

AUTOMATIC BODY DISINFECTION TUNNEL OF COVID-19 VIRUS WITH TEMPERATURE SCANNER AND UV-C RADIATION

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Abstract

Preventing the transmission of the COVID-19 in public places involves the use of disinfection tunnels that sterilize the outer body and clothing. However, most disinfection tunnels use conventional systems operated manually with nozzles constantly spraying disinfectant solution. Automation can be used to control the operation, minimizing not only wasteful disinfectant consumption but also physical contact. This paper proposes a control system design for an automatic body disinfection tunnel with a temperature scanner and UV-C radiation. This study uses an ESP8266 microcontroller and several sensors. The disinfectant solution sprayer is equipped with a 2–3 micron nozzle spray and a UV-C lamp of 30 watts integrated with the control unit. The control system is incorporated into a portable and modular arc-roofed disinfection tunnel. The system has been tested and performed with electrical measurements. The results show that the automatic system works and can be implemented as a disinfection tunnel in public areas to optimize transmission prevention.

Keywords: Automatic control system; COVID-19; disinfection tunnel; good health; temperature scanner; UV-C radiation; well-being

Introduction

The SARS-CoV-2 virus spreads fast and infects many people, causing the worst global pandemic in history. The symptoms are similar to influenzas, such as respiratory problems and high temperature. The transmission occurs when an infected person sneezes or coughs and the virus travels airborne or when there is physical contact, such as a handshake (Perveen *et al.*, 2020). The virus may stay on the skin or surfaces and infect a healthy individual. The virus is stable on air for up to three hours, on

copper surfaces for up to four hours, on steel and plastic for up to three days, and on cartons for up to 42 h (Shahid *et al.*, 2020). Spraying disinfectant will kill the virus and prevent infections (Ilyas *et al.*, 2020).

Educational facilities are hotspots of virus transmission. Managing educational facilities and contact tracing is difficult due to the large volumes of people entering and leaving the premises. According to Normalina, spraying disinfectant on

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the body surfaces is safe to eliminate the attached bacteria and viruses (Normalina *et al.*, 2020), particularly in public places. Installing sterilization booths or tunnels in educational buildings will reduce the transmission rate.

The first aspect to consider when providing sterilization booths or tunnels is the construction and costs. The structures can be chambers or tunnels (Biswal *et al.*, 2020). The next aspect is the disinfectant composition. Past research has suggested sodium hypochlorite solution as it can efficiently sterilize the COVID-19 virus (Soltaninejad, 2020). Past research also mentions the two types of liquid-based sterilization chambers are spray and ozone (Wang *et al.*, 2020). Spray or liquid disinfectant is often placed in a tank or drain. Then, air pressure with a pump machine pushes the liquid solution out. This spray is used to disinfect surfaces on the human body and clothing.

Meanwhile, ozone is formed when oxygen molecules (O_2) are split into oxygen atoms and collide with oxygen molecules to create an unstable gas. The splitting can be done by adding a high voltage of alternating current (6-20 kv) to the oxygen-containing dielectric gas discharge gap (Montazersadgh *et al.*, 2019). In addition to the disinfectant solution, UV-C is commonly added to clean surfaces, especially in hospitals. This UV-C aims to kill bacteria and virus DNA/RNA (Beck *et al.*, 2017). Because this method targets the outer part of the body and clothing surfaces, it is suitable for public facilities as people move in and out of public places.

Technology has greatly helped communities to prevent virus transmission. A previous study has developed a two-room smart tunnel disinfection system with three processes (Pandya *et al.*, 2020). The smart tunnel uses the internet of things (IoT) operated using solar cells. The development of an automated low-cost temperature scanner and sanitizer system at the disinfectant chamber is considered to quickly identifying persons with the symptoms of this viral infection, as described by Bhogal (Bhogal *et al.*, 2021). Past research has also recorded an innovative design, IoT-based disinfection for sanitation tunnels for the public (Dutta *et al.*, 2021). The system could detect the presence of a person, and disinfection can be done automatically. To make the system more robust and able to deal with anomalies, a temperature sensor and IoT-based relay module were added.

Meanwhile, Jha (2020) has developed a personnel sanitation enclosure that can spray all surfaces of a human body. The four sides spray works effectively due to no wind intrusion. The sprays continue 8 to 10 times and stop routinely after 10-15 sec. Khan *et al.* (2021) developed an

advanced disinfecting technology that can cover a large group of people. The system operates when it detects people within a 10 to 30 cm radius. The disinfection technology integrates a spraying system and a solar energy system. The spraying system consists of an electric nozzle and a pump, and the power supply to drive an electric pump is sourced from solar energy. The disinfectant solution is pushed into eight nozzles with a 55-degree angle and a spray pressure of 200 bar. They reduced operating costs by 70% using a solar-based system.

