Chapter 1

INTRODUCTION

This chapter introduces the IoT-based automatic tap with a touchless water dispenser and soap dispenser system. It highlights the need for a completely contactless hygiene solution, explains the relevance of IoT-enabled automation in public and domestic environments, and outlines the primary objectives and real-world applications of the system. The chapter also summarizes major research contributions in related domains, establishing the foundation on which this project is developed.

1.1 Problem Statement

In public and shared environments, maintaining proper hand hygiene is essential to prevent the spread of diseases, however, conventional handwash systems require physical contact with taps and soap dispensers, leading to water and soap wastage and increased risk of cross contamination. To overcome these limitations, there is a need for a contactless, efficient and safe system that automatically dispenses soap and water in a controlled manner. This project aims to design and implement an Arduino based automatic handwash system using an ultrasonic sensor and relay controlled pumps which detects the presence of a user's hand and sequentially dispenses soap and water for fixed durations while ensuring electrical isolation, user safety and efficient resource utilization.

1.2 NEED FOR THIS PROJECT

The demand for touchless dispensing technology has increased rapidly due to hygiene concerns, especially following global health crises. This project addresses several practical needs:

1. **Enhanced Hygiene:** Physical contact with taps and soap dispensers leads to the transfer of germs, increasing infection risks. A touchless system minimizes contamination.

2. **Water Conservation:** Traditional taps often remain open longer than necessary. Automatic detection-based dispensing significantly reduces unnecessary water flow.

3. **Public Safety in High-Traffic Areas:** Schools, hospitals, malls, and offices require contactless systems to ensure safety and minimize the spread of pathogens.

4. **Technological Advancement:** Integrating IoT with dispensing systems enables monitoring, maintenance alerts and the possibility of remote usage of analytics.

5. **Accessibility:** Touchless systems are highly beneficial for children, elderly individuals and persons with disabilities.

1.3 KEY OBJECTIVES

The primary objectives of the IoT-based automatic tap with touchless water and soap dispenser are:

- To automate water flow and soap dispensing using DC motors controlled by relay modules.
- To detect user proximity accurately using an ultrasonic sensor for initiating dispensing actions.
- To provide electrical isolation and safety using the REE32 relay module ensuring controlled switching of high-power loads.
- To design a compact, low-power system using Arduino Uno and a 9V battery for portability and convenience.
- To implement robust system connectivity through jumper wires, breadboard assemblies and USB interfaces for flexible prototyping.
- To enhance hygiene and reduce water wastage through fast, automatic and contactless operation.
- To establish a foundation for IoT integration, enabling future remote control, monitoring and analytics.

1.4 APPLICATIONS

The proposed system is suitable for a wide range of real-world applications including:

- **Public Restrooms**: Provides safe, contactless water and soap dispensing, reducing contamination.

- **Hospitals & Clinics**: Ensures strict hygiene protocols by preventing the spread of infectious agents.
- **Households**: Offers automated water usage and touchless soap dispensing for kitchens and washrooms.
- **Commercial Establishments**: Hotels, restaurants, offices and malls can adopt this system for improved sanitation practices.
- **Educational Institutions**: Encourages hygiene among students and staff by eliminating the need for physical contact.
- **Industrial Facilities**: Prevents contamination in environments requiring high cleanliness standards.

Chapter 2

EXISTING TECHNOLOGY

This chapter examines the existing technologies available for touchless water dispensing and automatic hygiene systems. It compares commercial and industrial solutions based on their features, advantages, limitations, and cost. Additionally, it highlights how our proposed system overcomes the drawbacks of current technologies to deliver a more efficient, cost-effective, and user-friendly, contactless dispensing solution. Sections are organized into available technologies, their strengths and weaknesses and steps taken to resolve their limitations.

