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Smart Water Automation System

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***Abstract*— The Smart Water Automation System automates the process of monitoring and controlling water levels in storage tanks through a microcontroller-controlled unit and sensors that operate in real-time. The water management practice where the system will be used usually requires that someone almost always be on the site to supervise it. This has resulted in problems like overflowing of tanks supplying water to nowhere, energy- consuming operating times of the motor that eventually leads to its failure.**

***Index Terms*— Marathi NLP, Word Sense Disambiguation, IndicBERT, Linguistic Preprocessing, Contextual Embeddings, Low-Resource Languages.**

I. INTRODUCTION

Water is one of the natural resources that are most essential for human beings, agriculture, and industrial development. The rising population, rapid urbanization, and unpredictable climatic conditions are the main reasons why the demand for water is increasing and at the same time, its availability is getting limited. Still, in a lot of households, residential buildings, farms, and factories, the water storage tanks are monitored and managed manually. This traditional method often leads to several problems which are waste of water due to overflow, shortage of water due to late motor activation, and even damage to pumps because of the running condition. Constant attention of the human eye is required when monitoring manually and it is also ineffective and susceptible to errors. The above-described problems serve as a distinct identification of the need to have an automated, reliable and intelligent water management system. The Smart Water Automation System is the answer to all these problems as it presents a complete automation solution for water level monitoring and pump operation controlling. The system makes use of water level sensors as the technology of detection of tank state (empty, partly full or full) which are put at different heights inside the tank. The system has a user-friendly feature that includes the OLED display that shows the water level and the status of the pump in real-time. Another accessory that comes with the device is a buzzer which is used for alert notifications, for example when the tank is full or almost empty.

II. LITERATURE SURVEY

Unlike existing Marathi Word Sense Disambiguation approaches that rely on static word embeddings, supervised The research on water management automation has been a hot topic because of water scarcity and the limitations of manual operation of pumps. An automatic water level control and monitoring system based on basic sensors and a micro controller was introduced by Gaikwad et al. [1].

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Their method resulted in less human involvement and no overflow but did not provide advanced monitoring capabilities. Narkhede and Wani [2] have designed an IoT based general water tank management system based on Nodes MCU and ultrasonic sensor to monitor their water tanks, which is integrated with cloud server to transmit data. Nonetheless, this system could not work in the absence of the internet connection. Like them, Ghorpade et al. [3] and Kumar and Singh [5] designed low-cost, microcontroller-based automatic water level controllers, based on the float sensor and conductive sensor. These systems could carry out simple automation processes, but the amount of interaction between the users and the systems was extremely minimal, and there was no way of notifying the users and information was shown. A prudent water management system using IOT that was proposed by Bhattacharya and Bhowmik [4] linked wifi devices and cloud services to research the consumption trend. The researchers confirmed that IoT was highly helpful in driving the data analytics but it had a disadvantage of complicating the system. The design of embedded water automation systems is being aided by such technical documentation materials as the STM32 Reference Manuals [6], the STMicroelectronics portal [7], and the Arduino documentation [8], [9]. Datasheet of sensors KY-017 and KY-029 [10], [11] includes the correct amount of information about the interface to integrate the hardware in a reliable manner. In a recent study article published by IEEE [12], [13], there has been a demonstration of the application of current smart water monitoring methods like cloud based dashboards, machine learning and tapping detection. The articles by Electronics For You [14], [15] are actual life examples of the automation of pumps implemented by the use of embedded technology which is not expensive. The literature in general is inclined towards the movement of mere sensor-driven automation to the level of IoT-based smart systems. The features of the older models were that they were a low-tech, low-cost, and local system, whereas the new models have the feature of remote monitoring, alerts, and analytics to it, but is based on network access and affordability. The proposed Smart Water Automation System builds on the advantages of the dependability of local automation as well as the real-time display and alert capabilities and remains scalable to the capabilities of the IoT in the future.

III. PROBLEM DEFINITION

Manual operation still prevails in various places like homes, industrial setups, farms, and water tanks of all types. Users are required to check the water level manually and turn the motor ON or OFF according to the water level which is not only a waste of time but also an inefficient and error-prone process. If the motor is on for an extended period, the tank overflows, and the water wasted is significant. On the other hand, if the motor is not switched ON when needed, the tank might run dry resulting in inadequate water supply and dry running of the motor which can eventually ruin the pump owing to overheating and burnout. The manual method of monitoring is more troublesome for multi-tank systems, extensive buildings, and places where users are not always there to control pump operation. Moreover, conventional systems do not keep the user updated with real-time information regarding tank status, alerts, or proper shutdowns of the overflow, or motor burnout. Hence, the main issue is the unavailability of an automated, trustworthy, and smart water management system that can oversee tank levels and operate the motor without the need for human involvement. The demand is for an automatic water level controller that has a low price, is effective, and is user-friendly, which not only ensures the minimum filling of tanks but also saves the water, protects the motor, and decreases the need for manual operation.

