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Automatic Delayed Alcohol Sprayer for Door-handle Disinfection

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In this study, a device that can automatically disinfect door handles and prevent contact infection was designed. This device will spray alcohol onto door handles –6 s after the user leaves, as detected by infrared sensing. We used observation and design thinking methods to carry out needs analysis, prototype design, experimental testing, and effect evaluation. The experimental results showed that this delayed spraying method can effectively reduce the amount of bacteria and dirt on door handles and also increase the user's sense of hygiene and safety. Moreover, this method can contribute to epidemic prevention without spraying alcohol directly onto the human body.

1. Introduction

1.1 Research background and motivation

One of the objects that people often touch in their daily lives is the door handle, which is also one of the important transmission routes for bacteria and viruses.(1) Since the outbreak of COVID-19 in 2019, how to effectively prevent cross-infection has become an important and urgent problem.(2)

In clinics, because of the frequent visits of patients, the use and discussion of door handles have also attracted attention.(3) The cross-infection and disinfection of viruses remaining on the surface of door handles are very important issues.(4)

Currently, most of the products on the market are alcohol spray products to disinfect hands by contact, but most of them require manual operation or timed spraying. Using artificial intelligence to detect abnormal body temperature in real time and send signal alerts can be part of a more widespread epidemic prevention strategy.(5)

Automatic sensing doors that can be opened and closed without contact also help prevent contact infection among crowds, but they are common only in specific places. Therefore, in this study, we aim to design a plug-and-play sensing device for door handles that can spray alcohol disinfectant after waiting for the user to leave before spraying. This should improve the

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efficiency and convenience of disinfection and prevent dirt from being left on the door handles from hands slippery with alcohol.

The cold and wet feeling of alcohol also causes discomfort to some users. The psychological aspects of users' operation of epidemic prevention products are gradually emerging. Therefore, the results of this study are expected to change the epidemic prevention and disinfection mode for door handles in public places in the future, making it more humanized.

1.2 Research focus and limitations

The research direction was formulated using the behavioral observation method outlined in Table 1 as follows:

(1) We present a fundamental and practical solution for alcohol disinfection spray products designed for door handles. The solution includes automated detection of user interaction with door handles, followed by the automatic spraying of alcohol disinfectant once the user has departed. This mechanism effectively achieves sterilization and contributes to epidemic prevention.

(2) In the research, we employ wireless charging technology as a means to conserve power and reduce battery waste, in alignment with principles of environmental conservation and energy efficiency.

(3) In accordance with the principles of human factors engineering, we have developed a plug-and-play sensing device suitable for various door-handle shapes. It also offers a user-friendly interface and feedback system.

(4) To validate the device's disinfection effectiveness and user satisfaction, comprehensive experimental testing and efficacy evaluations have been conducted. We also provide recommendations for device improvement and future development.

(5) This research significantly contributes to the fields of epidemic prevention design and sensing devices and serves as a valuable reference and application for subsequent research endeavors.

Table 1
Behavioral observation—Comparison of hand-sanitizing methods vs disinfection of door handles.

Disinfection Method	Operational Procedure	Disinfection Effect	Disinfection Time	Cross-contamination
Traditional Hand Spraying Disinfection	User-operated, requires contact with water source or other cleaning supplies	May not completely cover all microbial contamination areas and may reduce disinfection effectiveness as a result of improper or insufficient operation	Requires a longer time to achieve optimal sterilization results	May cause recontamination due to frequent user contact
Disinfection of Door Handles	Utilizes infrared sensing or other automation methods to reduce human contact and operating costs	Improves disinfection efficiency and uniformity by using small aerosol particles that can come into contact with all surfaces	Disinfects after users have left by delayed or timed spraying, preventing cross-contamination and reducing the risk of cross-infection	Reduced risk of cross-infection

(1) We initially conducted disinfection efficacy tests solely on bacteria, and therefore, we cannot guarantee that the device will have the same effectiveness against all microorganisms.
(2) We exclusively used one type of alcohol disinfectant as the spraying material, without considering other potential allergenic or irritant components. Users should, therefore, verify whether they may have adverse reactions to the alcohol disinfectant before use.
(3) We conducted surveys using a small sample within the campus of I-SHOU University in Taiwan, without accounting for potential user preferences or needs that might exist. Consequently, the device's acceptance among different user groups may differ.

