

# DESIGN AND IMPLEMENTATION OF AN IoT-CONTROLLED UV AND FOG BASED SANITIZATION ROBOT

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## Abstract:

*In recent times, maintaining proper hygiene and sanitization has become essential, especially in public places such as hospitals, colleges, and offices. Traditional cleaning methods involve human effort, which increases the risk of exposure to harmful pathogens. To address this issue, this project presents a UV and fog-based sanitization robot that helps in effective disinfection while reducing human contact. The system is designed to sanitize both surfaces and surrounding areas efficiently using ultraviolet (UV) light and fog spraying techniques.*

*The robot is built using an ESP32-CAM module, which enables real-time monitoring and remote control through a mobile interface. The ESP32-CAM acts as the main control and communication unit, allowing users to observe the sanitization process live and operate the system easily. The integration of UV disinfection and fog-based sanitization ensures better coverage and improved hygiene. This project provides a simple, cost-effective, and safe solution for modern sanitization needs.*

**Keywords:** *UV Disinfection, IoT, LCD, Ultrasonic Sensor, ESP32-CAM, Wi-Fi, APR33A3, Sanitization.*

## 1. INTRODUCTION

The increasing need for hygiene and infection control has led to the development of smart and efficient sanitization systems. This project presents a UV and fog-based sanitization robot integrated with ESP32-CAM technology to ensure effective and contactless disinfection. The system combines fog-based sanitization for uniform disinfectant spread and UV light for surface sterilization, enhancing overall hygiene. It also includes features such as ultrasonic sensing for detection, relay-based control for operation, and real-time monitoring through the ESP32-CAM module. The robot is manually controlled and designed to be portable, making it suitable for use in hospitals, colleges, offices, and other public spaces. Overall, this system provides a reliable, cost-effective, and user-friendly solution for modern sanitization requirements.

### 1.1 Literature Survey

P. Chanuakon et al. presents a UV sterilization robot designed for operating rooms and patient wards. The system uses three 19.3-W UV lamps arranged to provide 360° disinfection coverage. It

integrates a Raspberry Pi–based embedded system for intelligent navigation and obstacle avoidance. Experimental tests showed highly effective germicidal action, where *Staphylococcus Aureus* bacteria placed 35 cm away were eradicated within 8 seconds of UV exposure. This work demonstrates the feasibility of automated UV disinfection for healthcare environments.[1]

Akanksha Vyas et al. proposes a fully automatic floor-cleaning system capable of performing dry cleaning, wet cleaning, and UV sterilization. Unlike existing cleaners that support only one or two functions, this system integrates multiple cleaning modes into a single design. The goal is to deliver an efficient solution for homes, offices, and public facilities by ensuring both surface cleaning and microbial reduction. Their work highlights the importance of automation in modern hygiene systems.[2]

Bratu, Zolya, and Moraru presents RoboCoV Cleaner, an autonomous indoor robot designed for UV-C disinfection that emphasizes human and animal safety through a dual-redundant detection system. The robot integrates multiple PIR (Passive Infrared) sensors and an AI-based 360° camera using object-detection algorithms to reliably identify humans, even in challenging conditions such as darkness, wearing masks, or under UV illumination. Their experiments report > 90% human detection accuracy via PIR sensors and up to 99% accuracy with the AI camera at distances up to 30 meters.[3]