2.1 1. EXISTING TECHNOLOGY

Technology	**Features**	**Pros**	**Cons**	**Cost**
Infrared Based Automatic Faucets	User IR sensors to detect hand presence and activate water flow automatically. Widely used in public restrooms.	Reliable and widely available, reduces water wastage.	Expensive installation, IR sensor often misread reflections, not suitable for bright sunlight conditions.	High
Commercial Soap Dispenser Units	Infrared based touchless soap dispensing, compact and battery powered.	Easy to use, hygienic, portable.	Limited control of dispensing quality, cannot integrate with custom automation.	Moderate
Ultrasonic based Proximity Device	Use ultrasonic wave reflection to detect objects and trigger small actuators. Used in small automation applications.	Accurate distance measurement, unaffected by light, suitable for custom automation.	Not widely integrated into commercial tap systems, requires additional circuitry to drive motors/relays.	Variable

Table 2.1: Comparison of Existing Touchless Dispensing Technologies

2.2 2. RESOLVING LIMITATIONS

- **Cost-Effectiveness:** Existing systems are expensive and require specialized hardware. Our project uses Arduino Uno, basic relays and DC motors to significantly reduce costs.
- **Accuracy of Detection:** IR sensors suffer from false triggering in sunlight. Our system uses ultrasonic sensing, offering stable and accurate proximity detection regardless of lighting.
- **Customizability:** Commercial automatic taps cannot be customized. Our system supports adjustable distance thresholds, customizable dispensing time, and flexible motor control.
- **IoT Integration:** Many existing products lack IoT compatibility. Our design can be expanded to include IoT modules for monitoring usage, water consumption, or hygiene patterns.

- **Maintenance and Reliability:** High-end commercial systems require expensive maintenance. Our system uses easily available components, making repairs simple and affordable.

Chapter 3

WORKING PRINCIPLE

3.1 1. HARDWARE REQUIREMENTS

HARDWARE	COST	SPECIFICATIONS	URL
Arduino UNO	Rs. 400	Acts as the central microcontroller, processing input signals from the ultrasonic sensor. Executes the decision-making logic based on user proximity. Controls both relay modules, which in turn activate the DC water pumps. Provides easy interfacing through digital I/O pins.	Makerbazar.com
Ultrasonic sensor	Rs. 61	Working Voltage: 5V(DC). Static Current: Less than 2mA. Output Signal: Electric frequency signal, high-level 5V, low-level 0V. Sensor Angle: Not more than 15 degrees. Detection Distance: 2cm-450cm. High Precision: Up to 0.3cm. Input Trigger Signal: 10us TTL im-pulse. Echo Signal: output TTL PWL signal.	flyrobo.in
2 x REES52	Rs 60 (each)	Provides electrical isolation between the low-voltage Arduino UNO and higher-current DC pumps. Operates as an electronically controlled switch. When the Arduino outputs a HIGH signal, the relay energizes and closes the circuit to power the pump. Ensure safety and prevent back-flow current into the microcontroller.	Makerbazar.com

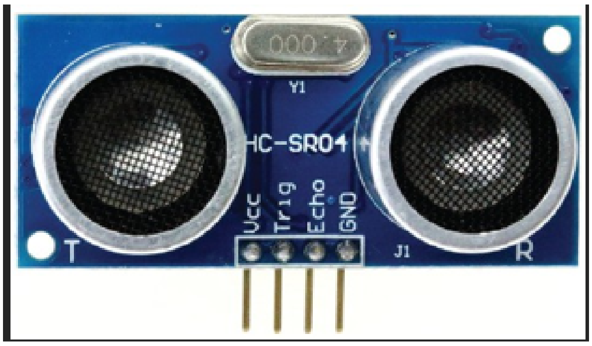
HARDWARE	COST	SPECIFICATIONS	URL
2 x Mini DC Water Pump	Rs 70	Used for: Water dispensing, Liquid soap dispensing. Key features: Compact and low power (9V operation). Submersible, making them suitable to place inside the two containers. Controlled via relay switching for precise dispensing duration.	Makerbazar.com
Breadboard	Rs. 53	Tie-point 840. Solderless. Wire size: Suitable for 29-20 AWG wires. Size: About 16.5*5.6*1cm.	flyrobo.in
Jumper wires	Rs. 100	1p1p pin male to female header. Compatible with 2.54mm (about 0.1 in) spacing pin headers.	flyrobo.in
USB to Micro-USB cable	Rs. 27	Current Electricity: Provides 5V DC From USB. Max Carrying Voltage: 12V. Max Bearing current: 3.1A.	Swiggy.com
9V Battery	Rs 20	Provides power to the pumps and Arduino board. Ensures portability of the system. Simple integration through snap connectors.	Makerbazar.com

