AMERICAN Journal of Science on Integration and Human Development
Volume 02, Issue 06, 2024 ISSN (E): 2993-2750

Monitoring Water Quality Wirelessly While Preserving Water

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Abstract: Among all of Earth's resources, water is paramount. Water quality has declined to an extremely low level in the past fifty years, according to surveys. In addition to being a drink, it has other practical uses in the kitchen and the bathroom, and we rely on it in many ways. This is why its preservation and prudent management are of the utmost importance. Keeping track of how much water we consume is obviously important. We want to address these issues by implementing a pH-sensor water quality monitoring system. This system will allow us to more accurately analyse the water and keep tabs on it. Using the pH sensor to measure the water's turbidity and pH value allows one to determine the water's quality. The digital flow metre allows us to track the water usage at each apartment's inlets, and the system's live web page allows us to generate accurate bills for each unit, analyse the data graphically, and prevent water leakage by detecting open taps and providing an alarm if there is no flow. Data can also be wirelessly monitored. When the payment is not paid, we may also set it up to automatically cut off the water connection. So, we will be able to save water more efficiently thanks to this effort.

Keywords: Wireless, Water Quality, Management, Water Conservation, Managed Economically, Electronic Systems, Integral Part of The Internet,

Introduction

The increasing global population and rapid industrialization have made environmental pollution a major issue. Analysis of activities and their effects on the environment, mining, oil, and power plants necessitates water quality monitoring systems [7-12]. The estimation of values for a number of significant and indicative parameters is essential for water quality determination. Temperature, activity, flow rate, and the presence of volatile organic compounds are some of the factors that affect water quality. The design of electrical systems for environmental monitoring is not always simple, even while there are popular and extensively used methods for measuring these parameters with the right sensors. Some of the engineering problems include: (a) sensor nodes being placed in inconvenient locations; (b) the need for resilient and easily reconfigurable systems for long-term deployments; (c) the requirement that sensor nodes operate autonomously in the specified environment; and so on [13-19].

In addition, sensors in this field need to be accurate, long-lasting, very sensitive, highly selective, and require little in the way of maintenance. Many issues have been resolved with the advent of the Internet of Things (IoT) in the contemporary world [20-27]. The Internet of Things (IoT) is being used to monitor water quality in order to address a number of concerns, including data collecting, communication, analysis, and early warnings. But in order to incorporate this into the picture, certain protocols and technologies are mixed to produce the intended result. Governments can employ the IoT for public services in almost any situation. City sewage, water quality, and trash can data may be better tracked with the use of sensor-enabled devices. The use of such devices can also aid in the monitoring of forests, waterways, and seas. It is challenging to conceptualise many environmental phenomena due to their complexity [28-35]. The Internet of Things (IoT) is a relatively new paradigm in communication that predicts commonplace items will soon be able to connect to the Internet and communicate with people and other devices through the use of microcontrollers, transceivers, and appropriate protocol stacks. Water quality in parks, congested places, and fitness paths may be easily monitored with an urban IoT. To make this service a reality, the city needs to install water quality and pollution sensors all over it and make the data from these sensors available to the public [36-43].

Literature Survey

Ensuring the safe, economical, and efficient operation of industrial production processes relies heavily on accurate monitoring of multiphase flow characteristics. The water holdup and velocity can be measured using a system that combines electrical and ultrasonic Doppler measurements, which is built on a compact peripheral component interconnect (CPCI) bus. This integrated sensor is made up of an ultrasonic Doppler, two sets of capacitance plate sensors, and a six-ring conductance sensor. The measurement system is built with functional modules and is based on a field-programmable gate array (FPGA). The system's inter-board communication and adaptable programming make it suitable for a wide range of measurement needs. The CPCI bus is used to transfer the demodulated data to a host computer for additional analysis, in accordance with industrial data transmission standards and to enhance the system's extensibility. Water holdup and velocity measurement using the multimodal system exhibits stable and superior performance across all flow patterns, as shown in dynamic testing. The capacitance and conductance sensor was able to measure the water holdup with an RMSE of 3.02 percent and estimate the total superficial velocity through cross-correlation with an RMSE of 0.09 m/s. Furthermore, by integrating the area of the velocity profile, the pulse ultrasonic Doppler transducer could estimate the total surface velocity with an RMSE of 0.08 m/s [1].

