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DEVELOPMENT OF A DISINFECTING FOG-BASED HAND WASH MACHINE

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Abstract: Conventional handwashing methods consume considerable amounts of water and often involve physical contact with taps and dispensers, increasing the possibility of cross-contamination in public environments. This paper presents the design and development of a Disinfecting Fog-Based Hand Wash Machine that provides a contactless and water-efficient approach to hand hygiene. The proposed system uses an Arduino UNO as the main controller, an IR sensor for contactless hand detection, and an ultrasonic fogger to generate fine disinfecting fog. A relay and transistor driver circuit are employed to control the fogger operation, while LED and buzzer indicators provide visual and audible status notifications. When a user's hands are detected, the controller activates the fogger to dispense disinfecting fog, reducing the need for conventional water-based handwashing. The hardware circuit simulation has been successfully developed, demonstrating hand detection, automated fogger control, and indicator operation. The disinfection chamber assembly and performance testing are currently in progress. Further testing is required to evaluate fog coverage, liquid consumption, sensor accuracy, response time, and microbial effectiveness. The proposed system aims to provide a convenient, automated, and resource-efficient solution for improving hand hygiene in public and institutional environments.

Keywords: Disinfecting fog, contactless handwashing, Arduino UNO, IR sensor, ultrasonic fogger, relay control, water conservation, automated hygiene system.

I. INTRODUCTION

Hand hygiene plays an important role in preventing the spread of infections and maintaining public health. Conventional handwashing methods generally require considerable amounts of water and involve physical contact with taps and dispensers, which may increase the possibility of cross-contamination, particularly in crowded public environments. In addition, excessive water consumption and wastage create a need for alternative and resource-efficient hand hygiene solutions.

The proposed work presents the design and development of a Disinfecting Fog-Based Hand Wash Machine that provides an automated and contactless approach to hand hygiene. The system uses an Arduino UNO as the main control unit, an IR sensor for detecting the presence of hands, and an ultrasonic fogger to generate fine disinfecting fog. A relay and transistor driver circuit are used to control the fogger operation, while LED and buzzer indicators provide information about the operating status of the system.When a user's hands are detected by the IR sensor, the signal is processed by the Arduino UNO, which activates the fogger through the relay and driver circuit. The generated disinfecting fog is intended to cover the hand surface while minimizing the need for conventional water-based handwashing. This automated operation reduces direct physical interaction with the machine and aims to minimize unnecessary liquid consumption.

The current implementation includes hardware circuit simulation, contactless hand detection, fogger control and indicator operation. The disinfection chamber assembly and performance evaluation are in progress. The proposed system focuses on developing a convenient, automated and water-efficient hand hygiene solution. Further experimental testing is required to evaluate fog coverage, disinfectant consumption, microbial effectiveness, sensor accuracy and overall system reliability.

A. Objectives

The main objective is to develop an automated, contactless disinfecting fog-based hand wash machine using an Arduino UNO and IR sensor. The system aims to generate fine disinfecting fog using an ultrasonic fogger, minimize water and

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disinfectant consumption, reduce cross-contamination, and improve hand hygiene in public environments.

II. RELATED WORK

Previous research has explored fog-based handwashing and disinfection systems as alternatives to conventional water-based handwashing methods. These systems focus on reducing water consumption, minimizing physical contact and improving hygiene through automated fog generation.

Several studies have investigated Arduino-based fog disinfectant handwashing devices, demonstrating the use of microcontrollers and automated control mechanisms for contactless operation. Research on dry handwashing machines using fog disinfection has also highlighted the potential of fine fog generation as a method of reducing water wastage.

The study on fog disinfection-based handwashing systems emphasizes the importance of efficient disinfectant delivery and uniform coverage of hand surfaces. Similarly, projects supported by the Karnataka State Council for Science and Technology have explored fog-based dry handwashing approaches to promote water conservation.

Recent developments, such as smart fog-based hand sanitization systems with hand-surface contamination detection, indicate the potential for integrating intelligent sensing and automated hygiene technologies.

A. Research motivation

The reviewed studies indicate the growing importance of contactless and water-efficient hand hygiene solutions. However, challenges remain in fog coverage optimization, real-time performance evaluation, microbial effectiveness and intelligent automation. The present project addresses these aspects by integrating an Arduino UNO, IR-based hand detection, an ultrasonic fogger and automated control mechanisms into a single prototype.