IV. METHODOLOGY

In numerous locations, including households, industries, agriculture, and all types of water storage, manual operations have not yet been replaced. People still have to check the water levels by hand, and depending on the result, they either switch the motor on or off, which is not only a time-consuming task but also an inefficient and error-prone process. If the motor stays on for too long, the water tank overflows, and the waste of water is remarkable. On the contrary, if the motor is not turned on when required, the water tank can run dry which means no water supply and continuous running of the motor that can eventually lead to the pump getting ruined due to overheating and burning out. The manual method of monitoring is more burdensome for multi-tank systems, extensive buildings, and staff-less places. Furthermore, conventional systems do not keep the user updated with real-time information concerning the tank status, alerts, or proper shutdowns of the overflow or motor burnout. Therefore, the principal challenge is the lack of an automated, reliable, and intelligent water management system that monitors tank levels and controls the motor without human intervention. An automatic water level controller is called for which is low-priced, efficient, user-friendly, and does not only assure the least possible filling of tanks but also saves water, protects the motor, and reduces the need for manual operations.

The Smart Water Automation System has been developed through a strict and extensive approach that considers the analysis of requirements, prototype development, and performance assessment as the key phases of the project. The initial step, explored all the problems that the old water systems possessed such as overflowing, dry up as well as manual monitoring as a way of monitoring. After that, an extensive literature analysis and patent research assisted in clearing up the existing market, technological gaps, as well as the field of innovation. System architecture was then created upon the requirements that incorporated, among others, block diagrams, workflow, and circuit schematics. Included parts installed like ESP32/ NodeMCU microcontroller, water level sensors, 4 channel relay module, solenoid balls, a pump, OLED display, and PVC hardware among others were chosen based on cost, quality and durability. The construction of a physical prototype was the next operation that needed the assistance of PVC pipes, fittings and plastic tanks that would represent a real multi-tank environment. Sensors have been fitted in their respective positions inside each tank and wiring had been made to relate to the sensors, relays, and valves as well as the display to the microcontroller. The software design included writing code that would run the embedded system to read sensor values, implement control logic, control relay operation, update OLED display, and alert via buzzer. The Lowe, Mid, and HIGH levels threshold values were established and adjusted in the process of testing the programs. The system was then subjected to a thorough testing period involving various conditions like filling of tanks with fluid, valves switching, pumps on or off and also when it is in low water condition. The criterion of the evaluation was the response time, precision, reliability and the energy consumption evaluation as consideration of the system robustness as shown in Figure 1.

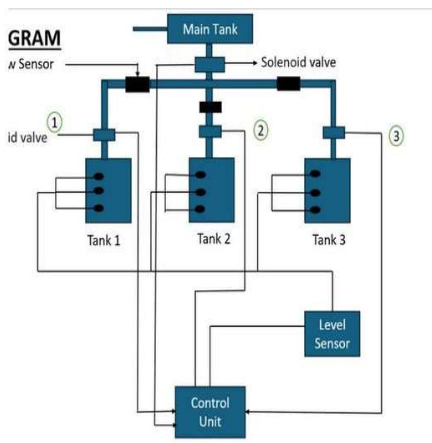

Figure 1: Block Diagram

The final step of methodology was the results analysis, the performance observations registration, the identification of its limitations, and the recommendations on the future improvements in scalability and the implementation of IoT. The fully operational, trustful, and efficient Smart Water Automation prototype was developed based on a solid methodology as shown in Figure 2.

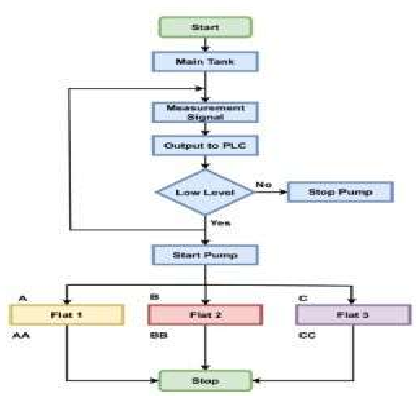

Figure 2: Flowchart of Model

The automated water distribution is done through the flow diagram presented below. To start with, the level in the main reservoir is checked; water level is measured and the location is transmitted to the PLC/control unit. Based on this measurement, the controller judges whether the water level is low. In case the level is not low, the system keeps the pump OFF. In case of a low-level condition, however, the controller switches on the pump to fill the storage lines that are connected. Subsequently, water comes through three different levels, interpretation levels 1, 2, and 3-respectively, including A, B, and C sections. Water is delivered to each flat through its specific branch until all sections reach the desired level. The system then automatically turns off after water distribution is completed, thus entering the stop state and guaranteeing an efficient and controlled water supply without the need for manual intervention.