This study proposes an automatic disinfection system fitted with a temperature scanner and UV-C radiation. The system is hands-free and autonomous to minimize contact and avoid virus transmission. It will spray a disinfectant solution, followed by exposure to UV-C radiation. The disinfection tunnel is modular with an arc roof, making it easy to unload and move. The aim is to develop an automatic disinfection system for lecturers and students in an educational facility to minimize the spread of COVID-19. Following the development, this study has also tested and analyzed to solve potential problems and improve the system.

Related Work

Maurya *et al.* (2020) proposed three disinfection stages to make the process more effective. First, a disinfectant solution is sprayed, followed by warm air at 70°C and far-ultraviolet light (207-222 nm). The tunnel uses ultrasonic sensors to detect a person. However, the proposed system cannot detect subjects more than 1.5 feet tall. In subsequent research, Murthy (2020) proposed a system to disinfect luggage items of transport passengers. This system facilitates recording and counting the number of goods entering the tunnel. On that system, it is designed for goods and not used to disinfect humans. Hafeez *et al.* (2020), in his research, proposed portable solar-powered devices to disinfect various things such as wallets, keys, smartphones, and equipment that are often held in hands. However, this system was not designed for human disinfection purposes. Meanwhile, Vasantharao and Arifunneesa (2020) developed a sanitation and disinfection system based on temperature detection using an automatic microcontroller. This system has a buzzer that will go off if the temperature exceeds the limit. Mascarenhas *et al.* (2021) proposed steps for building a disinfection room. They pointed out that ozone is one of the safest disinfectants. Many ozone generators have been installed to disinfect people, clothing, or equipment. However, no information was provided regarding the ozonation device, which

is a complicated process, requiring expensive devices and an innovative approach. In their research, Joshi (2020) proposed a portable tunnel designed based on simulation. However, the proposed study is a simulation-based approach that is difficult to test for implementation on the subject.

Materials and Methods

In this study, the automatic system uses the ESP32 microcontroller unit, which functions as an electronic circuit controller to process data received from the sensors (Yunardi and Dina, 2020). Wemos ESP8266 microcontroller operates at a voltage of 3.3V to 5V, has a 32-bit main chipset with a clock speed of 80 MHz, and 4 MB of external RAM.

The system can detect a user's movement and situations inside the tunnel using a passive infrared (PIR) sensor, ultrasonic, and an array of temperature sensors. A PIR is used to detect the entry and exit of a person from the tunnel (Panda *et al.*, 2021). Ultrasonic sensors are used instead of buttons to prevent physical contact. The array of temperature sensors monitors the movement in the disinfectant tunnel (Raka *et al.*, 2019). The two disinfectant devices are a spray nozzle and a UV-C lamp controlled by a microcontroller.

This research outcome aims to improve the manual disinfectant booth by solving the issue with the nozzle continuous sprays. With this, the disinfectant solution will not be wasted. The proposed system uses a temperature scanner and a UV-C radiator to increase the effectiveness of transmission prevention and an ESP8266 microcontroller as the control unit. The disinfection tunnel design is modular and portable, with an arc roof that is easy to assemble.

Results and Discussion

Electrical Controller Design

The PIR sensors can work automatically to detect a person entering and leaving the tunnel. These sensors are mounted above the entrance and the exit. Ultrasonic sensors are used in place of a push button to send commands to the microcontroller without pressing them. This sensor is installed in the electronic circuit system panel box. When an individual enters a tunnel, the PIR detects it. The solution is then sprayed with a nozzle powered by an electric pumping motor. The 24-volt electric pump is installed in the disinfectant tank, placed separately from the portable disinfection tunnel. Koggalage *et al.* (2021) mentioned that the duration of the spraying process is 10 sec so that the liquid in the tank can be used effectively to clean surfaces and clothes from bacteria and viruses.

The nozzle spray produces microns or mist to disinfect users. This is followed by UV-C radiation exposure. According to Lindblad (Lindblad *et al.*, 2020), the UV-C dose received by each object with a UV-C emitting unit varies depending on the distance between the light source and the radiation area. In the designed system, the tunnel's height is 200 cm, and the length is 100 cm. As such, the exposure time is set to five seconds. The 30-watt UV-C lamps produce radiation with a dominant wavelength of 255 nm (Chevremont *et al.*, 2012). They are installed inside the tunnel at a safe distance usage. All processes are controlled by an ESP32 microcontroller. The block diagram of the control design is shown in Figure 1.