Using solely the data gathered by water metres for flow, this article [2] discusses the necessity of categorising a community of water utility users according to their shared and unique characteristics. As a result of clustering, North American customers of individually metered water utilities can be better understood as belonging to either the "normal" or "strange" category based on their use habits. Not only does this study provide something new to the table, but it also addresses a real issue facing the utilities sector. In order to make the most of a utility's finite human, monetary, computational, and ecological resources, this paper presents an approach to agglomerative clustering that makes use of information theoretic distance measurements on Gaussian mixture models in a reconstructed phase space. When comparing Gaussian mixture models, the suggested weighted variation of information distance metric gives more weight to behaviours with more compact statistical distributions and less to those with wide variance. It adds

something new to the list of comparison choices that already exist. To prove that the clustering findings are logical and consistent, we do multiple tests using both actual and synthetic data.
By promptly identifying both minor and big leaks in water distribution pipes, proactive maintenance and repairs may be carried out, reducing water loss and extending the life of the network. Modern acoustic leak detection techniques are more suited to inspections that probe periodic, short-term data collected during the inspection process than to handling massive amounts of long-term data collected from monitoring programmes. Delineating weak leak-induced signatures in the extremely noisy and nonstationary auditory environment typical of uncontrolled, real-world operational water distribution systems is a common difficulty encountered in acoustic inspection methods and long-term monitoring of acoustic signatures. Without depending on controlled trials to gather data or expert user knowledge, it aims to solve the leak detection problem by characterising operational circumstances using long-term acoustic data monitoring. The main thing we've done is come up with a novel data-driven method that uses association rules (ARs) to pull data out of massive amounts of monitored acoustic data. This method can detect leaks even if the changes are modest. A leak indicator is developed to measure the deviation of leak-induced data from a reference leak-free model. It is achieved by using ARs to model and synthesise the information contained in long-term monitored acoustic data, and by identifying associations between statistical features obtained from these measurements. It will be demonstrated that the suggested indicator is effective in uncontrolled long-term monitoring scenarios, has a high detection rate, and can identify minor leakage [3].
Energy storage and Power-to-X applications will benefit from renewable hydrogen, which can be produced using water electrolysis in future renewable energy-based energy systems. As a result, hydrogen production's energy efficiency is likely to emerge as a key concern. In this work, the specific energy consumption of megawatt (MW)-scale alkaline electrolyzers is analysed and compared with an ideal DC power supply, as well as the effect of practical supply power converters. With regard to conventional thyristor rectifiers and converters based on transistors, the present quality and stack-specific energy consumption are investigated. The electrical equivalent circuit of the electrolyzer stack and the simulated current waveforms are used to examine the stack-specific energy consumption. When the current fluctuates between 5000 and 1000 A, the transistor-based converter provides electrolyzer stack specific energy consumption that is up to 14% lower than that of the 6-pulse thyristor rectifier and up to 9.2% lower than that of the 12-pulse thyristor rectifier. Reconciler losses are overshadowed by the predicted shift in stack-specific energy consumption for the MW-scale alkaline water electrolyzer. In addition, compared to transistor-based topologies, thyristor rectifier topologies may be more sensitive to the AC voltage level selection's negative impact on stack-specific energy consumption [4].

Policies aimed at improving energy efficiency must include measures to lessen the load on power grids that supply water to cities and other metropolitan areas. Water systems in Italy use about 2.3% of the country's total electrical energy usage, making cost reduction a top priority. Specifically, it examines the urban water systems in one section of Italy's Piedmont Region, breaking down the data collecting process and looking at how seven major water providers used energy. Using variable-frequency drives for the centrifugal pumps, power factor correction, and replacing current transformers with high-efficiency transformers can reduce energy usage, which is quantified in the discussion [5].