TABLE I. COMPONENT USED IN SYSTEM

Sr. No.	Component	Specification
1	Microcontroller (ESP32/NodeMCU)	32-bit MCU, 3.3V logic, Wi-Fi capable
2	Water Level Sensors	Float / Conductive, 3-level detection
3	Relay Module (4-Channel)	5V coil, 10A contact rating
4	Solenoid Valves	12V DC, Normally Closed
5	DC Water Pump	6–12V DC mini pump
6	OLED Display	0.96 inch, I2C interface
7	Buzzer	5V active buzzer
8	PVC Pipes & Fittings	½-inch pipes, elbows, tees
9	Prototype Tanks (Plastic Containers)	Transparent, 1–2 L capacity
10	Power Supply Unit	12V and 5V regulated supply
11	Connecting Wires & Cables	Jumper wires, multi-core wiring

V. PROPOSED SYSTEM

The Smart Water Automation System suggested in this paper and its components are given in Table I, such that complete solution automatically controls the flow of water from the main tank to the secondary tanks that are placed at different locations with the help of a sensor-based control and a microcontroller. The PVC pipeline network connects the main storage tank to the three individual ones, each equipped with a 12 V DC solenoid valve. Water level sensors are installed in every tank at various heights to identify LOW, MID and HIGH levels. These sensors send digital signals to an ESP32/Node MCU microcontroller continuously, which is the central control unit. The control unit, based on the sensor input, determines which tank needs water and activates the relay channel corresponding to that tank to open the solenoid valve of the tank. A DC mini water pump pulls water from the main tank and sends it through the pipeline to the chosen tank. When the tank level reaches HIGH, the controller shuts the valve and hence, the inflow is stopped which prevents overflowing. The main tank has an additional sensor that is used to shut the pump off when the water level in the tank becomes too low in order to prevent the pump from running dry. Also, an OLED display is integrated into the system, which shows the real-time tank and pump status along with a buzzer that generates audio alerts during critical conditions (like main tank empty or abnormal operation). The system operates on a single 12 V, 5 V power supply to supply power to all the components and the relay circuit is used as a non-grounded electrical isolator between the low voltage control signals and the high voltage actuators. The system architecture is both scalable and modular in nature such that an IoT could be included in the system and would provide ability to monitor remotely, send alerts via mobile in the future, as well as data log in to the cloud.

VI. OBJECTIVES

To design a microcontroller-based control unit (ESP32/Node MCU) that processes sensor data and intelligently controls solenoid valves and the water pump. The objective of the project is to implement an intelligent microcontroller-based control unit (ESP32/Node MCU) that will automatically do the controlling of solenoid valves and water pump in a smart manner based on the sensor data. The second objective is to completely automate the flushing operations so that there is no manual intervention involved by monitoring the tank levels and distributing the water automatically. Thirdly, the project will use accurate sensor feedback and control of valves to ensure that there is no overfilling of tanks and wastage besides this, the project will monitor the levels in the main tank and will switch off the pump when there is no water to keep the pump from running dry. In addition, the project will give real-time feedback to the user by means of an OLED display and buzzer alerts will be used to indicate the system status as well as critical warnings. Along with that, the aim is to develop a prototype that is low-cost, energy-efficient, and scalable which can be used for household, agricultural, and small industrial water management applications. Finally, a modular design would be created that would allow for future upgrades like the integration of IoT, mobile control, and analytics for smart water management.

VII. Results

The Smart Water Automation System was carried out and experimented in a running multi-tank model with immense success. The system was demonstrated to be valuable in terms of precision in detecting the water level, rapid response time, and efficient automation of the pump and solenoid valves. The testing has been done with the level sensors that accurately identified LOW, MID, and HIGH levels of each tank that in such a manner allowed the microcontroller to make relevant decisions. Response of the relay module to the controller signals was fast and the relay solenoid valves change their status smoothly ON/OFF, which, in turn, guaranteed the maintenance of the water flow. The method used in the system to avoid overflow was quite effective since the solenoid valves were immediately closed when the HIGH level was achieved. The connecting valve was automatically opened every time a tank was at the LOW level, therefore commencing the process of filling. Moreover, the main tank level sensor was quite stable and could not only avert a dry run but also be capable of halting the pump in case there was no water in the source tank. Therefore, this was a twofold protection of pumps and secure operation procedure. The OLED display continued to display the tank status and pump activities in the simplistic and real-time fashion; the buzzer was very fast to alert as well as very precise to notify the user in an eventuality like the tank empty or full prevention which were the crucial ones. The continued testing did not indicate any difference in performance and no activity alternate or malfunction was observed. The prototype had the capability of meeting the concurrent needs of multiple tanks hence proving its ability not only to be independent but also to coordinate the water distribution as shown in Figure 3.