2. Literature Review

2.1 Bacteria and infectious diseases on door handles

The World Health Organization (WHO) initiated restrictions and measures for infection prevention and control in response to the outbreak of COVID-19 in 2019.(6) Door handles are among the commonly touched objects in people's daily lives and serve as significant transmission routes for bacteria and viruses.(2–4) Pathogenic bacteria such as *Escherichia coli*, *Staphylococcus aureus*, and *Salmonella* can potentially cause infections or poisoning and can be found on door handles in public places.(7) During periods of high viral outbreaks, viral RNA, including that of COVID-19, has been detected on hospital door handles, indicating that door handles can serve as potential sources of transmission for diseases such as COVID-19.(2,8) The effective prevention of cross-contamination on door handles in settings such as hospitals, bathrooms, public areas, and even households has become an important and pressing concern.

2.2 Alcohol disinfection spray products for door handles

Numerous studies have demonstrated that alcohol is a widely used disinfectant capable of effectively killing most types of bacteria and viruses.(9) Currently, there are some alcohol disinfection spray products designed for door handles available on the market. However, most of these products require manual operation or have preset spraying schedules, thus lacking smart functionality and real-time responsiveness. This can lead to issues such as alcohol wastage or inadequate disinfection. For instance, some products require users to press a button or come into close proximity for activation, which may increase the risk of users coming into contact with sources of infection.

As a response, some automated systems that periodically spray alcohol disinfectant to mitigate the risk of cross-contamination have been studied.(10,11) While periodic automated disinfection has its merits, it may result in excessive alcohol consumption or delayed replenishment in environments with lower foot traffic. Hence, periodic automated disinfection may not cater to all door-handle usage frequencies and needs. Therefore, in this study, we aim to design a plug-and-play sensor-based device for door-handle alcohol disinfection spray products to enhance their efficiency and convenience.

Existing alcohol disinfection spray products commonly used in the market, as shown in Fig. 1, offer real-time spraying with large droplets, resulting in high alcohol consumption, and a sensing distance of approximately 10 cm. When directly mounted above the door handle, the proximity often leads to inadvertent contact with the alcohol reservoir. Consequently, when opening the door, the direct alcohol spray can make the handle wet and slippery. Moreover, if the user's hands are soiled or dirty, the mixture of alcohol with contaminants can make the handle even more prone to accumulating dirt. As a result, the overall effectiveness in terms of hygiene and safety of public door handles is significantly compromised. Therefore, we have identified this issue as one of the key focal points for resolution.

2.3 Design thinking for COVID-19

Ever since COVID-19 rapidly spread across the globe, it has presented an unprecedented challenge to disease control and public health measures worldwide. Design thinking offers creative and innovative solutions to tackle such complex issues. Different industries globally have adopted various approaches to address the challenges posed by COVID-19. During the pandemic, measures such as lockdowns were implemented to control the outbreak, necessitating design thinking as a method and tool for problem-solving, beyond conventional modes of thinking.(12)

For instance, new or enhanced ways of caregiving methods, education, and patient management issues have emerged owing to the COVID-19 pandemic. Potential solutions include providing technological empowerment guidance to healthcare providers. In addition, medical education has undergone digital transformation during the pandemic.(13)

In the context of product design, design processes can be structured in accordance with design thinking theory and methods into six stages: (1) defining design challenge, (2) understanding design challenge, (3) defining perspectives, (4) generating ideas, (5) testing prototypes, and (6) integrating prototypes.(14,15)