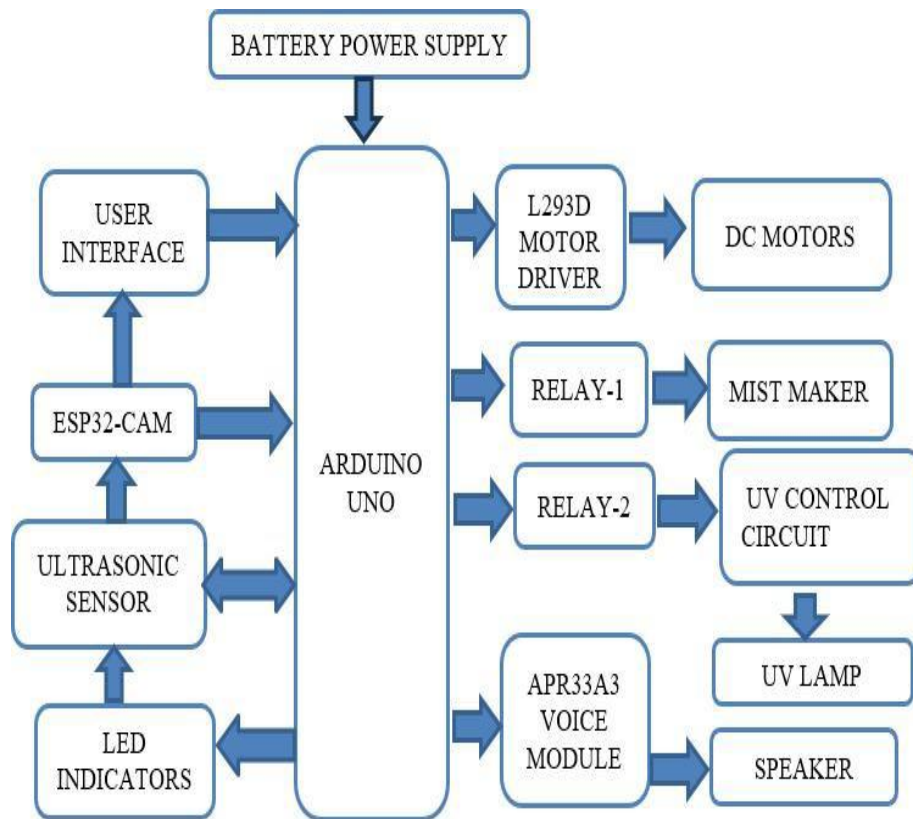
Yao, Ma, and Chen propose an autonomous mobile robot that combines ultraviolet (UV) radiation with a low-concentration hydrogen peroxide aerosol to enhance disinfection efficiency and coverage. Their system includes a human- computer interface, a mobile robotic platform, and disinfection hardware capable of both continuous and fixed-point sterilization modes. The authors developed a mathematical model to optimize key parameters such as speed, disinfection duration, and effective range, ensuring that the robot can operate safely and efficiently.[4]

## **2. BLOCK DIAGRAM**

The block diagram represents the overall architecture of the sanitization robot system. At the center is the Arduino UNO, which acts as the main controller coordinating all operations. The system is powered by a regulated power supply (5V) and optionally a battery for mobility. Input devices such as the ultrasonic sensor are used for hand detection, which triggers the sanitization process. Additionally, the ESP32-CAM module is connected to the Arduino to enable Wi-Fi communication, live video streaming, and remote control through a web interface.

On the output side, the Arduino controls multiple components based on the received inputs and programmed logic. The motor driver (L293D) is used to control the left and right motors, enabling robot movement in different directions like forward, backward, left, and right. For the sanitization process, a relay module is used to switch the fog generator ON and OFF, allowing sanitizer mist to be sprayed. A buzzer is also connected to provide audio indications during operation, such as process start and completion.

The ESP32-CAM plays a crucial role in IoT-based control by hosting a web server that allows the user to monitor and control the robot remotely. Through the web interface, the user can view live video and send commands for robot movement, LED control, and UV light operation. The Arduino



**Fig 1 Block Diagram**

processes these commands and performs the required actions, ensuring smooth coordination between hardware and software components. Overall, the block diagram shows how sensing, control, communication, and actuation are integrated to achieve an efficient and user-friendly sanitization robot system.

### 3. FLOW CHART

The system starts by powering ON all components, including the Arduino, sensors, motor driver, relay module, and ESP32-CAM. The ESP32-CAM connects to Wi-Fi and starts the web server for live video streaming and control. The system then enters standby mode, continuously waiting for input. If a hand is detected by the ultrasonic sensor, the hand sanitization process begins, where the fog generator and buzzer are activated. The system runs for a fixed time of 5–10 seconds, after which the fog generator is turned OFF and a buzzer sound indicates completion. The system then returns to standby mode, ready for the next operation.

If a command is received from the web interface, the robot operation starts. The user views live video and sends movement commands such as forward, backward, left, right, or stop. Based on the command, the Arduino controls the motors through the motor driver. During operation, the user can

also control additional features like turning the LED ON or OFF and enabling or disabling UV sanitization. If a stop command is given, the robot stops and the system returns to standby mode, completing the cycle.