Figure 3: Prototype of the Smart Water Automation System.

This reservoir is connected to 3 secondary tanks which are independently connected with the help of pipes and each of which works on a separate 12V solenoid valve installed into the center. With the PVC piping system, distribution of water is even and simultaneously, there are manual valves to adjust the flow in case of the test. A tank is put on an elevated platform to afford adequate gravitational positioning, and also to facilitate easy observation of the water level changes. Solenoid valves and sensors are interconnected to the electrical side of the control board that has the microcontroller and relay module to handle all the operations of the automation. This actual prototype supports the fact that the proposed system could be able to fill the tanks automatically, prevent leakage, and manage the movement of water in a real environment.

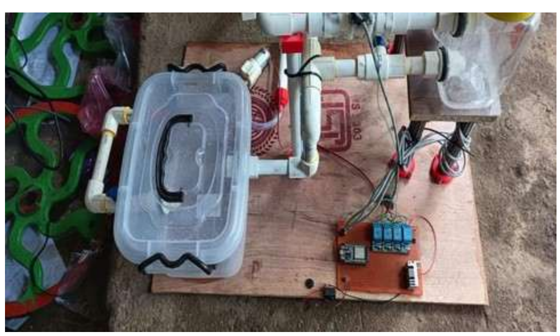

Figure 4: Overview of Model

Figure 4 illustrates the entire hardware implementation of the Smart Water Automation System which consists of the major reservoir, a PVC pipeline network, solenoid valves and an electrical control ingraffed. It has a transparent container, which is the main tank, which is linked to the distribution PVC pipes that conduct water to the individual tanks using the controlled solenoid valves. Special care is taken in tracing the wires out and to the control board where all the wiring of the valves and the sensors is neatly traced to the board where the ESP32 microcontroller and a 4-channel relay board to switch the pump and valves are located. All the system is attached by a wooden base to gain stability and appropriate position of the pump, piping and electrical parts. During the functioning panel, the microcontroller monitors the water-level indicators of all tanks and consequently activates the pumps besides closing the corresponding solenoid valves according to the demand. This prototype offers a beautiful illustration on how the automated system works in maintaining the control of the water levels without human intervention, therefore, enhancing smooth flow of water, proper sensing, and efficient control of the valves.

VIII. Conclusion

The Smart Water Automation System improved manual control over water tanks which is characterized with complications by offering a smart water management system, sensor-based, and with full control of water tanks. All composite parts of the system such as the water level sensors, microcontroller, a relay module, the solenoid valves, and the DC pump are interconnected with good monitoring and effective control mechanisms to provide smooth distribution of water between the tanks. The prototype proved to be operating continuously in terms of leaking, draining and constant level of water without human input. The immediate response of the OLED display and buzzer improved the interaction of the system users and ensured delivery of prompt perhaps messages in emergencies. The information received shows that the planned system would be able to work with a high level of accuracy, reliability and power saving. The modular design is not only able to scale up the system instantly but also to add futuristic monitoring and predicative water management capabilities to it with the use of IoT. The overall project has had an opportunity to develop low cost, eco-friendly, and easy to use smart water management system that can be implemented in houses, apartments, fields, and small-scale industries; therefore, the primary goal of the project being achieved. It will be a significant source of water conservation as well as this system will make the use of resources smarter both in cities and in rural regions.

Future Scope

The Smart Water Automation System has already shown a high potential improvement and a massive implementation in the future. The one that is most important is the adoption of IoT and connected cloud, making the users be able to check the level of water, control pumps, and receive notifications everywhere via a mobile app. Machine learning algorithms that result into the optimization of operations can be used to analyze the daily patterns of water consumption, forecast demand, and optimize the work of artificial pumps, which results in increased efficiency. The system might be expanded to include large residential areas, farms and industrial water systems where hundreds of tanks and pumps could be connected to a central control unit. Top of that, the method used to measure the level of water without touching it with a highly sensitive capacitive or ultrasonic sensor is bound to be much more accurate and would lead to minimization of maintenance which is usually one of the causes of corrosion or sediment. In addition to that, the system might also have flow sensors and leak detectors that would automatically alert to losses in terms of water and allow tracking consumption in real-time. The whole system is power able using solar power thereby rendering it eco-friendly and an appropriate option to the rural or off-grid settings.

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