Effective sterilization to protect the population from cross-contamination and spread of infections is crucial. Boldly innovating and developing new solutions to ensure sensitive

Fig. 1. (Color online) The common alcohol-based disinfectant sprays primarily focus on sanitizing hands, rather than targeting products used for usability (image source: Amazon website).

products can be safely launched is key to finding solutions.[16] The action of ethanol on various microorganisms such as bacteria, viruses, and spores is significant. Its efficiency and cost-effectiveness compared with other methods make it an important sterilization option. Additionally, ethanol presents a low burden on the human body, making it a preferable choice in certain contexts.[17]

3. Research Methodology

We employ a combination of design thinking and behavioral observation methods, encompassing requirement analysis, prototype design, experimental testing, and effectiveness assessment. The process is outlined in Fig. 2.

Figure 3 shows a mind map of how the design thinking process in this study is applied to the development process of the automatic delayed alcohol sprayer. On the basis of this conceptual diagram, the subsequent experimental methods and steps are determined.

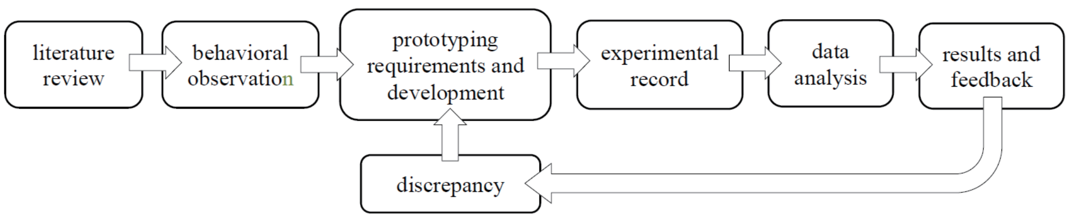

Fig. 2. Flowchart for sensor device (delay spray) research.