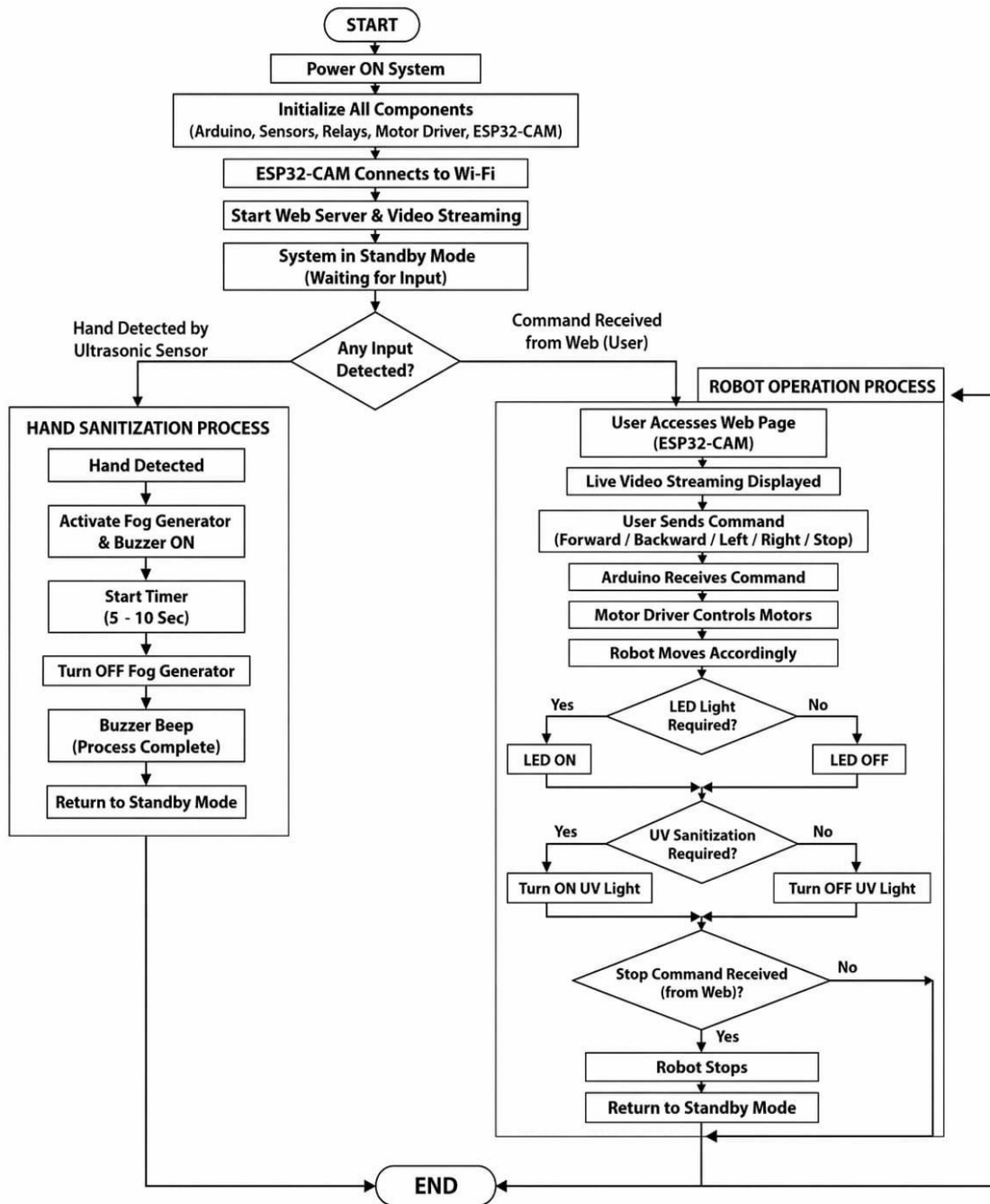
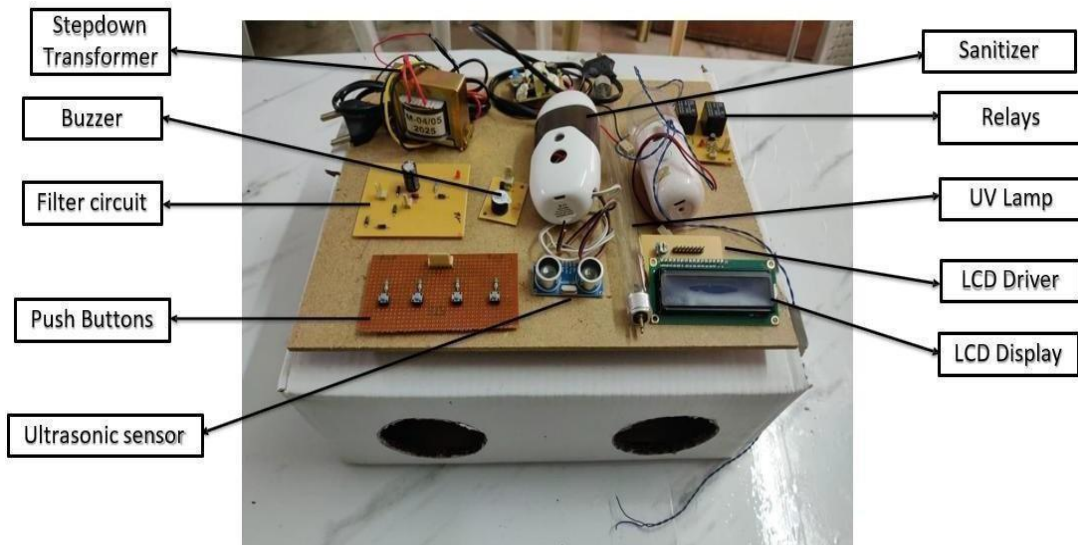