3.2 WORKING PRINCIPLE OF THE SYSTEM

The complete workflow of the system is described below:

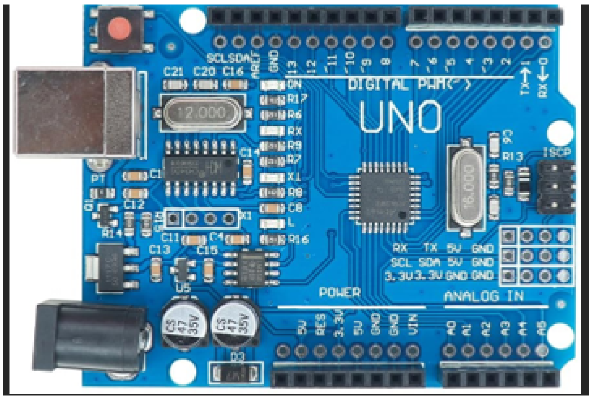
3.2.1 User Detection

The ultrasonic sensor continuously measures the distance in front of the tap. When a hand enters the detection zone (set threshold), a trigger is sent to Arduino.



3.2.2 Signal Processing

Arduino compares the measured distance with predefined conditions. If the user is detected, Arduino activates the required relay module.



3.2.3 Relay Activation

Relay module receives HIGH signal from Arduino. The relay switches ON, allowing 9V current to flow to the DC pump.

3.2.4 Pumping Mechanism

When activated, the DC pump draws liquid from the container. Water pump dispenses water; soap pump dispenses liquid soap. Dispensing continues for a programmed duration (e.g., 2–4 seconds).

3.2.5 System Reset

After dispensing duration ends, the relay switches OFF. Pump stops automatically. Sensor resumes detection for the next user.

3.3 PROTEUS / CIRCUIT SIMULATION

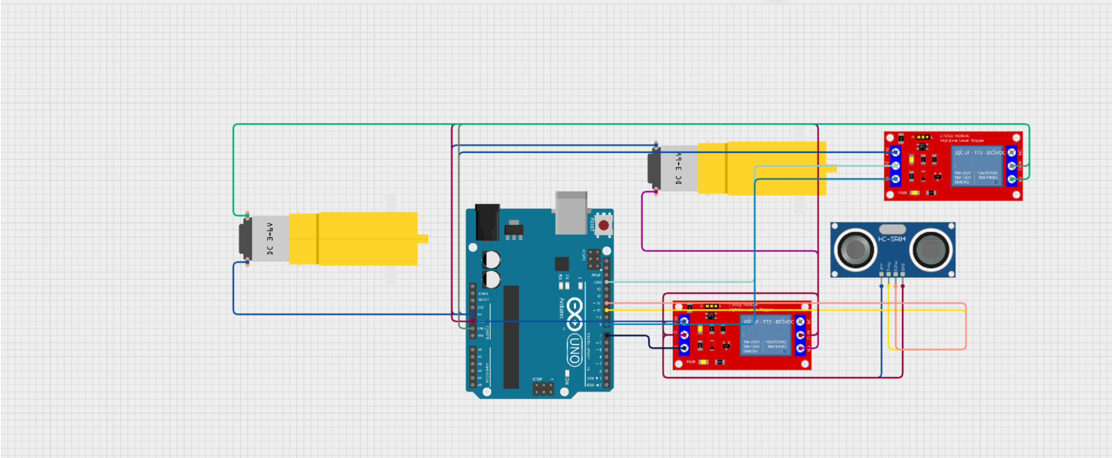


Figure 3.1: Circuit Simulation of the Automatic Tap with Touchless Soap and Water Dispenser