A mathematical model that is ideal for evaluating distributed water supply systems that use a two-stage pump station is presented. To reduce the overall power consumption of the system, a mathematical model is developed that takes into account rural water demand and time-of-use energy pricing, two factors that influence operation costs. One benefit of achieving optimal control of the system is achieving an improved dynamic programming algorithm (IDPA), which in turn reduces the cost of electricity. A rural deep-well water delivery system is used to accomplish consumption in a high-altitude environment. When compared to more traditional methods of controlling water levels, the IDPA can drastically cut down on simulation energy costs. In comparison to the branch-and-bound approach, it also shows that it can reduce computing time. The application's output demonstrates an effective model for energy optimization. Water distribution, sewage treatment, and storm drainage are all areas of municipal engineering that can benefit from the study's potential energy-saving approach [6].

System Analysis

For the sake of the industrial production process's safety, economy, and efficiency, the current technology guarantees precise measurement of multiphase flow characteristics. To detect the water holdup and velocity, a system based on the Compact peripheral component interconnect (CPCI) bus is used, which combines electrical and ultrasonic Doppler measurements. The following are some of the most important flawed and careless aspects of the current systems:

Proposed System:

Using this method, water quality can be measured and water consumption may be automatically calculated for each apartment in a building.

To find out how good the water is, the device employs a pH sensor to assess its pH value.

One new feature of this system is the computerised water metre. Using a live web page and a digital flow metre, we can acquire the flow consumption of each inlet of the flat, and we can also generate an accurate water consumption bill for each flat, with graphical analysis of data.

To prevent total water loss, the system excels at detecting leaks, open taps, and the absence of a flow detection alert.

Data can also be wirelessly monitored. When the payment is not paid, we may also set it up to automatically cut off the water connection. So, we will be able to save water more efficiently thanks to this effort.

System Study

In this stage, the project's viability is assessed, and a business proposal is submitted along with a high-level project plan and approximate costs [44-51]. The suggested system's feasibility research needs to be executed during system analysis. This makes sure the business won't have any problems with the suggested system. Familiarity with the system's primary needs is crucial for conducting a feasibility study.

Technology and System Feasibility

An outlined design of the system needs in terms of inputs, processes, outputs, fields, programmes, and procedures forms the basis of the evaluation [52-57]. Feasibility is the analysis of the basis

outline; this allows one to assess whether the new system will work effectively by quantifying data volumes, trends, update frequency, etc.

Most often, the efficacy of a new system is assessed by economic analysis. Often referred to as a cost-benefit analysis, this process calculates the potential savings and advantages of a potential system and then compares them to their associated expenses. Designing and implementing the system is decided upon if the advantages surpass the disadvantages. Before taking any action, an entrepreneur must carefully consider the pros and cons [58-67].

How effectively a suggested solution addresses the issues is measured by operational feasibility. It makes use of the possibilities found during the scope definition step and how it meets the needs found during the requirements analysis phase of developing the system [68-73].

When a project's completion time exceeds its usefulness, it is considered a failure. This usually entails making an estimate of the time required to construct the system and whether or not it can be finished within a specified time frame using techniques such as a payback period. Timeline feasibility refers to how realistic the project's timeline is [74-81]. Are the projected completion dates fair, considering our level of technical competence? Timeliness is of the essence while starting some tasks. You should find out if the deadlines are required or optional; that would help.

Software Description

Code refactoring and IntelliSense (a code completion component) are both built into Visual Studio's code editor. You can use the integrated debugger to debug at both the source and machine levels. Code profiles, web designers, class designers, database schema designers, and designers for creating graphical user interface applications are among the other built-in tools. Supporting source control systems like Subversion and Git and introducing new tool sets like editors and visual designers for domain-specific languages or toolsets for other parts of the software development lifecycle are just a few examples of how plug-ins increase its capability at practically every level. The Community edition of Visual Studio, which is the most basic version, is available for free. A free, fully-featured integrated development environment (IDE) for individuals, open-source projects, and students is the tagline of Visual Studio Community edition.

Xampp

The Apache HTTP Server, MariaDB database, and interpreters for scripts written in Perl and PHP make up the bulk of XAMPP, a free and open-source cross-platform web server solution stack bundle created by Apache Friends. You may easily go from a local test server to a live server using XAMPP because it uses the same components as most real web server implementations.