Fig 2 Flow Chart

#### 4. HARDWARE MODULE

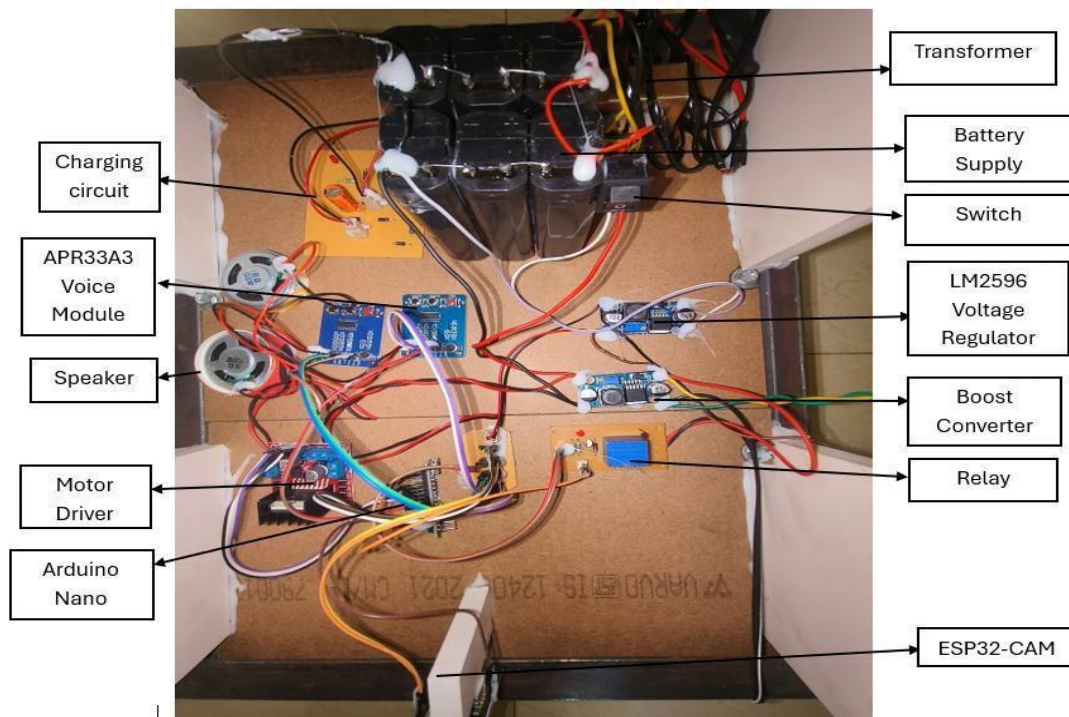
The hardware module of this project consists of a compact system designed to perform automatic sanitization using UV light and fog spray. The main controller used is an Arduino Nano, which acts as the brain of the system. It is connected to an ultrasonic sensor that detects the presence of hands

or objects. Based on this detection, the controller activates the sanitization process. A motor driver is used for controlling movement, and an ESP32-CAM module is included for monitoring and live streaming purposes.



