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Automatic Water Dispenser Based on Ultrasonic Sensor and Arduino Uno to Improve Hygiene

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ABSTRACT

Automatic water dispensing technology can reduce direct contact with dispenser surfaces and support better control of water use. This study aimed to design and develop an automatic water dispenser using an HC-SR04 ultrasonic sensor and Arduino Uno to improve hygiene during the water dispensing process. The research used a design and development approach consisting of problem identification, literature study, hardware and software design, prototype assembly, system integration, testing, and evaluation. The HC-SR04 sensor was used to detect the presence and distance of a glass, while the Arduino Uno processed the sensor readings and controlled a water pump through a relay. System testing was conducted at several glass detection distances and through repeated measurements of the volume of water dispensed. The results showed that the sensor detected a glass at distances of 3, 5, 7, and 10 cm, while an object positioned beyond 12 cm was not detected. Five water volume tests produced 190, 195, 200, 192, and 198 mL, with an average volume of 195 mL per filling cycle. Functional testing also showed that the pump turned on when a glass was detected and turned off when the glass was removed. These findings indicate that the prototype operated according to the designed system and enabled water dispensing without direct contact. In practical terms, the system can support more hygienic dispenser use and reduce unnecessary water flow by activating the pump only when a glass is detected. Further development can focus on water-level monitoring, IoT integration, enclosure improvement, and longer testing.

INTRODUCTION

The development of automation technology has encouraged the use of electronic systems that can operate with limited direct interaction from users. Automation systems combine sensors, microcontrollers, and actuators to detect changes in the surrounding environment and perform specific actions based on programmed conditions. This approach is increasingly relevant for household equipment and public facilities because automated systems can support operational efficiency, convenience, and hygiene. In this context, the development of an automatic water dispenser provides an opportunity to apply sensor-based control to a commonly used device (Kristyawan & Kholil, 2021).

Conventional water dispensers generally require users to interact with a mechanical control to dispense water, whereas automatic dispenser systems use sensors to activate the dispensing process (Mazzotta et al., 2021). Previous studies have therefore explored automatic dispensing mechanisms that use object or gesture detection to activate the water dispensing process. Repeated physical contact with these components can be a concern, particularly when a dispenser is used by many people. An automatic operating mechanism can therefore be developed to reduce direct physical interaction during the dispensing process. One approach is to detect the presence of a glass and use the detection result as the control condition for the water pump. In this approach, water is dispensed only when the receiving container is detected within a predetermined range (Lembang & Safua, 2023).

Previous studies have demonstrated the use of microcontrollers and distance sensors in automatic water dispensing systems. Previous research developed an automatic dispensing system using an Arduino-based controller and an ultrasonic sensor (Marwan Hakim, 2023). Ultrasonic sensors are suitable for object detection because they determine the distance to an object based on the reflected ultrasonic signal. Other studies have also applied ultrasonic sensors to water-related measurement and control systems (Mirmahdi & Shirazi, 2021) Ramadhani et al., 2022). These studies indicate that ultrasonic sensing can be applied as an input mechanism for automatic control systems involving water.

Although previous studies have demonstrated the application of sensors and microcontrollers in automatic dispenser systems, differences remain in the methods used for object detection and water-flow control. Some systems use infrared sensors, while others apply timers or different actuator mechanisms. These approaches provide different control mechanisms, while the present study specifically focuses on using real-time glass detection as the direct condition for controlling the water pump. Previous research has developed automatic dispenser systems using infrared sensing and Arduino-based ultrasonic sensing (Singgeta & Manembu, 2021) Therefore, this study focuses on

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implementing an HC-SR04 ultrasonic sensor to detect the presence of a glass and directly control the operation of the water pump based on the detected distance.

The proposed system is designed to provide a simple and responsive control mechanism for automatic water dispensing. The HC-SR04 ultrasonic sensor serves as the main input for detecting the presence of a glass, while the Arduino Uno processes the detection data and controls the relay module. The relay then operates the water pump according to the detection condition. This integration allows the dispensing process to operate automatically when the glass is detected within the configured range and to stop when the glass is removed. The system provides a practical implementation of sensor-based automation for daily-use water dispensing equipment (Juwita et al., 2026).

Based on this background, this study aims to design and implement an automatic water dispenser using an HC-SR04 ultrasonic sensor and Arduino Uno. The proposed system is designed to detect the presence of a glass, activate the water pump when the glass is within the configured detection range, and stop the pump when the glass is removed from the detection area. The performance of the prototype is evaluated through sensor detection testing and water volume measurement. These tests are conducted to determine the detection capability of the sensor and the amount of water dispensed under different operating conditions, as well as to determine whether the developed prototype operates according to the specified design and control conditions.