3.4 HARDWARE OF THE SYSTEM

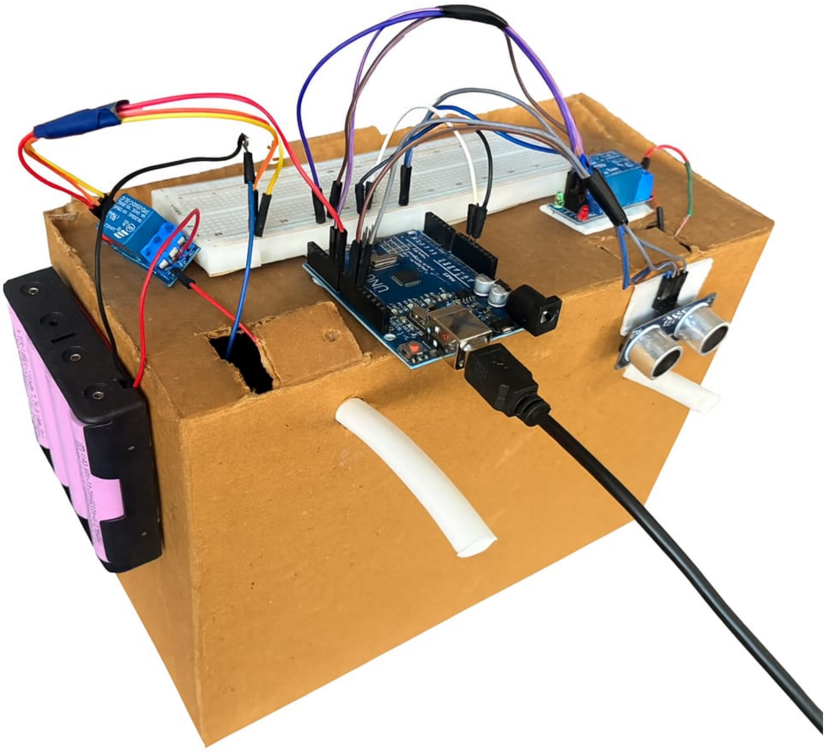


Figure 3.2: Hardware of the Automatic Tap with Touchless Water and Soap Dispenser

3.5 ARDUINO UNO PROGRAMMING

The Arduino Uno acts as the main controller of the touchless dispensing system. The microcontroller receives distance measurements from the ultrasonic sensor and activates water and soap pumps using two relay modules. The code is written to ensure:

- Accurate proximity detection
- Controlled dispensing timing
- A fixed sequence (SOAP → WATER)
- Safety timeout to prevent pump damage
- No repeated triggering unless the user removes their hand

This section presents the full Arduino code used for implementing the system logic:

ultrasonic_dispenser.ino

```
#define TRIG_PIN 10
#define ECHO_PIN 11

#define SOAP_RELAY 6     // Active LOW
#define WATER_RELAY 7    // Active LOW

int getDistance();   // ---- FUNCTION DECLARATION ----

// -------- SETUP --------
void setup() {
  Serial.begin(9600);

  pinMode(TRIG_PIN, OUTPUT);
  pinMode(ECHO_PIN, INPUT);

  pinMode(SOAP_RELAY, OUTPUT);
  pinMode(WATER_RELAY, OUTPUT);

  digitalWrite(SOAP_RELAY, HIGH);
  digitalWrite(WATER_RELAY, HIGH);

  Serial.println("Handwash System Ready");
}

// -------- LOOP --------
void loop() {
  int distance = getDistance();
```

```
  Serial.print("Distance: ");
  Serial.print(distance);
  Serial.println(" cm");

  if (distance > 0 && distance < 12) {

    Serial.println(">>> HAND DETECTED <<<");

    Serial.println("SOAP ON");
    digitalWrite(SOAP_RELAY, LOW);
    delay(2000);
    digitalWrite(SOAP_RELAY, HIGH);
    Serial.println("SOAP OFF");

    Serial.println("RUB TIME");
    delay(5000);

    Serial.println("WATER ON");
    digitalWrite(WATER_RELAY, LOW);
    delay(9000);
    digitalWrite(WATER_RELAY, HIGH);
    Serial.println("WATER OFF");

    Serial.println("WAITING FOR HAND REMOVAL");
    while (getDistance() < 12) {
      delay(100);
    }
```

```
    Serial.println("HAND REMOVED");
  }

  delay(100);
}

// -------- ULTRASONIC FUNCTION --------
int getDistance() {
  long duration;

  digitalWrite(TRIG_PIN, LOW);
  delayMicroseconds(2);
  digitalWrite(TRIG_PIN, HIGH);
  delayMicroseconds(10);
  digitalWrite(TRIG_PIN, LOW);

  duration = pulseIn(ECHO_PIN, HIGH, 30000);

  if (duration == 0) return 50;   // no echo

  return duration * 0.034 / 2;
}
```