III. SYSTEM ARCHITECTURE

The proposed Disinfecting Fog-Based Hand Wash Machine consists of an IR-based hand detection unit, Arduino UNO microcontroller, relay and transistor driver circuit, ultrasonic fogger, and LED and buzzer indicators. The IR sensor continuously detects the presence of a user's hands and sends the corresponding signal to the Arduino UNO. The microcontroller processes the input and activates the ultrasonic fogger through the relay and driver circuit to generate disinfecting fog. LED and buzzer indicators provide visual and audible feedback about the system's operating status.

The system is designed to provide contactless operation and controlled fog generation, reducing unnecessary liquid consumption and physical interaction with the machine.

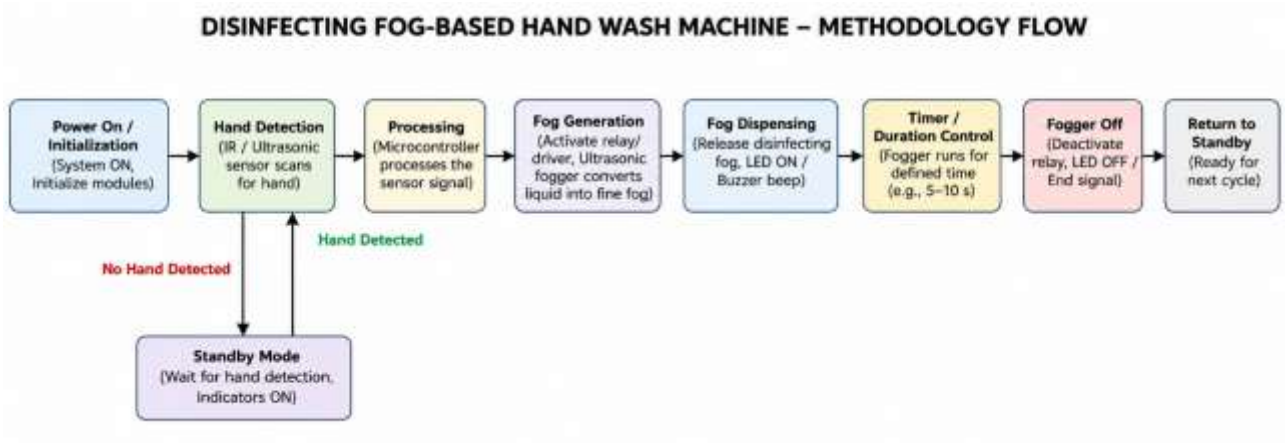


Fig. 1. Overall architecture of the proposed disinfecting fog-based handwash machine.

Methodology flowchart of the proposed disinfecting fog-based hand wash machine illustrating the sequence of hand detection, microcontroller processing, automated fog generation, dispensing, timer control and return to standby mode.

A. Sensor and Control Communication

The proposed disinfecting fog-based hand wash machine uses wired communication between the IR sensor, Arduino UNO microcontroller and fogger control circuit. The IR sensor continuously detects the presence of a user's hands and sends a digital signal to the Arduino UNO. The microcontroller processes the received signal and controls the relay and transistor driver circuit to activate the ultrasonic fogger.

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When hand presence is detected, the Arduino UNO triggers the fogger to convert the disinfectant liquid into fine fog. The generated fog is released through the dispensing arrangement, while LED and buzzer indicators provide visual and audible notifications about the system's operation.

The system follows an automated control mechanism without requiring internet connectivity or wireless communication. The fogger operates according to the programmed control conditions and predefined duration. After the completion of the dispensing cycle, the controller deactivates the fogger and returns the system to standby mode, making it ready for the next user.