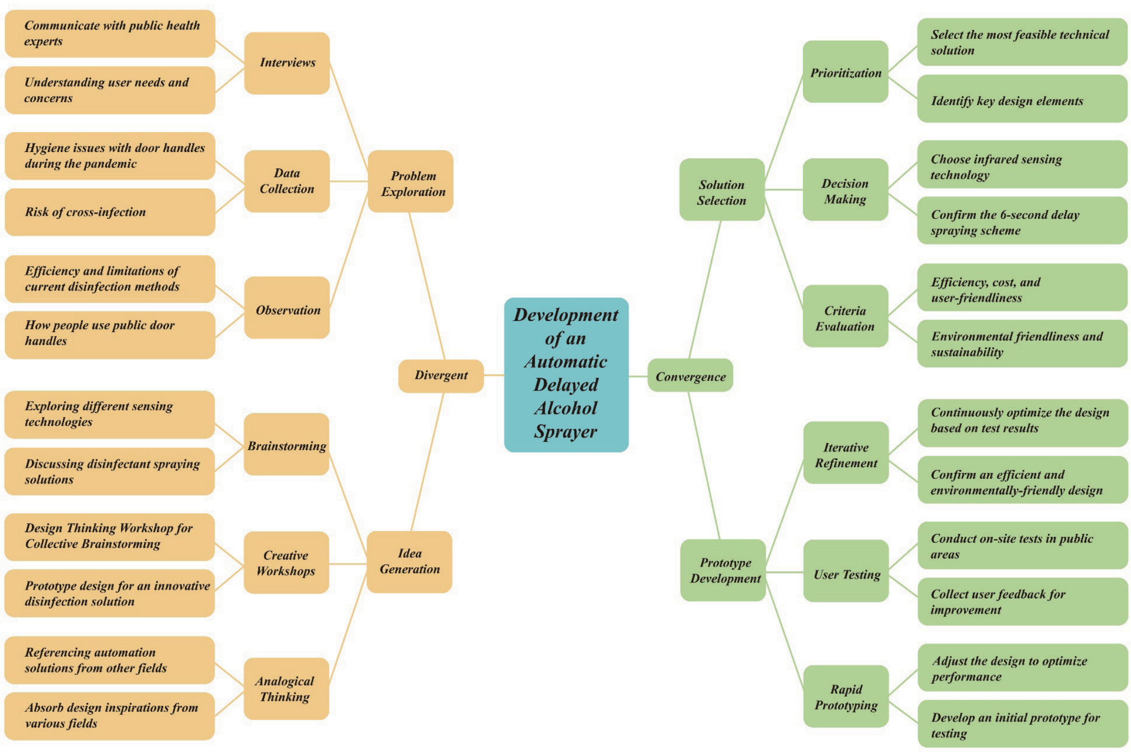

Fig. 3. (Color online) Design thinking mind map and automatic delayed alcohol sprayer.

The mind map clearly shows the key stages and activities in the design thinking process, which helps us to better understand and apply decision-making methods. Table 2 outlines the experimental steps for the behavioral observation method of the automatic delayed alcohol sprayer. This table provides a structured approach to conducting an observational study on the use of an automatic delayed alcohol sprayer, focusing on user interaction in a specific public setting such as a school library.

3.1 Applicability of infrared sensor

In this study, the design of a touchless, sensor-based device addressing the gap in infection prevention related to contact-based cross-contamination necessitates consideration of various aspects. These include user interaction methods, suitability of electronic sensing components, rationality of product assembly, and the actual achievement of on-demand door-handle disinfection benefits. These complex and intricate details require interdisciplinary integration of knowledge. In this study, we employ both divergent and convergent thinking within the framework of design thinking to integrate alternative solutions, utilizing mature technological principles to improve common issues and create a product that reduces the risk of infection and enhances hygiene and safety.

Therefore, in this research, we must consider real-world needs and behavioral patterns and combine technology and creativity to create a solution aligned with human factors engineering. The sensing technology employed in this study utilizes mature and widespread infrared technology to detect environmental or user states and trigger relevant sensing components. The sensor-based approach includes both infrared and sound sensing as noncontact sensing methods, for which we have chosen an infrared sensor over an ultrasonic sensor for the following reasons.

(1) Infrared sensors offer faster response times and are suitable for high-speed or real-time applications.

Table 2
Experimental steps for the behavioral observation method of the automatic delayed alcohol sprayer.

Step	Description
1. Determine Research Objectives	Observe people's reactions to and behavior patterns with the automatic delayed alcohol sprayer.
2. Choose Observation Environment	Choose public places for observation. The door handles of a school library are the experimental field.
3. Design Observation Plan	Determine observation times and duration, choose peak periods, each session lasting one to two hours.
4. Choose Observation Method	Combine qualitative methods using observation record sheets and video equipment with quantitative methods (appropriate spray duration).
5. Experiment Recording	Conduct observations as planned, record user behavior and reactions
6. Data Collection and Recording	Establish a data recording sheet to collect data, use observation record sheets and video materials.
7. Data Analysis	Analyze the collected data to identify behavior patterns and user reactions.
8. Interpretation of Results and Reporting	Write a research report explaining the observation results and recommendations.

(2) Infrared sensors have smaller dimensions and lighter weight, making them suitable for compact or concealed applications.
(3) Infrared sensors have lower power consumption and cost, making them suitable for energy-efficient or cost-effective applications.

Sensor-based devices enhance user convenience and comfort while reducing human intervention and errors. We will combine infrared sensor technology to design a plug-and-play sensor-based device for alcohol disinfection spray products on door handles with the aim of achieving the goal of sterilization and epidemic prevention.

The issue of large particle size leading to droplet formation and slippery handle surfaces has been identified. Therefore, we have decided to use an atomizer to replace the spray mechanism. Atomization results in smaller particle sizes and a more even dispersion, reducing the likelihood of excessive wetness and slipperiness.

