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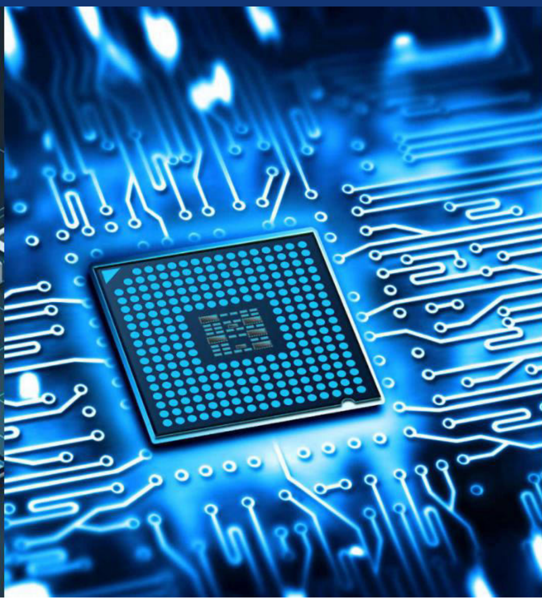


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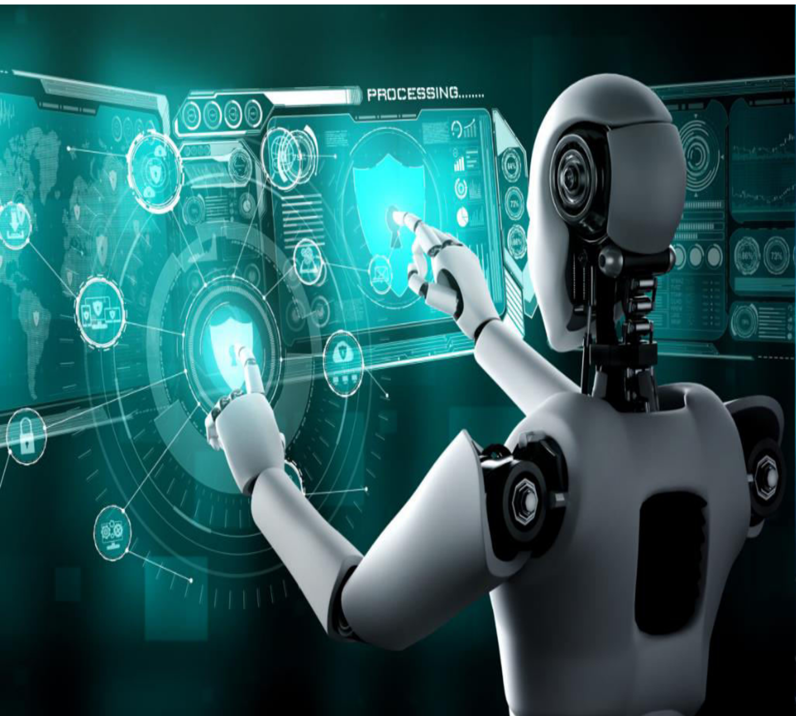

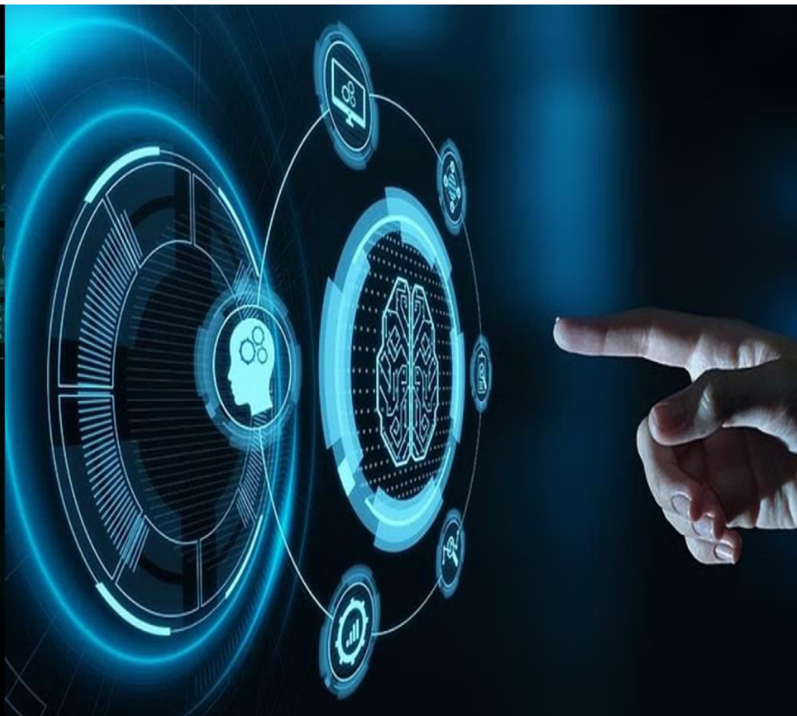

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Monitoring Input and Output Water Quality through Smart Sensing in Home Water Purifiers