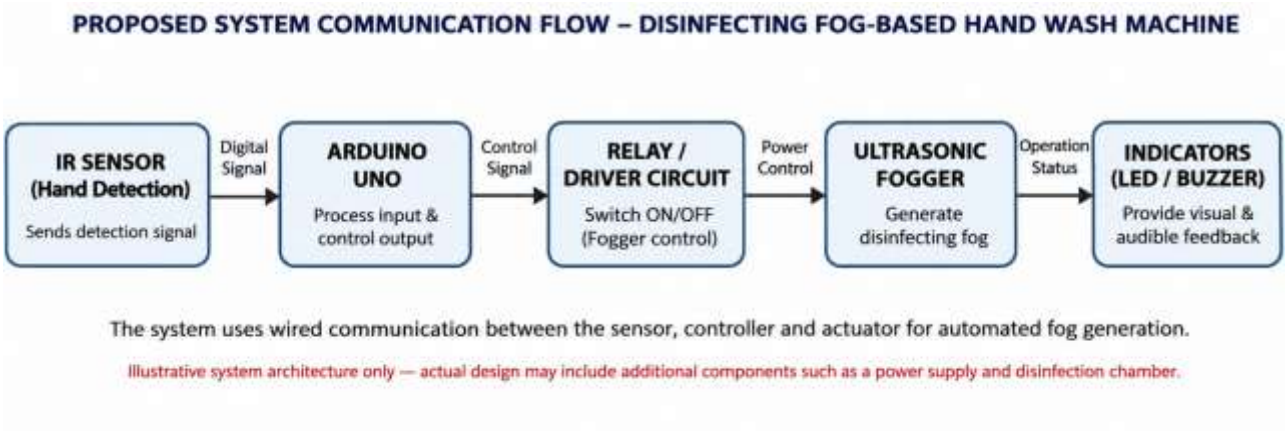


Fig. 5. Proposed system communication flow of the disinfecting fog-based hand wash machine.

The IR sensor detects the presence of hands and sends a digital signal to the Arduino UNO microcontroller. The Arduino processes the input and sends a control signal to the relay/driver circuit to activate the ultrasonic fogger. The fogger converts the disinfectant liquid into fine fog for dispensing. LED and buzzer indicators provide visual and audible feedback during system operation.

IV. HARDWARE DESIGN AND INTERFACING

A. Main hardware components

Component	Function in prototype
Arduino Uno	Sensor acquisition, packet preparation and transmitter control.
IR Sensor	LoRa wireless transmitter and receiver modules.
Ultrasonic fogger	Receiver-side controller.
Relay Module	Methane-sensitive gas sensor module; calibration required.
Transistor Driver	Broad-response air-quality sensor module; not gas selective.
LCD	Temperature and relative-humidity measurement.
Buzzer	Optical pulse-rate and SpO_2-related estimation.

B. Arduino UNO Transmitter/Controller Pin Mapping

Interface	Arduino UNO connection
IR sensor VCC	5V
IR sensor GND	GND
IR sensor OUT	D9
Relay VCC	5V
Relay GND	GND
Relay IN	D7
LCD VCC	5V
LCD GND	GND
LCD SDA	A4
LCD SCL	A5

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The IR sensor is connected to the Arduino UNO to detect the presence of hands. The sensor sends a digital signal to the microcontroller whenever hands are detected within its sensing range. The Arduino processes this signal and activates the relay through the driver circuit.

The relay controls the ultrasonic fogger, which generates fine disinfecting fog from the liquid. LEDs and a buzzer are connected to the Arduino to indicate the operating status of the machine. All components are powered through an appropriate power supply with suitable voltage and current ratings.

The system uses a 5V DC power supply to operate the Arduino UNO and associated control circuit. The IR sensor is connected to the Arduino for hand detection, while the relay/driver circuit controls the ultrasonic fogger. The LED and buzzer are connected to the controller for visual and audible indications.