With XAMPP, a developer may easily install a WAMP or LAMP stack on an operating system. What's more, popular add-on programmes like WordPress and Joomla! can also be installed with the same ease using Bitnami.

CVAVR

For the AVR8, AVR8X, AVR DA, and XMEGA processors, CodeVisionAVR is the sole IDE available with CodeWizardAVR, an Automatic Program Generator. In addition to its own integrated development environment (IDE), CodeVisionAVR V3 is now available as an Extension for Microchip Studio 7.

System Implementation

Power Supply Module: A step-down transformer, which converts 230 volts to 12 volts, is part of the power supply circuit. A bridge rectifier, made up of four diodes, provides the capacitor filter with pulsating DC voltage in this circuit. The rectifier's output voltage is sent via the filter to remove any remaining a.c. components.

Sensing Module

The potentiometric measurement of hydrogen ion concentration or activity, or pH, in an aqueous solution can be accomplished with the help of a pH metre.

A glass electrode, a reference electrode made of calomel, or a mix of the two are common components. While standard pH metres are designed to measure the acidity or alkalinity of liquids, semi-solids may occasionally need the employment of specialised probes. Two pins, one for transmitter and one for receiver, make up a pH sensor.

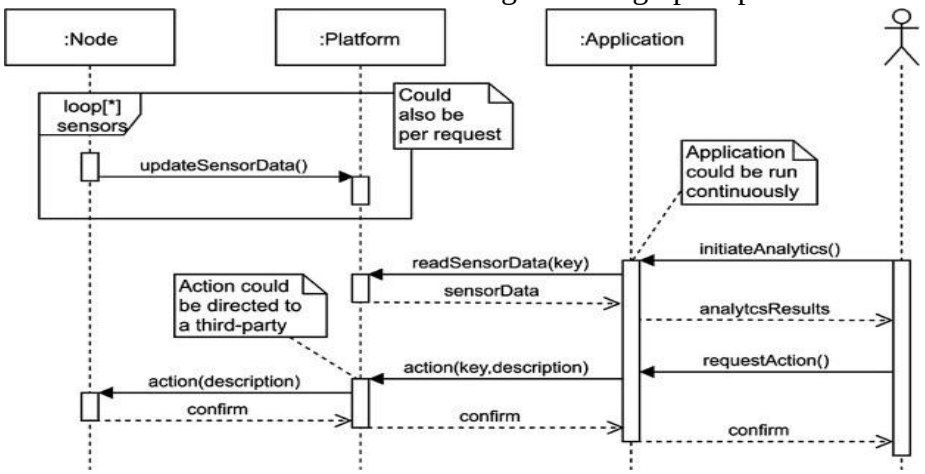
Turbidity Sensor: In the context of fluids, turbidity refers to the degree to which suspended particulates, which are typically imperceptible to the human eye, cause the fluid to appear cloudy or hazy. The amount of light scattered by suspended solids in water can be measured by turbidity sensors. A higher concentration of total suspended solids (TSS) causes a more turbid (or cloudy) water [82-95].

A plastic valve through which water can flow makes up the water flow sensor. To detect and quantify water flow, a hall effect sensor and a water rotor are utilised. The rotor is spun as water passes through the valve. You may see this shift in the motor's speed. A pulse signal is produced by the hall effect sensor after it estimates this change. So, the water's flow rate may be found [96-101].

Module for Gateway Intermediary: The ESP8266 acts as a bridge between the hardware and software components. One inexpensive Wi-Fi chip that can function as an MCU (microcontroller unit) that has a complete TCP/IP stack is the ESP8266. Many hackers were interested in exploring the module because of its low price and the fact that it had few external components, both of which indicated that it may someday be produced in large quantities at a low cost [102-107].

This system relies on the microcontroller module, which takes sensor input, processes it, and then outputs the results. It notifies you whenever it detects an alert and calculates the LPM, daily water usage, and overall consumption. It monitors the system's water flow rate. In this case, the processing module is an ATmega16 microcontroller [108-113].