LITERATURE REVIEW

Automation systems generally consist of input, processing, and output components that work together according to programmed conditions. In an automatic water dispenser, sensors provide input information, a microcontroller processes the sensor data, and an actuator performs the required action. Arduino-based control systems have been applied in automatic dispenser designs to regulate water dispensing based on sensor detection. Previous research has demonstrated the integration of an ultrasonic sensor, Arduino Uno, relay, and water pump in an automatic dispenser system (Juwita et al., 2026) .

The HC-SR04 is an ultrasonic distance sensor that detects objects based on the travel time of ultrasonic waves. The sensor consists of a transmitter and a receiver. The transmitter emits an ultrasonic signal toward an object, while the receiver detects the reflected signal. The measured travel time can then be used to determine the distance between the sensor and the object. This non-contact detection principle makes the HC-SR04 applicable to object detection in automatic systems. The application of HC-SR04 with Arduino Uno has also been demonstrated in water-related measurement systems

The application of ultrasonic sensors is not limited to object detection (Ramadhani et al., 2022) applied an ultrasonic sensor as a prototype for measuring water level in a wastewater tank. Their study demonstrates that ultrasonic sensing can be used to obtain distance-related information without direct contact with the measured object. This principle is relevant to the present study because the HC-SR04 sensor is also used to determine the distance between the sensor and the detected glass.

Arduino Uno is a microcontroller board that can process input data from sensors and generate control signals for output devices. In automatic dispenser systems, Arduino Uno can process ultrasonic sensor readings and control the water dispensing mechanism. The integration of Arduino Uno, an ultrasonic sensor, a relay, and a water pump has been applied in previous automatic dispenser research (Marwan Hakim, 2023). This configuration demonstrates the application of Arduino-based control for automatic water dispensing (Collins et al., 2021). Arduino Uno has also been applied as the central controller in automatic water and pump control systems, where sensor readings are processed to determine actuator operation.

Previous studies have developed automatic dispenser systems using different sensing and actuator mechanisms. Automatic dispenser systems have been developed using ultrasonic sensors, Arduino Uno, relay modules, and water pumps (Wahyudi et al., 2025). Other studies have applied Arduino Uno and ultrasonic sensors with servo motors as the actuator for controlling the water outlet (Lembang & Safua, 2023). These studies demonstrate that ultrasonic sensing and Arduino-based control can be applied to automate the water dispensing process. Ultrasonic sensors have also been used for water-level detection (Soleh & Subiyanta, 2021). Recent research has also developed an automatic dispenser using an Arduino Uno, an HC-SR04 ultrasonic sensor, a relay module, and a DC pump to support touchless water dispensing (M et al., 2023).

Based on the reviewed studies, automatic dispenser systems have been implemented using ultrasonic sensors, Arduino-based controllers, and different actuator mechanisms. The present study applies the HC-SR04 ultrasonic sensor to detect the presence of a glass and uses Arduino Uno to process the detected distance. A relay module is used to control the water pump based on the programmed detection condition. The system is evaluated through sensor detection and water volume testing to assess its operational performance.

METHOD

The research method used in this study is a research and development approach, which aims to design, implement, and test an automatic water dispenser based on an ultrasonic sensor and Arduino Uno. This method was selected because the research focuses on developing a functional prototype that operates automatically without direct physical contact. The research process was conducted systematically, starting from problem identification, system

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design, hardware and software implementation, and system testing. Testing was performed to evaluate the ultrasonic sensor detection, water volume, and automatic pump response to determine whether the developed system operated according to the designed specifications.

Research Flow

This research uses an experimental method aimed at designing, building, and testing an automatic water dispenser based on an HC-SR04 ultrasonic sensor and Arduino Uno. This method was selected because the developed system can be directly implemented and tested based on its functional performance. The research stages were carried out systematically, starting from problem identification and literature review, followed by system requirements analysis, system design, implementation, testing, and results analysis. The research stages are shown in Figure 1.

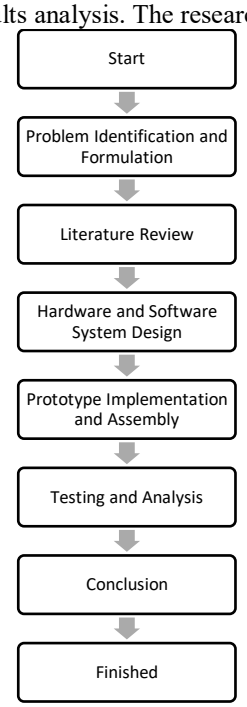


Figure 1. Research flow diagram

Figure 1 illustrates the research stages used to develop the automatic water dispenser system. The process began with problem identification and a literature review to determine the system requirements. The next stages involved system design, hardware and software implementation, and prototype testing. The test results were then evaluated to determine whether the system operated according to the intended specifications.