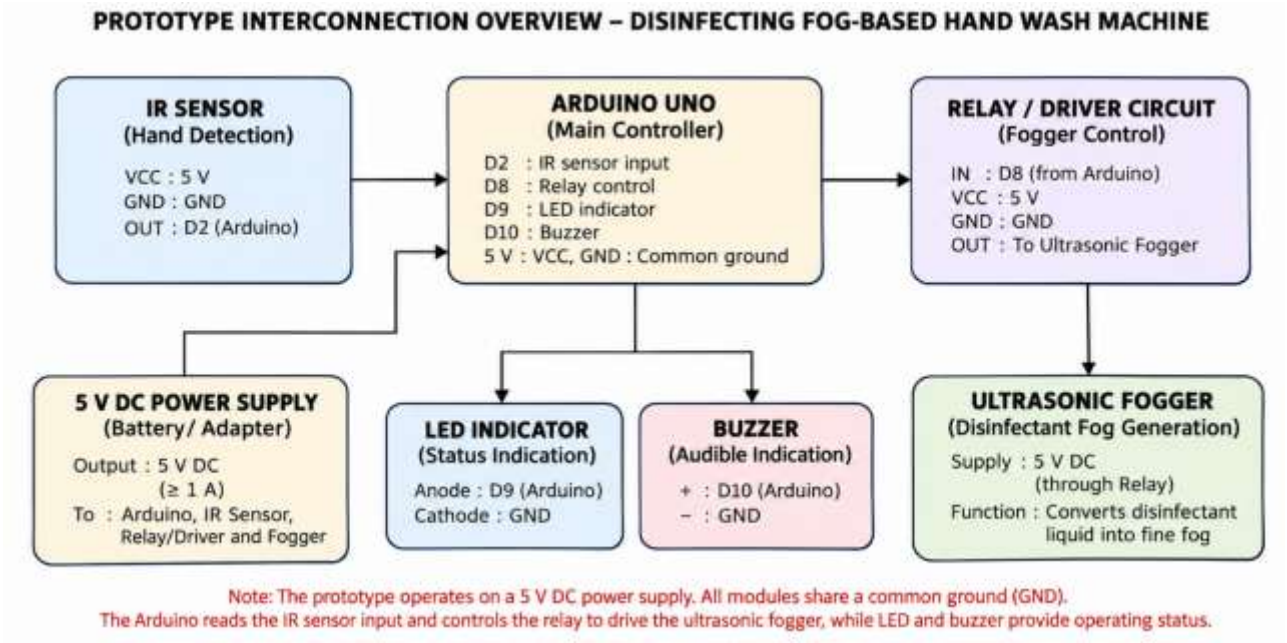


Fig. 2.Prototype interconnection diagram based on the pin assignments documented during development; verify level shifting and final wiring before fabrication.

V. METHODOLOGY AND SOFTWARE IMPLEMENTATION

A. Hand Detection and Sensor Data acquisition

The IR sensor is used to detect the presence of a user's hands near the machine. It continuously monitors the detection area and sends a digital signal to the Arduino UNO. The microcontroller receives this signal and determines whether hand presence has been detected.

B. Signal Processing and Control Operation

The Arduino UNO processes the input received from the IR sensor according to the programmed conditions. When hand presence is detected, the controller generates an output signal to activate the relay and transistor driver circuit. If no hand is detected, the system remains in standby mode.

C. Fog Generation and Dispensing

When the relay is activated, the ultrasonic fogger starts operating and converts the disinfectant liquid into fine fog. The generated fog is released into the disinfection chamber through the dispensing arrangement. This process provides an automated and contactless approach to hand hygiene.

D. Timer and Duration Control

The fogger operates for a predefined duration according to the programmed control conditions. The timer-based operation helps regulate fog generation and avoid unnecessary disinfectant consumption. After the specified duration, the Arduino UNO deactivates the relay and switches OFF the fogger.

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E. Monitoring and Indication

LED and buzzer indicators are incorporated into the system to provide visual and audible feedback. The LED indicates the operating status, while the buzzer provides an audible notification during the dispensing cycle. Once the operation is completed, the system returns to standby mode and waits for the next hand detection.

F. Software Implementation

The software implementation is developed using the Arduino IDE, with embedded C/C++ programming for the Arduino UNO microcontroller. The program initializes the IR sensor, relay, LED and buzzer pins and continuously monitors the sensor input.



Fig. 3. Operational flow of Disinfecting fog-based hand wash machine

VI. PROTOTYPE IMPLEMENTATION AND OUTPUT

The final prototype of the proposed Disinfecting Fog-Based Hand Wash Machine integrates the Arduino UNO controller, IR sensor, relay and driver circuit, ultrasonic fogger, and indicator modules. The system detects the presence of hands and automatically activates the fogger to generate disinfecting fog. LED and buzzer indicators provide visual and audible feedback during operation. The prototype demonstrates the integration of contactless hand detection and automated fog generation for improved hand hygiene

A. Observed dashboard output

Dashboard parameter	Observed Output	Interpretation
Arduino UNO	Operational in Simulation	Main controller
IR Sensor	Hand detection demonstrated	Contactless detection
Relay Module	Switching operation demonstrated	Fogger control
Ultrasonic fogger	Control operation simulated	Fog generation control
LED Indicator	ON/OFF operation	Visual indication
Buzzer	Operating indication	Single displayed observation.
Power Supply	No valid numerical value visible	Audible feedback

The preliminary implementation of the proposed Disinfecting Fog-Based Hand Wash Machine demonstrates the operation of contactless hand detection, automated fogger control and indicator functionality through hardware circuit simulation. The Arduino UNO successfully processes the IR sensor input and controls the fogger through the relay and driver circuit.