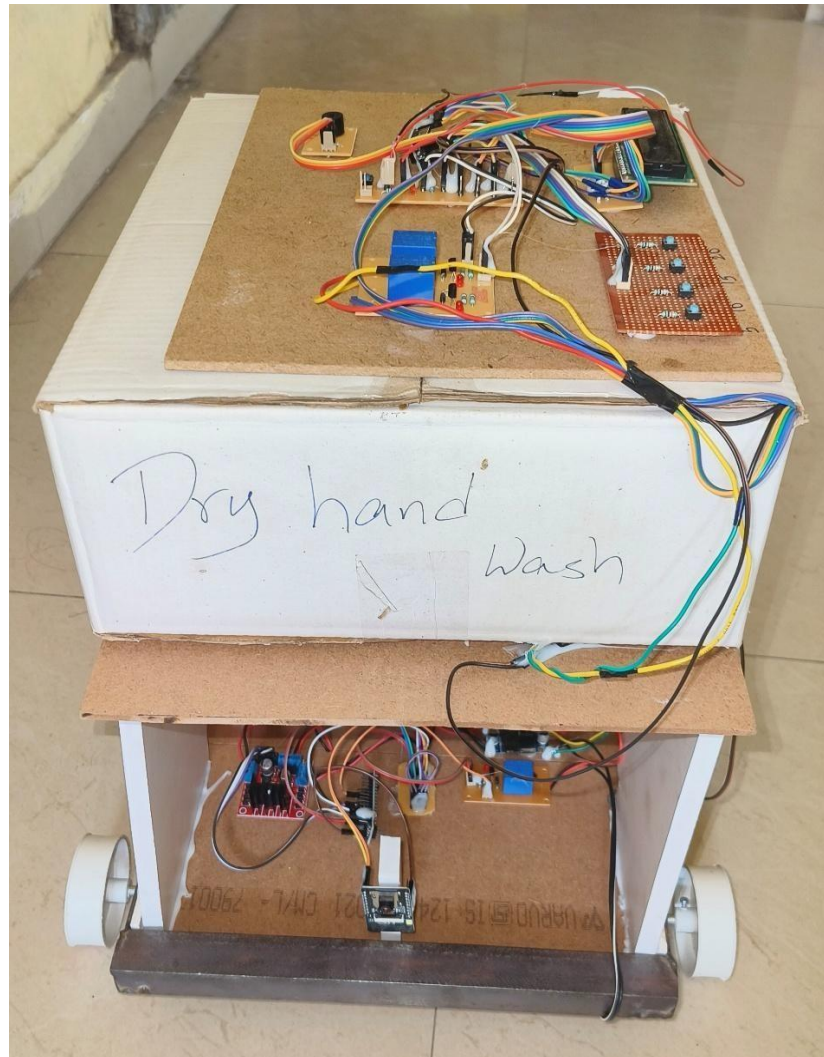
**Fig 3 Dry Hand-Washing Machine**

The power supply section includes a battery, step-down transformer, charging circuit, and voltage regulators like LM2596 to provide stable voltage to all components. A boost converter is also used where higher voltage is required. Relays are used to switch high-power devices like the UV lamp and sanitizer spray. Additional components such as switches, push buttons, and a buzzer are used for control and indication.



**Fig 4 UV based sanitization robot**

For sanitization, the system uses a UV lamp for surface disinfection and a fogging mechanism to spray sanitizer liquid. The LCD display shows system status and instructions, while the ultrasonic sensor ensures touch-free operation. All components are mounted on a base structure with proper wiring and connections. This hardware setup makes the system efficient, automatic, and suitable for maintaining hygiene in public and private spaces.