Chapter 4

DEPICTION OF THE SYSTEM

The system depiction illustrates the complete hardware arrangement of the IoT-based automatic tap with touchless water and soap dispenser. It shows how the Arduino UNO interfaces with the ultrasonic sensor, relay modules, and DC pumps to achieve contactless dispensing. The diagram represents the logical flow of signals, power supply lines, and output components involved in the dispensing sequence.

The system is structured into three major sections—Input, Control, and Output—each playing a critical role in the functioning of the touchless mechanism.

4.1 A. System Block Diagram Description

1. **Input Block**
   Ultrasonic Sensor (HC-SR04) – Continuously emits sound waves. Measures echo time to compute user hand distance. Sends distance data to Arduino UNO.

2. **Control Block**
   Arduino UNO Microcontroller – Processes distance readings. Checks if hand is within threshold. Initiates the programmed sequence (SOAP → pause → WATER). Controls relay switching via digital I/O pins.

3. **Output Block**
   Relay Module 1 → Controls Soap Pump.
   Relay Module 2 → Controls Water Pump.
   Both relays act as electrically isolated switches that allow low-power Arduino signals to control high-current DC pumps safely.

4. **Power Supply Block**
   9V Battery for water and soap pumps. USB Cable for powering the Arduino UNO. Ensures complete portability of the system.

4.2 B. System Description

The hardware setup consists of two liquid containers—one filled with water and the other with liquid soap. Each container houses a mini DC water pump. These pumps are connected to their respective relay modules, which in turn are connected to the Arduino UNO.

The ultrasonic sensor is positioned near the tap or dispensing point. When the user's hand enters the detection range (10 cm), the sensor immediately sends distance readings to the microcontroller. The Arduino then triggers the soap pump first for a fixed duration, waits for a programmed pause, and subsequently activates the water pump. This sequence ensures proper handwashing following hygiene protocols.

All components are interconnected using jumper wires and mounted on a breadboard for easy prototyping and testing.

4.3 C. Flow of Operation

1. Hand detection → Ultrasonic sensor detects hand within threshold distance.
2. Signal processing → Arduino evaluates the sensor reading.
3. Sequence initiation → Soap pump ON → Pause → Water pump ON.
4. Relay switching → Arduino outputs LOW signal to activate relays.
5. Dispensing → Pumps transfer liquid from containers to the outlet.
6. Completion & Reset → Device waits until the hand is removed from detection zone. System resets for next user.

Chapter 5

RESULTS AND DISCUSSIONS

This chapter presents the outcomes of the IoT-based Automatic Tap with Touchless Water and Soap Dispenser system. It evaluates the performance of the prototype, highlights the effectiveness of the sensing and dispensing mechanism, identifies observed limitations, and explores the potential improvements that can be implemented in future iterations. The results demonstrate the reliability of the ultrasonic sensor for proximity detection, the accuracy of the relay switching mechanism, and the overall usability of the system in real-world scenarios.

5.1 LIMITATIONS

Despite satisfactory performance, the system has certain limitations:

- **Ultrasonic Sensor Sensitivity**
  Performance reduces slightly in environments with high humidity or steam (e.g., bathrooms). Sensor may detect unintended reflections from glossy surfaces or metallic sinks.
- **Fixed Dispensing Times**
  The system currently uses fixed delay values for soap and water dispensing. Users with different preferences cannot modify the duration without reprogramming the Arduino.
- **Power Dependency**
  Pumps draw significant current, requiring a reliable 9V external supply. Battery discharge reduces pump performance over time.
- **No IoT Integration Yet**
  Although the system is automated, it does not currently feature remote monitoring or control. Usage analytics, refill alerts, or maintenance notifications are not available.

5.2 FUTURE SCOPE OF THE PROJECT

Several improvements can enhance the system's functionality, scalability, and user experience.

5.2.1 Hardware Enhancements

- Integration of flow sensors for precise measurement of dispensed water and soap.
- Addition of refill level sensors inside containers to alert when levels are low.
- Use of waterproof casing to improve durability in humid environments.