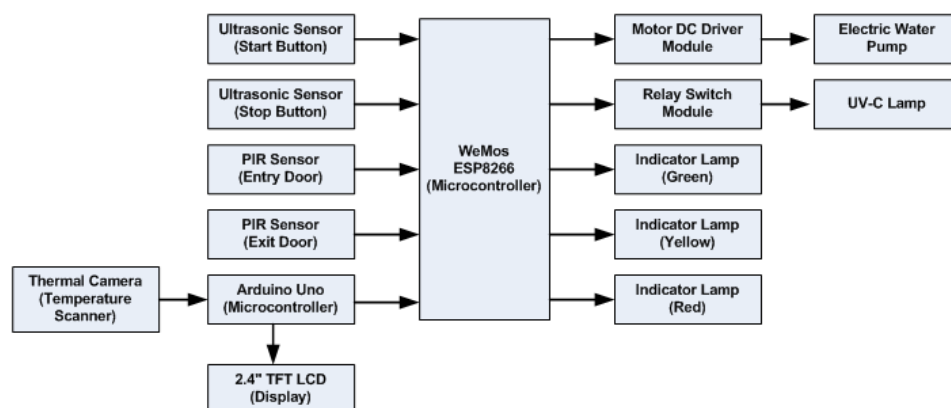


Figure 1. Block diagram of the control design

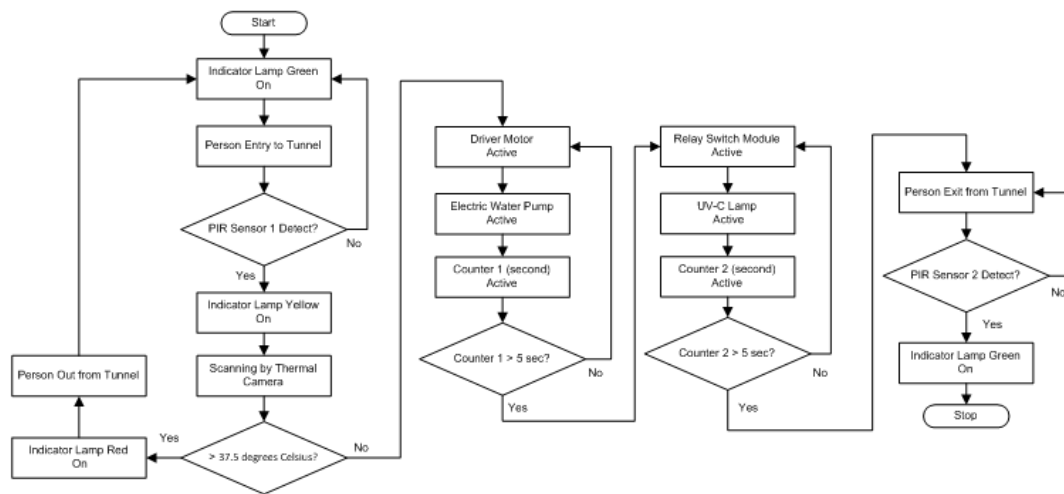


Figure 2. Workflow of the proposed system

Workflow of the Automatic Body Disinfection Tunnel

The workflow of the proposed system is shown in Figure 2, consisting of two main parts: 1) when the sensors detect a person entering the tunnel, and 2) when the automated system disinfects them by using a nozzle spray and UV-C light. The green indicator light is on while the automated tunnel is on standby. In the disinfection process using spray and light radiation, when a user enters the tunnel, the yellow indicator light is on until they exit. Before entering the tunnel, their body temperature is scanned. The red indicator light will be active if the temperature is over 37.5 degrees Celsius.

The Portable Disinfection Tunnel's Structural Design

The novelty of the portable tunnel design in this research is the arc roof, as shown in Figure 3. Conventional tunnels are mostly a cube with flat roofs. This model is more suitable for a portable tunnel to be placed outdoors. The arc-shaped roof will help drain water and minimize dust buildup. The arch roof will also avoid an overload of the frame structure so that the tunnel is more durable. In the design of a prototype disinfectant tunnel, as shown in Figure 4, the frame is made of a hollow aluminum bar. This material is chosen because they are lightweight, rigid, and malleable. The frame is 2 m² wide and 230 cm high. The walls and roof use transparent PVC sheets. The doors use a curtain made of 3 mm transparent PVC sheets. Vinyl plates were used for the flooring.

The tank size is 22 liters, filled with a disinfectant solution recommended by WHO. The tank is mounted with an electric pump and

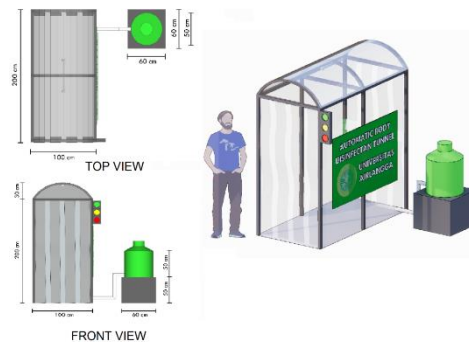


Figure 3. Disinfection tunnel structural design



Figure 4. The proposed design of the disinfection tunnel

a flexible plastic hose. The hose is connected to six spray nozzles. Four nozzles are mounted on the four corners of the tunnel at one-meter height. Two nozzles are mounted on top of the frame facing each other at two-meter height. Two UV-C lamps are fitted with a position parallel to the upper nozzles.

