IoT : Automatic Water Dispenser Using Arduino

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I. Introduction

For the Indonesian people, using a manual gallon water dispenser is still considered more practical, easy, and affordable than using modern drinking water dispensers, because the more sophisticated a dispenser is, the harder it is to understand, especially for the elderly. Moreover, there are other problems such as the inefficiency of using manual gallon water dispensers [1].

Currently, filling drinking water using a manual dispenser takes quite a bit of time, causing many workers and students to delay refilling their drinking water when they are engaged in tasks that cannot be postponed or left behind, which often proves to be inefficient in terms of time. However, the difficulties are not only faced by students and workers, but also by young children, the elderly, and those with physical limitations.

All people with disabilities also experience many obstacles in carrying out social interactions in everyday life. Especially for blind people who have limited vision will have difficulty in carrying out their activities. A simple example is taking water for drinking in a dispenser [2]. They will have difficulty in pressing the button or pumping the level to fill the water, while they have to hold their bottles of varying sizes. This is a special concern for young children, the elderly, and people with disabilities who have limited physical abilities

Not only that, based on research conducted at the University of Wisconsin, United States, comparing drinking bottles brought by school students and found the number of bacteria was greater than in the toilet. It was studied that within 4 hours of being filled, there had been significant bacterial growth [3]. Often when filling water, the lip of the glass often comes into contact with the mouth of the water dispenser, causing contamination so that if the bottle is easy to become a breeding ground for bacteria to spread to the mouth of the dispenser where the water comes out.

Seeing many problems from various circles, we developed a gallon drinking water dispenser technology that can fill water and stop automatically without having to press a button or pump. This dispenser is also equipped with a sensor that can measure the volume of water and the size of the glass or drinking bottle, the results of which will later be calculated when the water is full so that it will not cause waste or spillage of water. We also added an alarm that can sound when the glass or drinking bottle is full, which can be a reminder for the user.

II. Literature Review

A. *Conventional Electronic Approach*

The non-microcontroller approach uses a basic circuit based on IR sensors, transistors, and relays that has been studied by Gagana B S, et al. (2023) [4] and Bagas Alvando (2021)[5]. This system has the ability to automatically activate the pump when it detects a human hand, but unfortunately it is not equipped with an intelligent processing system and automatic stopping based on volume. Conventionally, it is very profitable in terms of cost, but limited in terms of flexibility and accuracy.

B. *Microcontroller*

The use of microcontrollers, such as Arduino Uno and NodeMCU which are used as control cores through the integration of gesture, ultrasonic, and temperature sensors allows the system to respond more accurately to environmental conditions and user interactions, based on studies conducted by Yudi Kristyawan, Zahid Faizal Kholil (2021) [6], Ali Nur Fathoni, et al. (2020) [7], and Suhas. B. Khadake, et al. (2023) [8]. With a microcontroller and its control logic, it is able to perform automatic stops based on certain conditions.

C. *Automatic Volume Measurement*

Rido F. Sihotang & Ricky Maulana (2024) [9] is the main focus in the development of an automatic water filling system based on flow sensors using flowmeters and proximity sensors. This system is able to calculate the volume of water based on pulses from the YF-S201 sensor and automatically stop the flow of water after the target volume is reached, reflecting the direct implementation of a volume-based control system. Research by Muhammad Saleh & Supriono (2024) [10] even equips the system with a load cell to verify the water volume, as well as providing dual mode features (automatic/manual) and a real-time notification system.

D. *Touchless interaction innovation by the User*

Non-contact interaction features are becoming a major trend. Suhas. B. Khadake, et al. (2021) implemented gesture sensors, Ankit Kumar et al. (2022) [11] used voice commands via Bluetooth, and Nimesh Kuthe et al. (2024) [12] utilized a mobile application interface. This approach increases the convenience and hygiene of use, especially in the context of public facilities.

E. Performance Validation and System Accuracy

Evaluation of system performance is a critical aspect. Rafika Fitria et al. (2022) [13] recorded a filling accuracy of up to 97%, Nurul Muamaroh et al. (2024) [14] recorded a sensor error of 1.3%, while Muhammad Saleh & Supriono (2024) [15] managed to reduce errors to 0.03%. Validation was carried out using the black-box method, software-hardware integration, and efficiency testing.

F. Technical Challenges and Innovative Solutions

Several limitations such as dependence on internet connection [16], [17], [18], sensor accuracy that depends on environmental conditions [19], [20], and the absence of integration of water quality measurement [21], [22] are challenges in themselves. Therefore, it is recommended to integrate TDS sensors, GSM communication as a network backup [23], and optimize fuzzy logic [24] and power efficiency through adaptive sleep mode [25].