Hardware and Software

The hardware used in this study consisted of an Arduino Uno as the main controller, an HC-SR04 ultrasonic sensor for detecting the presence of a glass, a relay module for controlling the water pump, and a water pump as the actuator for dispensing water. A battery was used as the power source, while connecting wires were used to connect the components. The software used in this study was Arduino IDE, which was used to develop and upload the control program to the Arduino Uno.

System Design

The HC-SR04 ultrasonic sensor was connected to the Arduino Uno through the Trig and Echo pins. The Trig pin was connected to digital pin D9, while the Echo pin was connected to digital pin D10. The relay module was connected to digital pin D8 and used to control the water pump. The Arduino Uno processes the distance detected by the ultrasonic sensor and determines the pump condition according to the programmed detection range. The circuit design of the automatic water dispenser is shown in Figure 2.

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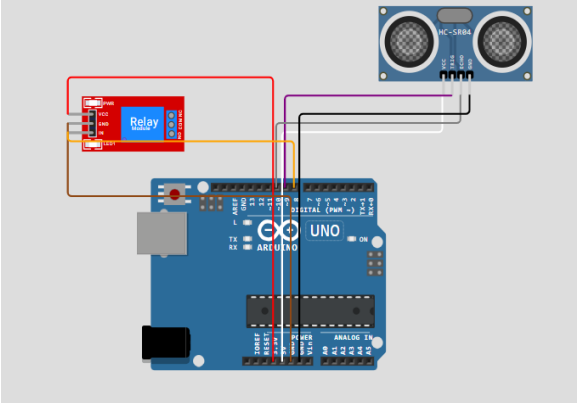


Figure 2. System circuit design

Figure 2 shows the circuit design of the automatic water dispenser system. The HC-SR04 ultrasonic sensor is connected to the Arduino Uno through the Trig and Echo pins, while the relay module is connected to digital pin D8 to control the water pump. The sensor detects the distance of the glass, and the Arduino Uno processes the measured distance to determine the pump operation. This circuit enables the dispenser to operate automatically based on the programmed detection conditions.

System Operation

The automatic dispenser operates by detecting the presence of a glass using the HC-SR04 ultrasonic sensor. The sensor sends an ultrasonic signal toward the object and receives the reflected signal. The Arduino Uno processes the detected distance and compares it with the predetermined detection condition. When a glass is detected within the specified range, the Arduino activates the relay, causing the water pump to turn on. The pump then dispenses water into the glass. When the glass is removed from the detection area and is no longer detected by the sensor, the Arduino deactivates the relay and the water pump turns off automatically.

Testing Procedure

The system was tested through three types of testing. First, the ultrasonic sensor was tested at several distances to determine the effective glass detection range. Second, water volume testing was conducted through five filling trials to measure the amount of water dispensed during each filling cycle. Third, functional testing was performed by observing the response of the ultrasonic sensor and water pump when the glass was placed, remained in the detection area, and was removed. The results of these tests were used to evaluate the operation of the developed automatic dispenser according to the designed specifications.

RESULT

The implemented prototype integrated the ultrasonic sensor, Arduino Uno, relay, and water pump into one automatic dispensing system. The prototype was designed so that the user only needs to place a glass in the detection area. The system then controls the water flow automatically.

The developed automatic water dispenser was implemented by integrating the HC-SR04 ultrasonic sensor, Arduino Uno, relay module, and water pump. The prototype was designed to detect the presence of a glass and automatically control the water pump based on the detected distance. The system testing included ultrasonic sensor detection, water volume measurement, and overall system performance. The test results were analyzed to evaluate whether the developed system operated according to the designed control mechanism.



Figure 3. Automatic Dispenser Prototype

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Figure 3 presents the developed automatic water dispenser prototype, which integrates the HC-SR04 ultrasonic sensor, Arduino Uno, relay module, and water pump. The prototype operates by detecting the presence of a glass within the sensor's detection range. When the glass is detected, the Arduino Uno activates the relay to turn on the water pump. When the glass is removed, the pump turns off automatically. This implementation demonstrates the integration of sensor-based detection and automatic water flow control in the developed system.

Ultrasonic Sensor Detection Test

The ultrasonic sensor was tested to determine its ability to detect the presence of a glass at different distances. The sensor was tested by placing the glass at several distance variations from the sensor, and the system response to the detected object was then observed. This test was conducted to ensure that the ultrasonic sensor could operate consistently as the main input component of the automatic dispenser system.

Table 1. Ultrasonic Sensor Detection Test

No	Glass Distance (cm)	Sensor Condition	Detection Status
1	3	Normal	Detected
2	5	Normal	Detected
3	7	Normal	Detected
4	10	Normal	Detected
5	>12	Normal	Not detected

The sensor detected the glass at distances of 3, 5, 7, and 10 cm. At a distance greater than 12 cm, the object was not detected. These results indicate that the prototype operated within a practical detection range of 3 to 10 cm under the tested conditions.