Testing the HC-SR501 PIR Sensor

The testing aims to find the effective distance between the object and the PIR sensor, often the maximum distance. When no object is detected, the output voltage on the PIR sensor is 0.13 volts. When an object is detected, the output voltage on the PIR sensor is 4.43 volts. The test results of the voltage against the object distance are shown in Table 1.

Testing the SR04 Ultrasonic Sensor

This test aims to determine the ultrasonic sensors' accuracy based on the distance and identify a possible issue. This sensor is a hands-free command to turn the system on and off. In this case, the distance between the palm and the sensor is adjusted from 5 to 10 cm. This test was performed ten times by comparing the accuracy of the output of a command with the system. The accuracy of the ultrasonic sensor to detect the command is 98%.

Table 1. The test results of the voltage against the object distance

Distance (m)	Voltage (V)	Response time to motion detection (s)
1	4.38	2.61
2	4.23	2.63
2.5	4.34	2.64
3	4.24	2.69
3.5	4.86	2.74
4	4.23	2.74
4.5	4.66	2.75
5	4.32	2.78
5.5	4.56	2.79
6	4.51	2.79
6.5	0.12	-
7	0.18	-
7.5	0.15	-
8	0.17	-

Table 2. Comparative results PWM signal and voltages value

No	Distance (cm)	Voltage (V)
1	50	12.46
2	60	15.34
3	70	17.75
4	80	19.24
5	90	21.86
6	100	23.71

Testing the AMG8833 Thermal Camera

The thermal camera testing aims to determine the accuracy of the temperature scanner. The testing was carried out by placing a thermal sensor at a human head's height. The distance between the camera and the human is 50 and 100 cm, with a walking position in front of the camera. The test results show the maximum temperature readings when a person passes the sensor with thermal gun readings at the head position. These test results are shown in Figure 5. The difference in the measurement value is influenced by the distance and speed of moving objects on the camera and other objects that emit interference infrared.

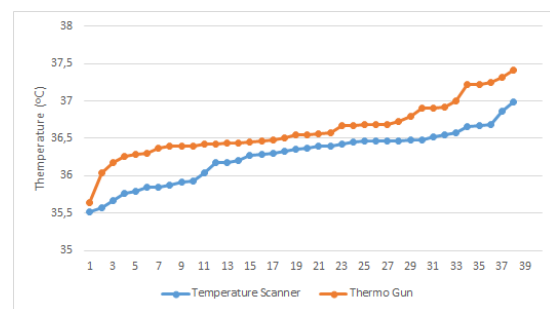


Figure 5. Comparison of temperature scanner and thermo-gun

Testing the UV-C Lamp Controller

This test aims to determine the performance of the UV-C radiation automatic lamp control circuit, a relay module managed by a microcontroller. The light is on when the relay is active, and vice versa. Based on the microcontroller command, the test shows that the UV-C lamp works well and switches on with an adjustment time of five seconds.

Testing Electric Water Pump Voltage

This test is conducted on the electrical water pump by looking at the measured voltage value. The value of the voltage defines the speed of the electric motor. The microcontroller generates the voltage value from the pulse width modulation (PWM) signal sent by the microcontroller. The PWM duty cycle is a value that can be expressed in percentage units. Each PWM signal is tested sequentially at 50%, 60%, 70%, 80%, 90%, and 100% of the microcontroller pins as input signals to the driver module. The PWM value is compared with the motor driver voltage using a voltmeter, as shown in Table 2.

Conclusions

This paper discusses the design and development of an automatic tunnel disinfectant. The improvement relies on the use of a temperature scanner and UV-C radiation to increase efficiency. The automation system uses a microcontroller as a data processing unit and an ultrasonic sensor as a touchless button. A temperature scanner device is placed in the tunnel to detect body temperature. An automation system is proposed to detect the presence of a person entering the tunnel by using a PIR sensor on the entrance door. Disinfection is done by spraying the solution for 10 sec, followed by UV-C radiation exposure for five seconds at a safe distance. The process is automatically operated until the person exiting the tunnel is detected by the PIR sensor on the exit door. This tunnel is designed with an arch-shaped roof to strengthen the construction. The whole structure is made of aluminum and PVC sheets suitable for public areas. Future studies could develop the sensor systems by testing different methods.

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