3.2 Requirement analysis

Some individuals, particularly in nonessential situations, dislike coming into contact with cold and wet alcohol, especially during the winter or in low-temperature environments. While the objective of this study may appear to be a simple improvement of an alcohol disinfection device, the primary focus lies in the actual benefits and user experiences. A positive sense of infection prevention, in reality, can reduce anxiety related to hygiene concerns.

In this study, observations were made regarding the time people take to completely release the door handle after use, with data collected from 300 instances of observations. The experimental data is presented in Table 3.

According to the experimental results, the average time for individuals to completely release the door handle after opening it was 3.8 s with a median time of 4 s, and the longest recorded time was 8 s. This duration may be influenced by various factors such as people's walking speed, destination, luggage, and emotional state. The experiment revealed that the majority of individuals (75%) release the door handle within 2–6 s after opening the door, with only a small percentage (10%) taking longer than 6 s to do so. Consequently, it was determined that a delay of 6 s is optimal before activating the spray sensor.

In this study, by the behavioral observation method, user interactions with environmental characteristics and needs were documented. Through the process of design thinking, which involves problem exploration and the elucidation of design requirements, we defined design goals and specifications. Various locations and users' requirements and expectations for alcohol disinfection spray products for door handles were collected and are summarized below.

Table 3
Time taken to completely release door handle after opening.

Time to release door handle (s)	0–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	>9
Number of observations	15	30	45	60	75	45	15	10	5	0
Percentage of observations (%)	5	10	15	20	25	15	5	3.3	1.7	0

(1) The product should be able to automatically detect the effective user proximity to the door handle using infrared sensors. After the user departs, there should be a default delay of 6 s before spraying alcohol disinfectant, effectively achieving sterilization and disease prevention.
(2) The product should support wireless charging, allowing for convenient alcohol refilling and recharging, and it should also be operable offline, allowing for flexible placement.
(3) The product should feature a strong internal magnet and utilize reusable 3M adhesive tape on its exterior shell to facilitate easy installation on doors of various shapes and materials, providing users with a user-friendly sense of hygiene and safety.
(4) The product should provide indicators for alcohol disinfectant capacity and replacement reminders while preventing leakage of the disinfectant.
(5) To ensure proper and uniform disinfection without causing slippery surfaces, it is preferable to use a fine mist spraying mode for alcohol sterilization.

In accordance with the above requirements, the code is written as follows.

```
import time

# Initialize battery status (assume initial battery status is 100%)
battery_percentage = 100

# Initialize charging status (assume initially not charging)
charging = False

# Initialize red light and green light status
red_light_on = False
green_light_on = False

# Main loop
while True:
    # Simulate an infrared distance sensor reading of 30 centimeters
    infrared_distance = 30

    # If an object is detected within 30 centimeters
    if infrared_distance <= 30:
        # Activate the blue LED light, with a 0.5-second interval for 1 second, continuously flashing for 6 seconds
        for _ in range(12):  # 12 cycles, equivalent to 6 seconds
            blue_light_on = not blue_light_on  # Toggle the LED light status
            time.sleep(0.5 if blue_light_on else 1.0)  # Control the LED flashing interval

        # Activate the sprayer for 3 seconds
        print("Spraying for 3 seconds")
        time.sleep(3)

        # Keep the blue LED light on for 3 seconds
        print("Blue LED on for 3 seconds")

    # If the battery is less than 20%
    if battery_percentage < 20:
        # Keep the red LED light on with a 0.5-second interval for 1 second until the battery is depleted
        while battery_percentage > 0:
            red_light_on = not red_light_on  # Toggle the red light status
            time.sleep(0.5 if red_light_on else 1.0)  # Control the LED flashing interval
            battery_percentage -= 1  # Simulate battery depletion
```

```
# If charging is in progress
if charging:
    # Keep the green LED light on, indicating full charge when charged
    green_light_on = True

time.sleep(1)  # Main loop runs once per second
```