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ABSTRACT: The smart home water purifier system proposed in this paper includes detection and control systems that receive and transmit input and output water quality data in realtime. To check the presence of impurities and to identify the safety of water, the system now comprises a TDS (Total Dissolved Solids) sensor used to measure the approximate level of dissolved solids in it. The flow sensor measures and records the flow rate and amount consumed with liters as the unit and has the capability of measuring leakages. The ESP32 microcontroller used in the design supports wireless connectivity for real-time notification and water quality and usage monitoring. The collected data is stored and analyzed in the analytical database to review the trends of historical data in water resource planning. This use of water quality monitoring technology provides homeowners with an effective way of enhancing their quality of health, safety, and sustainability.

KEYWORDS: TDS Sensor, ESP32 Microcontroller, LCD, Flow Sensor, pH Sensor

I. INTRODUCTION

Approximately 71% of the earth is covered with water, and water is one of the most important things in our life. However, the review shows that only about 3 percent of this water is safe for human consumption. Scarcity of water has become a big problem due to the growing number of people in the world and the changeful climate. As a solution to this problem, better water management practices should be developed.
Some literature has appeared over the last few years on the use of sensor technologies and IoT in the field. The efficient and immediate tracking of water quality and the consumption patterns, which are facilitated by these technologies, helps encourage timely decisions.

As a result, several important parameters must be evaluated when determining the water quality, including the pH level, the flow rate, and TDS. Another parameter that plays a crucial and significant role when checking the quality of water is the Total Dissolved Solids (TDS); these sensors measure those. Of all the parameters that need to be quantified to evaluate the quality of water, the acidity or basicity of water is thought to be extremely important, and it is measured using pH sensors. In this manner, flow sensors quantify the amounts of water that arise in some specified time period for effective rationing of the resource.

The purpose of this research work, therefore, is to design an intelligent water management system whereby proper utilization of data analysis, sensor technology, IoT, and the like will be used to observe water quality and consumption on a real time-basis. As outlined below, we are going to use an ESP32 microcontroller, the cloud-based data analysis system, a pH sensor, a flow sensor, and a TDS sensor. In addition, the given system also has an Android application through which the customers can get certain information about the quality of the water and the usage tendencies at present.

Real-time water quality and usage, identification of leaks and other related issues, and real-time water distribution are other applications of smart water resource management. There are always anomalies and circumstances that, if they occur, the system can alert the users and pass on notice to enable them to make proper constructive decisions. Although there are advantages associated with the suggested system, which includes the ability to evaluate the water's quality and the

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pattern in which it is used, identification of leakages and abnormities, and the ability to improve the water distribution system. The generated result may present the findings of any irregularities or issues to pursue and, as such, will inform and remind the users to take actions properly

II. LITERATURE

The high level of urbanization and industrialization has led to acute water pollution, hence the development of enhanced systems for the provision of clean and safe water. The literature presents several methods for the real-time monitoring of water quality by employing smart sensing technologies. One of the more common action plans is the application of an IoT-based system, which employs many sensors to detect features such as pH, turbidity, conductivity, and temperature. These metrics are analyzed in real time, and then the data is transferred to cloud environments in order to continue observations and receive inputs from users.

Low-cost in-pipe sensor networks can also be found in water transportation pipes; some work explores the use of such sensor technology to test distribution water quality. These systems employ electrochemical and optical technologies to identify the microbes and heavy metals, respectively. The output of data fusion algorithms is used to perform a comprehensive checkup of contamination concerns, and users are alerted. The other consists of transmittable sensing systems, with various probes measuring indices such as nitrate concentrations or phosphate concentrations, acidity, and temperature. Most of these systems incorporate machine learning techniques to enhance the detection sensitivity and, at the same time, provide information.