Dashboard for the Front End: This section allows us to keep tabs on data wirelessly using an app built on the node platform. To build the app's front end, developers employ HTML and CSS. Nodejs Downloading the monthly invoice and comparing the cost per day of usage are both made possible by this module. We can also monitor the usage data in graph representation to make easy



analysis possible (Figure 1).

Figure 1: Sequence Diagram

System Testing

In preparation for Information and Technology Services' PeopleSoft upgrade, we have prepared this testing strategy paper. The paper provides a high-level outline of the testing tasks that need to be executed in the event that an application is enhanced, upgraded, or new modules are added to the existing programme. Critical business operations, testing time minimization, and risk mitigation are the primary goals. It's worth noting that the likelihood of issues after going live is increased when testing is reduced during upgrades. It is up to management to decide, upgrade by upgrade, how much risk is acceptable [114-121]. After the integration testing phase collects all the integrated modules of the individual components, system testing takes it a step further by combining all the elements into a system and testing it as a whole. Now that all the components are working together as one system, it is necessary to test the system to identify and fix any mistakes or issues. In addition to looking for bugs, system testing also determines if the system performs as expected, defines its functionality, and meets the expectations of the end user [122-128].

Individual pieces of source code, groups of one or more computer programme modules, related control data, usage processes, and operating procedures are evaluated for their suitability for use through unit testing, a software testing approach in computer programming. A unit is the smallest component of an application that can be tested, as one might expect. A module is one possible unit in procedural programming, while functions and procedures are the most popular types. A full interface, like a class, or even just a single method can be considered a unit in object-oriented programming. Short pieces of code called "unit tests" are written by developers or, on occasion, white box testers. In a perfect world, every test case would run on its own. To help test a module independently, you can use test harnesses, mock objects, fakes, and method stubs. Unit tests are commonly used by software engineers to verify that code is designed to work as expected and conforms to specifications.

Complete and integrated software is tested at the system level of software testing. To determine whether the system meets the defined criteria, this test is conducted.

To ensure the correct operation, performance, and dependability amongst units and to reveal any interface problem, software components are bundled together and tested in big aggregates after unit testing. Integration testing describes this procedure.

Using a hierarchical path, incremental testing is a classic method of testing that adheres to tradition. Another way to break it down is into two days:

First, top-level integrated units are tested using top-down testing. Then, lower-level modules are examined step-by-step.

Bottom-Up Testing: Unlike the traditional top-down strategy, this methodology allows testing to begin at the lowest level and work its way up the hierarchy. It is commonly used in situations when a bottom-up approach to development is taken.

One method that combines elements of both top-down and bottom-up testing is known as sandwich testing.

Big Bang Testing: This method involves testing the majority of software modules simultaneously. While Big Bang testing does speed things up, the results aren't always spot on. Because of this, the development team may encounter difficulties and be unable to complete their testing objectives.

Acceptance Testing

The purpose of acceptance testing in engineering and related fields is to verify that the agreed-upon specifications and contractual obligations have been satisfied. It could include tests of physical properties, chemical analyses, or performance.

Software, large quantities of produced mechanical parts, or chemical product batches are all examples of systems that might undergo black-box testing as part of systems engineering prior to delivery.

Before agreeing to a transfer of ownership, software developers will typically differentiate between system provider acceptance testing and customer acceptance testing. User acceptability testing (UAT), end-user testing, site acceptance testing, and field acceptance testing are all terms used to describe customer-performed software acceptance testing.

Before adding a build to the main testing process, it is common practise to conduct an acceptance test using a smoke test.

Conclusion

It will illustrate the successful implementation of a real-time technique to measuring water quality and usage that is based on the internet. The disadvantages of conventional water metering systems can be circumvented by utilising a flow sensor to measure the quantity of water that is given.

Prepaid billing and automatic water treatment based on the type of contamination are two examples of systems that fall under this category. As a result of the elimination of the difficulties associated with traditional water metering systems, automated invoicing will be implemented using water metering systems. In the future, there will be effort done to extend the network to a larger area by utilising routing algorithms that are more efficient. Integration of turbidity, dissolved oxygen, and colour sensors into the sensors that were used in this work is another example of work that will be done in the future.

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