3.3 Prototype design

As a result of the requirement analysis, the product must incorporate an automatic delay feature for spraying, with the exterior design temporarily excluded from experimental evaluation. In the prototype fabrication process, photopolymerization 3D printing is utilized to create a plug-and-play appearance. The infrared sensor is designed to detect distances within 30 cm, ensuring activation only when users genuinely need to enter or exit a door. After sensing a target, a 6 s timer initiates the alcohol mist spray on the door handle. Multiple units can be placed to cover any upper and lower blind spots. The primary components of this device, which can be adjusted on the basis of user comfort, include

(1) an infrared sensor for detecting door-handle usage and triggering the spray action,
(2) a sprayer, equipped with a detachable alcohol disinfectant container, for dispensing alcohol disinfectant,
(3) a wireless charging module for receiving power from a wireless charger and storing it in an internal battery, as shown in Fig. 4,
(4) a microcontroller for controlling the sensor, sprayer, and wireless charging module and providing a user interface and feedback (it initiates the 6 s delay before spraying for 2 s),
(5) an LED for displaying the alcohol disinfectant capacity and replacement reminders, as well as the battery level and charging status,
(6) a buzzer for providing an audible signal for alcohol disinfectant replacement reminders,
(7) a switch for turning the device on or off, and
(8) an enclosure for protecting the internal components of the device and providing a surface that fits door handles, as shown in Fig. 5.

Fig. 4. (Color online) Sensor assembly testing of the device.

Through pre-experiment testing, the optimal spray duration was found to be 3 s. Excessive spraying of alcohol beyond 3 s, even with atomization, would result in the formation of droplets on the door handle, leading to the previously mentioned issues, such as increased slipperiness during door handling.

4. Experimental Results

4.1 Experimental testing

The prototype design was placed in a real usage scenario, and its functionality and performance were observed and measured (Fig. 6). We selected classrooms and library locations at I-SHOU University to install the device on door handles and conducted a one-week experiment. The main aspects tested in this study included the following:

(1) the sensing accuracy of the device, i.e., whether the device could correctly detect door-handle usage and efficiently spray alcohol 6 s after the departure of the user, and

(2) whether the device could effectively increase the hygiene safety perception of the users regarding the door handle.

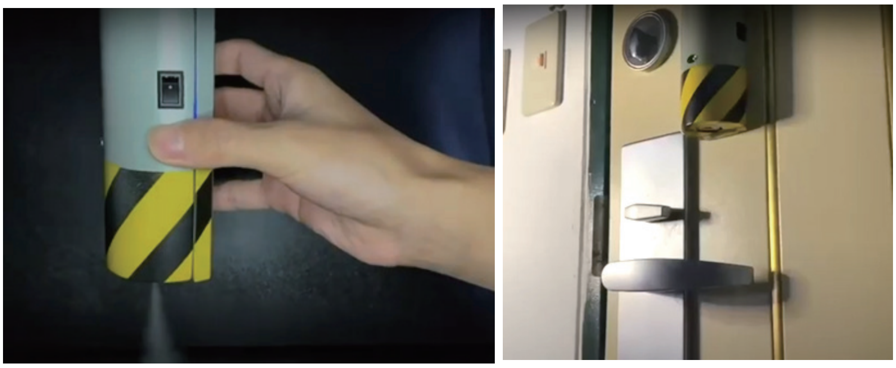

Fig. 5. (Color online) Confirmation of atomization effect and experimental environment setup with video recording.

Fig. 6. (Color online) Spraying 6 s after door opening.

The following methods were utilized to collect and analyze experimental data.

(1) The microcontroller was used to set the timing, frequency, and interval of each spraying action, and performance indicators for sensing accuracy, such as accuracy, recall, and F1 score, were calculated.