In addition, spectroscopic methods, particularly when combined with artificial intelligence, have been reviewed for evaluating factors like COD (Chemical Oxygen Demand) of pollution. These systems have multisensor fuses and neural network data analysis, hence making the monitoring of complicated water quality variables in real time feasible.

For domestic uses, systems have been designed to detect both water quality and water consumption. Often, these systems include smart meters as well as the online interfaces—the so-called 'dashboards'—for' monitoring the analytical values of water quality and/or usage patterns. In cases where one or the other of the parameters deviates from the established norms, the user gets an SMS or an e-mail to enable him to quickly take corrective measures.

Thanks to the smart sensing technology, many strategies for water quality monitoring are now available. A classic example of the use of this strategy is the IoT system, which is a collection of a number of sensor nodes that are used to, for instance, measure pH, turbidity, temperature, or conductivity. These systems use LoRa or Wi-Fi to transfer information to deployment platforms where current and archival data might be retrieved. This strategy makes availability possible and makes it easier for an organization to respond quickly to any kind of quality issue.

Another approach that is now under development is portable water monitoring systems equipped with sensors made of substances based on multiwalled carbon nanotubes (MWCNTs). These systems are quite responsive to some chemicals, including nitrates and phosphates. They often employ EIS (Electrochemical Impedance Spectroscopy) for quantitative measurement and incorporate it with machine learning algorithms on trends relating to water quality based on sensor data.

Similarly, pollution parameters have also been estimated with the help of spectroscopic techniques that comprise artificial intelligence. UV(Ultraviolet)-visible spectroscopic sensors acquire absorbance spectra and are later analyzed with the help of neural network analysis to derive values such as COD. These strategies give high accuracy, and they are very effective for the determination of organic pollutants in water.

The real-time monitoring systems have also been incorporated into domestic applications; this has been added. These include systems using solenoid valves that are established to regulate the flow of water depending on the quality parameters, besides the interfaces that use mobile applications or short messages to provide notifications. For such systems to facilitate full monitoring of drinkable water, the following are integrated sensors: dissolved oxygen, turbidity, and conductivity.

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In-pipe monitoring of water distribution systems has been made possible by the development of low-cost sensor networks. Often these networks incorporate multi-sensor nodes that are able to measure physicochemical conditions and observe contamination events. The most important feature of fusion algorithms is the use of detected sensor data; they help to delete false alarms and provide exact contamination notifications.

Further, energy-efficient solutions have been explored for water monitoring in low-resource environments. Techniques that involve energy collection by some systems, like the solar power system, make sensors installed in remote or different stations have a longer duration than any anticipated. Such apparatus facilitate the constant monitoring of water quality in most corners of the world without necessarily involving heavy maintenance charges.

IoT frameworks, new-generation sensing technologies, machine learning, and efficient power management solutions are well-established fundamentals for the current century's water quality monitoring systems. These approaches form the technical platform for the designing of smart sensing systems targeting input and output water quality for the home water purifiers inputs.

III. METHODOLOGY

1. Wireless Communication and IoT Platforms:

Wireless Protocols:

IoT systems use the ESP32 microcontroller, which supports various wireless communication protocols, including:

- **Wi-Fi** module is integrated into the ESP32 and helps in easy connectivity for local as well as remote monitoring.
- **Bluetooth** is a short-range communication system used for pairing with different mobile smart devices.
- ESP32 can be associated with the **LoRaWAN** modules for transmitting the signal to far destinations with low power. It also supports IoT platforms.

IoT Platforms:

- For storage, visualization, and alarming, the collected data from ESP32 is sent to basic platforms like ThingSpeak, Blynk, or even generic cloud dashboards.
- Real-time dashboards allow for user-friendly monitoring and tracking of water quality indices and trends in real time.

2. Sensor Integration and Data Acquisition:

Sensors Used:

Various sensors monitor essential water quality characteristics, such as:

- pH Sensor: pH sensors are used to measure either acidity or alkalinity - an important measure in detecting chemical pollutants.
- Turbidity Sensors: Estimate of cloudiness resulted from suspended particles that may contain contaminants.
- TDS Sensors: Use TDS to decide water quality besides ion concentration.
- Flow Sensors: Closely watch the traffic of water through the system, as they are relevant for measuring usage and normally include the aspect of leaking or blocking.

Hardware Interface:

Data acquisition is made easier thanks to the fact that the ESP32 microcontroller has its own ADC (Analog-to-Digital Converter) that can process analog signals smoothly.