5.2.2 Smart Features and IoT Integration

- Adding Wi-Fi (ESP32/ESP8266) allows remote monitoring, usage statistics, automatic refill reminders.
- Integration with smart home ecosystems (Alexa/Google Assistant).

5.2.3 Adaptive Control

- Machine learning models can adjust dispensing time based on user patterns.
- Dynamic control of pump speed for optimal flow.

5.2.4 Energy Optimization

- Use of rechargeable Li-ion batteries.
- Incorporating solar panels for high-traffic outdoor environments.

Chapter 6

CONCLUSION

6.1 SUMMARY

This project presented the design and development of an IoT-based Automatic Tap with Touchless Water and Soap Dispenser aimed at improving hygiene through hands-free operation. The system combined an ultrasonic sensor for proximity detection, an Arduino UNO microcontroller for control logic, and relay-driven DC pumps for dispensing soap and water sequentially. The integration of these components enabled the creation of a fully automated, user-friendly handwashing station that minimizes physical contact and reduces the transmission of infectious agents.

The hardware was systematically assembled and tested under different conditions to evaluate accuracy, responsiveness, and reliability. The experimental results demonstrated that the ultrasonic sensor detected hand presence effectively, the Arduino executed the programmed sequence consistently, and the pumps delivered stable flow rates. A safety timeout mechanism ensured protection against continuous operation, enhancing durability and operational safety.

The report also explored the potential scope of integrating AI and IoT for future enhancements, such as predictive dispensing, refill monitoring, cloud analytics, gesture recognition, and mobile app connectivity. These additions would significantly improve user interaction, efficiency, and system intelligence, making the design suitable for smart homes and large public facilities.

Overall, the system achieved its intended objectives and demonstrated that low-cost electronic components can be effectively combined to create a practical automation solution that addresses real-world sanitation needs.

6.2 FINAL REMARKS

The IoT-based touchless water and soap dispenser developed in this project represents a meaningful step toward modernizing hygiene infrastructure through embedded technology. While the system already performs its intended function effectively, it also lays a strong foundation for future innovations. With advancements in AI, IoT, computer vision, and smart sensing, the device can evolve into an intelligent hygiene management platform capable of making autonomous decisions, analyzing usage patterns, and improving operational efficiency.

Chapter 7

REFERENCES

Banzi, M., & Shiloh, M. (2014). Getting Started with Arduino. Maker Media, USA.

Siegwart, R., Nourbakhsh, I., & Scaramuzza, D. (2011). Introduction to Autonomous Mobile Robots. MIT Press.

Pattison, S. (2019). Arduino: A Technical Reference. O'Reilly Media.

Paliya, S., & Sharma, R. (2020). "Touchless Automation for Hygiene Improvement Using Sensors," International Journal of Engineering Research, Vol. 9, Issue 3, pp. 42–47.

Sharma, A., & Gupta, S. (2021). "Design of an Automatic Hand Sanitizer and Water Dispensing System Using IoT," International Journal of Advanced Trends in Computer Science, Vol. 10, pp. 335–341.

Khan, M. et al. (2020). "Ultrasonic Sensor-Based Proximity Detection for Smart Applications," IEEE Sensors Journal, Vol. 20(14), pp. 8123–8130.

Arduino Official Documentation. "Arduino UNO Technical Specifications." Available at: `https://www.arduino.cc/en/Main/ArduinoBoardUno` (Accessed 2025).

HC-SR04 Ultrasonic Sensor Datasheet. Elecrow Technologies.

Song, Y., Mahajan, P., & Srivastava, V. (2021). "IoT Applications in Automated Hygiene Systems," Journal of Smart Systems, Vol. 12(2), pp. 115–122.

Relay Module (5V) Product Sheet. SunFounder Electronics, 2022.

Kashyap, A. (2020). Internet of Things: Principles and Paradigms. Morgan Kaufmann.

Practical Electronics for Inventors (4th Edition). Paul Scherz & Simon Monk, McGraw Hill Education.

Tinkercad Circuits Online Simulator. Autodesk. `https://www.tinkercad.com` (Accessed 2025).