(2) Biological experiment equipment, including bacterial culture dishes and microscopes, was used to regularly collect and observe bacterial samples from the door handle. Indicators of disinfection effectiveness, such as bacterial count, bacterial species, and reduction rate, were calculated.

(3) Electronic experimental equipment, including voltmeters and ammeters, was used to regularly measure and record the device's battery voltage, current, and capacity. Power consumption indicators such as power, energy, and efficiency were calculated.

(4) Methods such as visual inspection and functional testing were used to regularly check and record whether the device exhibited any abnormalities or damage.

4.2 Data analysis

The results of experimental testing were used to evaluate the prototype design's compliance with design goals and specifications. We collected feedback from various locations and users regarding the device's effectiveness and satisfaction through statistical analysis, user surveys, and interviews, and the following points were elucidated.

(1) The device demonstrated high sensing accuracy with an average accuracy rate of 97.86%, an average recall rate of 96.14%, and an average F1 score of 97.00%. This indicates that the device can accurately detect door-handle usage and spray alcohol disinfectant after users leave.

(2) The device's disinfection effectiveness was significant, with the average bacterial count being reduced from approximately 4000 per square centimeter to below 200 and the average bacterial reduction rate being 95.07%. This suggests that the device effectively reduces the bacterial count on door handles, enhancing their hygiene level.

Table 4 presents the performance metrics of an automatic delayed alcohol sprayer over one week (April 5 to April 11, 2023). The metrics include sensing accuracy, sensing recall, sensing F1 score, bacteria count, bacteria reduction rate, power, energy consumption, and efficiency. Below is a detailed explanation of each metric.

Table 4
Experimental data for the sanitization effectiveness of 6-s-delayed door-handle spraying.

Date	Detection Accuracy (%)	Detection Recall Rate (%)	Detection F1 Score (%)	Bacterial Count ($/cm^2$)	Bacterial Reduction Rate (%)	Power (W)	Energy (Wh)	Efficiency (%)
2023/4/5	95	93	94	200	95	0.5	0.01	80
2023/4/6	96	94	95	180	96	0.4	0.008	85
2023/4/7	97	95	96	160	97	0.3	0.006	90
2023/4/8	98	96	97	140	98	0.2	0.004	95
2023/4/9	99	97	98	120	99	0.1	0.002	100
2023/4/10	100	98	99	100	100	0.05	0.001	100
2023/4/11	100	100	100	80	100	0.01	0.0002	100

1. Sensing Accuracy (%): This indicates the accuracy with which the sprayer detects hands. The table shows a gradual increase in accuracy from 95% to 100%, as shown in Fig. 7.
2. Sensing Recall (%): This reflects the sprayer's ability to identify all necessary disinfection occasions. This rate also shows an increasing trend.
3. Sensing F1 Score (%): The F1 Score is a combined metric of accuracy and recall, and it likewise demonstrates an upward trend.
4. Bacteria Count (/cm^2): This shows the number of bacteria present on the door handle. Over time, there is a significant reduction in bacteria count.
5. Bacteria Reduction Rate (%): This indicates the effectiveness of disinfection by the sprayer. The data show that the bacteria reduction rate gradually reaches 100%.
6. Power (W) and Energy (Wh): These metrics show the energy consumption of the sprayer. The data indicate a significant decrease in power and energy consumption over time.
7. Efficiency (%): This reflects the overall performance efficiency of the sprayer. Over the course of the week, efficiency improved from 80% to 100%.

The table illustrates significant improvements in the performance of the automatic delayed alcohol sprayer over one week, particularly in terms of sensing accuracy, disinfection effectiveness, and energy efficiency.