3. Data Processing and Analysis:

Preprocessing:

In this work, preprocessing of data occurs on the ESP32 for noise reduction, normalization of readings, and also to detect abnormalities like very high turbidity levels implying the presence of pollutants.

Alternative to machine learning:

Rules-Based Systems: If values get out of the standard operating limits, programmed alarms set the criterion. For instance, low water flow may be an indication of obstruction, and it may have a value below which such a conclusion can be made.

Statistical analysis: The other approach will focus on future prospective problems by the use of time-series data and patterns.

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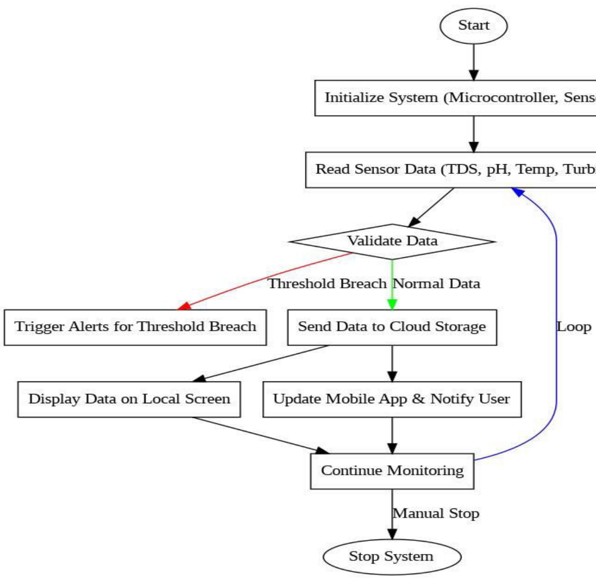
These issues allow long-term data analytics to discover annually recurring fluctuations of the water determination, enhancing the dependability and the prediction abilities of the system.

4. Cloud Integration and Remote Monitoring:
Cloud Services:
AWS IoT, Azure IoT, and Google Cloud IoT are some of the cloud platforms that are currently compatible with the ESP32, enhancing safe and scalable storage and access to data. APIs let the website interconnect with the user applications.
Mobile and Web Apps:
Mobile and web applications for cars allow the monitoring of use, use patterns, and notifications at a distance. Data is presented in easily understandable graphical form, and some graphical signs are used for water safety.

5. Notification and Alert Systems:
Threshold-Based Alerts:
Notification and alert systems utilize threshold types of warnings to send SMS, email, or push messages when TDS or flow rate is above or below certain set limits.
Dynamic Alerts:
Sophisticated systems use parameters that are adjusted by previous trends, hence minimizing false alarms and improving the sensitivity.
Predictive Maintenance:
Thus, real-time performance metrics effectively substitute actual information about maintenance requirements as, for instance, a filter.

6. Experimental Validation:
Laboratory Testing:
Pre-tests in real yet structured settings are performed to assess the reliability of the sensors as well as the stability of the whole system with confirmed water sample data.
Field trials:
Application cases in a home or an industry put the system through real-world values, including water pressure, flow, and temperature.
Performance Metrics:
Metrics reduce to the promptness of response, the precision of the sensors, the reliability of the system, and the speed of the data transfer. References to traditional approaches have invariably served to corroborate system improvements.

IV. FLOW CHART



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V. CONCLUSION

The Smart Water Monitoring System (SWMS) discussed in this paper involves the use of enhanced sensors and IoT to present a viable solution for online water quality/usage analysis. Hence, the system provides constant and accurate data of the water purity through the multi-parameter sensors in detecting the TDS, pH, turbidity, and temperature in the water. In addition, flow sensors offer accurate means by which the usage of water is monitored, hence encouraging the use of water sparingly.

Real-time data acquisition by using networks such as wireless network technologies like Wi-Fi or Zigbee makes remote monitoring through cloud-based platforms convenient and more under the control of the end user. Used in conjunction with alarm systems, corresponding elements of predictive analytics help to detect cases of water contamination early and respond to them appropriately. A chance to address increasing water scarcity and contamination issues is only achievable since the system is capable of overseeing water quality at individual home fronts and large industries.

The Smart Water Monitoring System (SWMS) discussed in this paper uses advanced sensor technologies as well as an IoT framework to introduce a viable solution for real-time monitoring of water quality and usage. The system provides steady and accurate information about the water quality by having multi-sensor parameters that can detect TDS, pH, turbidity, and temperature of the water. Furthermore, flow sensors used in the system ensure identification of the amount of water actually being used, hence encouraging proper usage of water.

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