**Fig 5 Robot Setup**

## **5. TESTING AND RESULTS**

### **CASE 1: Hands Sanitization**

The fog disinfection mode in this system works by generating a fine mist of sanitizer to effectively disinfect hands and small surfaces. When the ultrasonic sensor detects the presence of a hand, the Arduino activates the fog generator through a relay module, producing a uniform spray that covers the area for efficient sanitization. This process runs for a fixed duration to ensure proper disinfection, while a buzzer may indicate the start and completion of the cycle. The fog spreads evenly, reaching

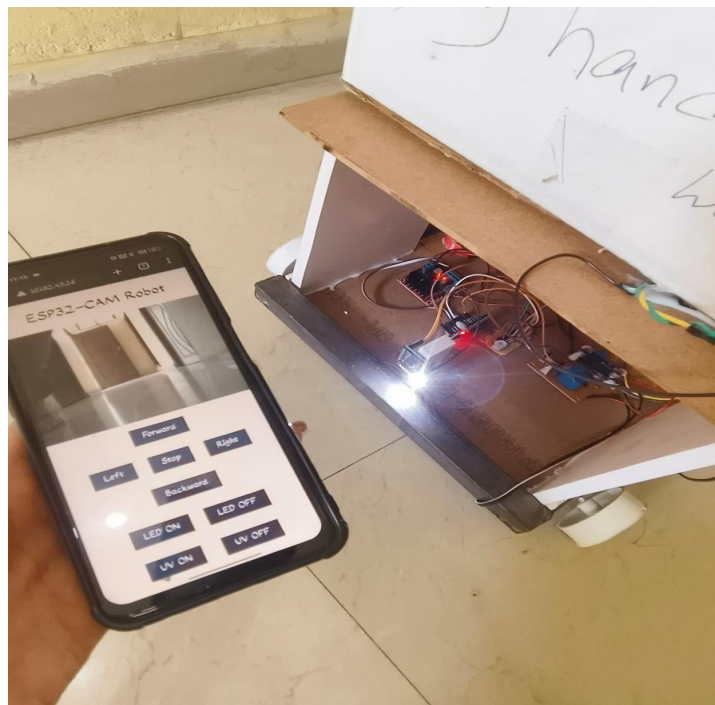
small gaps and surfaces that are difficult to clean manually, making the system more effective and hygienic. After the set time, the fog generator automatically turns OFF, and the system returns to standby mode, ready for the next use.



**Fig 6 Fog Disinfection**

### **CASE 2: LED ON**

The LED ON function in this system is used to provide illumination during robot operation, especially in low-light or dark environments. When the user selects the LED ON option from the web interface, the command is sent through the ESP32-CAM to the Arduino, which then activates the LED. This helps in improving visibility for the live video streaming, allowing the user to clearly monitor surroundings and control the robot effectively. The LED remains ON until the user sends an LED OFF command, making it a simple and useful feature for better navigation and operation.



**Fig 7 LED Light ON**

### CASE 3:UV Surface Disinfection

UV Surface Disinfection is a process in which ultraviolet (UV) light is used to eliminate harmful microorganisms present on surfaces. In this system, when the UV mode is activated through the web interface, the Arduino controls the UV light to disinfect nearby surfaces effectively. The UV light works by damaging the DNA of bacteria and viruses, thereby preventing their growth and spread. This feature is useful for maintaining hygiene in areas such as floors, tables, and frequently touched surfaces. The UV light operates only when required and can be turned OFF manually through the control system, ensuring safe and controlled disinfection.



**Fig 8 Surface Disinfection**

## 6. CONCLUSION

The proposed project successfully demonstrates a manually controlled sanitization robot integrated with fog-based hand sanitization and UV surface disinfection features. By using Arduino and ESP32-CAM, the system enables real-time video streaming and remote operation through a web interface, making it user-friendly and efficient. The ultrasonic sensor-based hand detection ensures contactless sanitization, while additional controls like LED and UV improve functionality and usability. Overall, the project provides a cost-effective, practical, and hygienic solution for reducing human contact and maintaining cleanliness in various environments, showcasing the effective integration of embedded systems and IoT technologies.

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