Water Volume Testing Results

The water volume test was conducted to determine the amount of water dispensed during each filling cycle. The test was performed five times under the same system conditions by placing the glass in the sensor detection area. The volume of water collected in each trial was measured using a measuring glass.

Table 2. Water Volume Testing Results

No	Trial	System Condition	Water Volume (ml)
1	1st	Glass detected	190
2	2nd	Glass detected	195
3	3rd	Glass detected	200
4	4th	Glass detected	192
5	5th	Glass detected	198
	Average	Glass detected	195

The test results show that the water volume obtained in the five trials was 190, 195, 200, 192, and 198 mL, respectively. The average water volume was 195 mL per filling cycle. The measured volume varied slightly between trials under the same testing conditions.

Automatic Dispenser Functional Test

The functional test was conducted to evaluate the response of the automatic dispenser when the glass was placed in and removed from the sensor detection area. The test focused on the relationship between the ultrasonic sensor response and the operation of the water pump. The system was observed under four conditions, namely when the glass was placed, remained in the detection area, removed, and when no glass was present.

Table 3. Automatic Dispenser Function Test

No	System Condition	Sensor Response	Pump Status	Description
1	Glass placed	Detected	On	Normal
2	Glass remains	Detected	On	Normal
3	Glass removed	Not detected	Off	Normal
4	No glass	Not detected	Off	Normal

The functional test shows that the pump turned on when the glass was detected and remained on while the glass was within the detection area. When the glass was removed, the sensor no longer detected the object and the pump turned off. When no glass was present, the pump also remained off. These results show that the sensor and pump responded according to the programmed system conditions.

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DISCUSSION

The test results demonstrate that the automatic dispenser prototype can detect the presence of a glass and control the water pump according to the programmed conditions. The HC-SR04 ultrasonic sensor detected the glass at distances of 3, 5, 7, and 10 cm, while the glass was not detected at a distance greater than 12 cm. This result indicates that the detection range used in the prototype was sufficient to identify the presence of a glass within the intended dispensing area. The detection results are consistent with the use of ultrasonic sensing in automatic water dispensing systems. (Bolimera, n.d.) used an ultrasonic sensor to detect the position of the container and control water dispensing automatically.

The functional test also shows that the integration of the HC-SR04 sensor, Arduino Uno, relay, and water pump operated according to the designed control logic. This result is consistent with the study (Hutabarat, 2026), which integrated an Arduino Uno, HC-SR04 ultrasonic sensor, relay module, and DC motor for automatic liquid dispensing. When the glass was detected, the pump turned on, and when the glass was removed, the pump turned off. The pump also remained off when no glass was present. This finding is consistent with previous research (Juwita et al., 2026), which implemented an automatic dispenser using an ultrasonic sensor, Arduino Uno, relay, and water pump.

The water volume test produced measurements ranging from 190 to 200 mL, with an average volume of 195 mL per filling cycle. The variation between trials indicates that the amount of water dispensed was not exactly identical in every cycle. However, the measured values remained within a relatively close range under the same testing conditions. This result shows that the prototype was able to dispense water with a relatively consistent volume during the testing process (Hutabarat, 2026).

The water volume results can be compared with (Sistem et al., 2026), who developed an Arduino Uno-based automatic water dispensing system with volume measurement using a YF-S401 water flow sensor. Their study evaluated dispensing volumes of 150, 200, and 300 mL and reported relatively consistent filling performance. In the present study, the measured water volume ranged from 190 to 200 mL, with an average of 195 mL per filling cycle. Although the sensing and control methods differ, both studies demonstrate the use of Arduino-based systems for controlling and evaluating automatic water dispensing.

The use of an HC-SR04 ultrasonic sensor and Arduino Uno in this study is also comparable to the approach reported (Lesmana, 2025) Their study developed an automatic dispenser using Arduino Uno and an HC-SR04 sensor and reported that the sensor could detect objects and provide input for automatic control. The present study applies a similar sensor-based control concept, while using a relay and water pump to control water dispensing.

The automatic operation of the prototype reduces the need for direct physical interaction with the dispenser during the dispensing process. When no glass is detected, the pump remains off, so water is not continuously dispensed. This operating mechanism supports the objective of developing a touchless dispenser and provides more controlled water delivery. Similar automatic dispensing systems have also been developed to reduce direct contact during water dispensing

CONCLUSION

The automatic water dispenser based on an HC-SR04 ultrasonic sensor and Arduino Uno was successfully designed and implemented. The system was able to detect a glass at distances of 3–10 cm and automatically control the water pump through a relay, while the pump turned off when the glass was removed. The water volume testing produced an average of 195 mL per filling cycle. These results indicate that the prototype operated according to the designed conditions and provided touchless water dispensing that supports the hygiene objective of the system.

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