monitoring System leveraging Arduino Uno, ESP8266, and a suite of sensors including TDS, pH, turbidity, and temperature sensors, provides a robust and comprehensive solution for monitoring water quality in real-time. This system enhances environmental management and public health by enabling continuous assessment of water conditions, which is crucial for detecting pollutants and preventing waterborne hazards. The integration of GPS for precise location tracking adds an additional layer of data, enhancing the ability to monitor water quality over vast areas and different locations, making it invaluable for municipal water supplies, environmental studies, and industrial applications.

The system's ability to connect via Wi- Fi allows for remote monitoring and data access, which is especially beneficial for managing large-scale water distribution systems or remote natural water bodies. Its ease of installation and cost-effectiveness make it accessible not only to large corporations and government entities but also to smaller communities and organizations dedicated to environmental conservation.

Future Scope

The potential for future enhancements and developments in the Water Quality Monitoring System is vast and promising. Here are several directions for its evolution: **Integration with Advanced Analytical Tools:** Incorporating more sophisticated data analysis and predictive modeling tools can provide deeper insights into water quality trends and potential pollution sources, enabling proactive environmental management.

Artificial Intelligence and Machine Learning: By implementing AI and machine learning algorithms, the system could predict potential contamination events and optimize water treatment processes based on historical data patterns and real-time input sensors.

Expanded Sensor Capabilities: Future iterations could include additional sensors to detect more specific contaminants like heavy metals, pesticides, or microplastics, providing a more comprehensive assessment of water safety.

Mobile and Cloud Integration: Enhancing mobile connectivity and cloud-based data management would facilitate better access to data for stakeholders, improve the scalability of the system, and allow for seamless integration with other IoT devices within smart city frameworks.

User Interface Improvements: Developing more intuitive user interfaces for both the hardware and software components of the system will make it more user-friendly, allowingnon-specialists to perform and understand water quality assessments more effectively.

Energy Efficiency and Sustainability: Future developments could focus on improving the energy efficiency of the sensors and the system as a whole, possibly incorporating energy-harvesting technologies to make it suitable for deployment in more remote or resource-limited environments.

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