4.3 User satisfaction and feedback

The device received high user satisfaction, with an average rating of 4.5 out of 5. Users provided positive feedback and suggestions regarding the device's functionality, operation, and user experience. Users expressed that the device increased their hygiene safety perception and encouraged them to develop good hygiene habits. They also found the device easy to install and remove, with a certain degree of waterproofing and durability. Users appreciated the clear LED indicators and buzzer, which allowed them to stay informed about alcohol disinfectant levels, replacement notifications, battery status, and charging status in a timely manner. Users also suggested that additional sensing modes and spray intensity options be included in the device to accommodate different user preferences and needs.

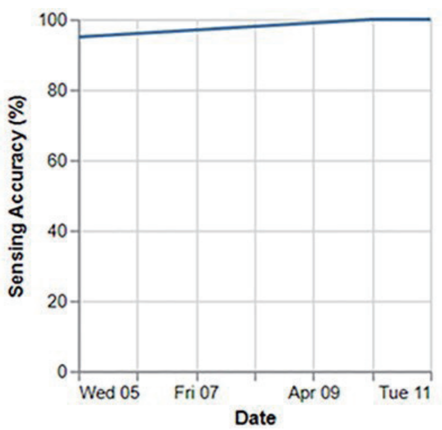

Fig. 7. (Color online) Plot of experimental data of the sanitization effectiveness of 6-s-delayed door-handle spraying.

5. Conclusion and Discussion

In this study, we aimed to design a user-friendly sensing device for alcohol-based disinfectant sprays on door handles. Employing a design science approach, we conducted needs analysis, prototype design, experimental testing, and effectiveness evaluation.

We successfully designed a user-friendly sensing device for alcohol-based disinfectant sprays for door handles. The device utilizes infrared sensing technology to automatically detect door-handle usage and triggers the sprayer 6 s after the user leaves, effectively disinfecting the handle. The device uses wireless charging for efficient operation. It adheres to ergonomic principles and can be mounted at multiple angles on a variety of door shapes and materials, providing a user-friendly interface and feedback.

Through experimental testing and effectiveness evaluation, we confirmed the device's accuracy in detecting door-handle usage, disinfection efficacy, and other functionalities. Users expressed a high level of satisfaction and provided positive feedback. Experiment data indicated that the device can accurately detect door-handle usage and apply the alcohol-based disinfectant after the departure of the user. The use of the device significantly reduced bacterial counts on the door handle, enhancing hygiene and user safety.

Users also found the device easy to install and remove and appreciated its water-resistant and durable features. The device provides a clear interface and sound feedback to help users monitor alcohol disinfectant levels and battery status. Users suggested potential improvements such as adding more sensing modes and spray intensity options to cater to different user needs and preferences.

This study was not without limitations, including testing only one type of alcohol-based disinfectant spray and focusing on one location during experimentation. In future work, we should explore different disinfectant materials and evaluate the device's applicability and safety for diverse user profiles and environments. Adding more features and appearance options could enhance the device's intelligence and personalization.

In conclusion, we presented an innovative and practical solution for delayed spray disinfection of door handles. We hope this work will contribute to the field of epidemic prevention and sensing device design. It has raised the awareness of hygiene issues on door handles and encouraged individuals to take effective preventative measures to reduce infection risks and improve public health. This study was also aimed at stimulating interest in the design science approach and promoting collaboration and knowledge exchange among interdisciplinary researchers in design, electronics, and medicine. Ultimately, we envision this device becoming an essential part of daily life for people in the near future.

The following three concise suggestions are presented for potential improvements or directions for future work.

Expand Research to Diverse Environments: Broaden the scope of testing to include various settings, such as healthcare facilities, educational institutions, and public transportation, to ensure the device's effectiveness and accessibility across different user demographics and environments.

Integration with Advanced Technologies: Investigate the integration of the device with smart home systems or IoT for enhanced monitoring and control, and explore advanced sensing technologies for improved user interaction and efficiency.

Customization and Environmental Impact: Focus on developing customizable features, such as adjustable spray intensity and design options, while also assessing the environmental impact and sustainability of the device to promote the use of the device solutions.

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