To overcome these limitations, we propose an innovative approach that uses a microcontroller by integrating a flow sensor with an ultrasonic sensor to enable more precise volume measurements. Even though the microcontroller takes up quite a lot, this is not a limitation for this project, we can use any version of the Arduino Uno, where we use the Arduino Uno R3 and tools that still have a low budget. The ultrasonic sensor measures the water level inside the bottle based on the principle of ultrasonic wave reflection, while the flow sensor provides real-time data on the volume of water dispensed. By combining the height of the bottle with the distance measured by the ultrasonic sensor, the system can automatically calculate the water level through the difference between the height of the bottle and the detected distance. This method facilitates automatic and accurate control of water flow without the need for manual intervention, thus significantly improving the efficiency of water use in the dispensing system. After the filling is complete, there will be an alarm that will sound like a microwave to remind the user.

III. Methodology

This research applies a direct experimental method with an automation approach based on the ATmega328 microcontroller (Arduino Uno DIP R3) that can operate wirelessly without physical distance limitations for the user. This microcontroller acts as a central unit that processes data from sensors and controls the Solenoid Valve, which plays a role in opening and closing the water flow.

Architecture that is used in this project includes:

- Arduino Uno R3 as the main microcontroller responsible for processing sensor inputs and controlling output components,
- HC-SR04 ultrasonic sensor for detecting the presence and measuring the height of the bottle to estimate its volume[26],
- YF-S201 flow sensor for calculating the amount of water dispensed in real-time, a 12V solenoid valve for regulating the flow of water based on system commands,
- IRF540N MOSFET as an electronic switch to control the solenoid valve efficiently, resistors (1kΩ and 10kΩ) for ensuring circuit stability and proper signal conditioning,
- Breadboard along with jumper wires for assembling and connecting all the components into a functional prototype circuit

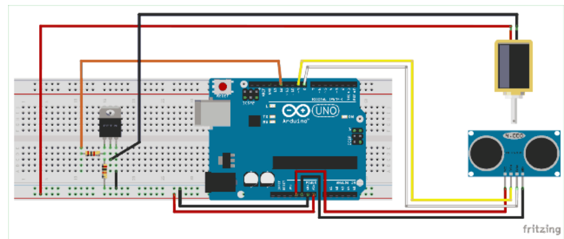

Fig. 1. Circuit design of an Automatic water dispenser system.

The system is designed by integrating the HC-SR04 ultrasonic sensor to detect the height of the glass or bottle being used, as well as the YF-S201 flow sensor to measure in real-time the volume of water flowing. Additionally, this research also uses the Arduino IDE Software to design a program that can perform calculations from the data provided by both sensors, so that when the glass is full, the Solenoid Valve will automatically close and provide a notification in the form of an alarm indicating that the drinking water filling is complete. This approach not only improves the efficiency of water filling, but also enhances accuracy and comfort in everyday use.

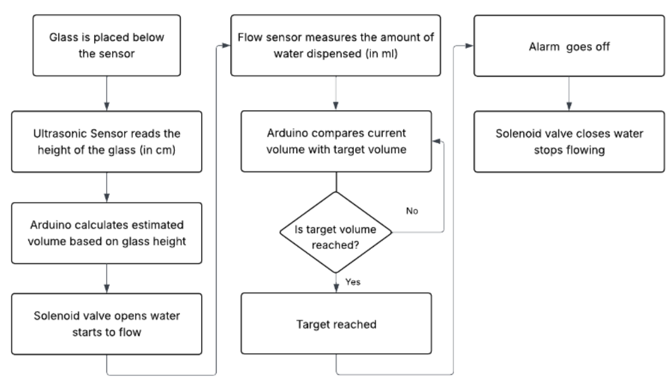

Fig. 2. Workflow of the Automatic water dispenser system

To assess the system's performance, several tests were conducted using various sizes of glasses and bottles. The measurement metrics used include the accuracy of volume estimation based on the size of the glass, the accuracy of the flow sensor volume, the response speed of the ultrasonic sensor when detecting the presence of the glass, the timing accuracy of the system in closing the solenoid valve after the volume is reached, and the consistency of the filling results over several repeated tests. These metrics are used to evaluate the performance, accuracy, and efficiency of the dispenser as a whole.

The system implements a flow sensor pulse-counting algorithm to measure water volume in real time. Each pulse generated by the YF-S201 sensor represents a fixed amount of water flow. The total volume is calculated using the formula:

Volume (L) = Pulse Count / Calibration Factor

Where the calibration factor is determined through experimental calibration (e.g. 450 pulses per liter). Once the measured volume reaches the predefined target, a threshold based control algorithm is triggered, which automatically closes the solenoid valve to stop the water flow. This integration ensures accurate volume dispensing and prevents overfilling.

The system, also used an algorithmic approach is used that combines geometric calculations and sensor readings, with formula :

Water Height (h) = Distance between the Sensor - Water Surface from Total Height of the Bottle

Furthermore, the volume of water is estimated using the formula for the volume of a cylinder, which is

$$V=\pi\times(D/2)^2\times h$$

where D is the diameter of the bottle and h is the measured height of the water [27]. This approach allows the system to automatically and accurately estimate the volume of water based on sensory data.

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