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B. Preliminary Results

The preliminary results indicate that the developed hardware simulation performs the expected control operations. Hand detection through the IR sensor triggers the programmed control sequence, allowing the relay and fogger control circuit to operate. LED and buzzer indicators provide additional feedback during system operation.

The results demonstrate the feasibility of the proposed control architecture. However, actual fog coverage, disinfectant consumption, microbial effectiveness and overall system performance require validation using the completed physical prototype.

VII.RESULTS AND DISCUSSION

The proposed Disinfecting Fog-Based Hand Wash Machine was developed to provide a contactless and water-efficient approach to hand hygiene. The preliminary hardware simulation demonstrates the integration of the Arduino UNO, IR sensor, relay/driver circuit, ultrasonic fogger control and LED and buzzer indicators.

The IR sensor detects the presence of hands and sends a signal to the Arduino UNO. The microcontroller processes the input and activates the relay circuit to control the ultrasonic fogger. The LED and buzzer provide visual and audible indications during system operation.

The preliminary implementation demonstrates the expected control sequence, including hand detection, fogger activation and automatic control. However, the actual fog coverage, liquid consumption and microbial effectiveness have not yet been experimentally validated.

The preliminary results indicate that the proposed system can integrate contactless hand detection with automated fogger control. The use of an IR sensor reduces the need for physical interaction, while the ultrasonic fogger provides the mechanism for generating fine disinfecting fog.

The Arduino-based control arrangement provides coordinated operation of the sensor, relay and indication modules. The 5V DC power supply supports the control circuit as specified for the prototype.

However, the current implementation has certain limitations. The physical disinfection chamber assembly, fog coverage evaluation and microbial effectiveness testing are still pending. Therefore, the system's actual disinfection performance and water-saving efficiency cannot yet be established.

A. Experimental metrics to collect

Test area	Required data for future evaluation
Hand Detection	Detection accuracy, sensing distance and response time.
Fog Generation	Fog density, generation time and coverage area.
Disinfectant Consumption	Liquid consumption per cycle and total usage.
Environmental Performance	Water consumption and comparison with conventional handwashing.
System Response	Relay activation time, fogger operating duration and switching reliability.
Indicator Performance	LED and buzzer response during operation.
Power Consumption	Supply voltage, current consumption and battery operating duration.
Disinfection Effectiveness	Microbial reduction testing under controlled laboratory conditions.
System Reliability	Repeated operating cycles, errors and failure observations.

VIII. LIMITATIONS AND SAFETY CONSIDERATIONS

- IR sensor accuracy may be affected by surrounding light conditions and detection distance.
- Uniform fog distribution and coverage over the hand surface require further testing.
- Actual microbial disinfection effectiveness has not yet been verified through laboratory testing.

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- Disinfectant consumption and water-saving efficiency require experimental evaluation.
- Proper electrical insulation, moisture protection and safe handling of the 5V DC supply are essential.
- Suitable disinfectants must be selected, considering potential inhalation, skin irritation and eye exposure risks.

IX. CONCLUSION

The proposed Disinfecting Fog-Based Hand Wash Machine provides an automated and contactless approach to hand hygiene using an Arduino UNO, IR sensor and ultrasonic fogger. The developed hardware simulation demonstrates hand detection, relay-based fogger control and LED and buzzer indication. The system aims to reduce physical contact, minimize liquid consumption and improve hygiene in public environments. The preliminary implementation validates the basic control mechanism, while physical prototype assembly and performance testing are still in progress. Further evaluation of fog coverage, disinfectant consumption and microbial effectiveness is required to establish the system's practical performance and reliability.

X. FUTURE WORK

Future work will focus on completing the physical hardware assembly, including the disinfectant tank, dispensing chamber and fogging nozzle setup. The electronic components will be fully integrated, and the IR sensor detection distance and fogger operating duration will be optimized. Further testing will be conducted under different environmental conditions to evaluate system reliability, fog coverage and disinfectant consumption. Microbial effectiveness testing will also be performed to assess the disinfection capability of the generated fog. Finally, performance analysis, complete project documentation and final prototype demonstration will be carried out.

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