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Original Article

Design of Arduino Uno Microcontroller Disinfection System for Wall Bucky Stand

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Abstract *- Radiological equipment disinfection is one of the disinfection processes that must be routinely carried out in order to prevent transmission during a pandemic. Wall bucky stand is a chest x-ray examination tool that has a part where the chin is placed so that it can transmit the Covid 19 virus. This research aims to design and develop a disinfection tool that is designed to work automatically to conduct disinfection in the wall bucky stand using an Arduino Uno microcontroller. The design components include pump steam, sprayer, adapter, microcontroller, buzzer, and PIR sensor. Component analysis is made based on the design of the x-ray room and the size of the wall bucky stand. The microcontroller is utilized to set the disinfectant spraying time automatically upon the patients' movement detected through the PIR sensor. This study is an initial study to produce a prototype of an automatic disinfection tool with a microcontroller. The equipment specifications use an Arduino Uno R3 SMD CH340 ATMEGA328P microcontroller, HC-SR501 PIR Motion Sensor Module, and hollow cone nozzle, with a spraying time of 2 seconds, which is done after waiting 60 seconds without detection of patient movement. With the above specifications, disinfectant spread, the sensor work's precision and the spray time are effective.*

Keywords *- Disinfection system, Arduino Uno, Microcontroller, Wall bucky stand.*

1. Introduction

During the pandemic, chest X-rays are a routine examination for screening, diagnosis and treatment follow-up. Transmission of the coronavirus through direct droplet contact with infected people and through the surface of equipment in medical services [1] [2]. Wall Bucky Stand (WBS) is a supplementary tool for examining chest X-rays for patients who are still physically able to walk or for special needs patients. The use of WBS in examining a pulmonary patient is suspected of causing the transmission process from patient to patient to occur quickly because of the WBS modality; there is a place to put the patient's chin. That place will be the facility for transmission of the virus. To minimize the risk of coronavirus transmission on surface areas that are often used to treat COVID-19 patients, proper cleaning and disinfection must be carried out [3]. World Health Organization states that the frequency of disinfection of medical equipment that is often used to treat COVID-19 patients must be carried out routinely, which is done after every patient visit.

Disinfection is a method to break the spread of infection, so the implementation of disinfection must be conducted continuously to minimize the spread. The use of disinfection in efforts to prevent and spread COVID-19 has been intense during the pandemic, either by spraying disinfectants directly or using wipes (microfiber cloths) and disinfection chambers [4]. The purpose of disinfection is to eliminate microorganisms or pathogens on the surface of objects by using chemical-based disinfectant liquids [5]. Routine disinfection is room disinfection using chemicals and UVC. Automatic disinfection has been developed, but it is more emphasized for room disinfection. UV disinfection uses robots to avoid human contamination during disinfection, shorten disinfection time, and increase the effectiveness of the disinfection process [6], [7]. Surface disinfection of medical equipment still uses chemical disinfectants manually, which applies directly. Disinfection of the surface of medical devices is performed at a certain time, not after each examination. In fact, the surface of medical devices is one of the transmission routes for viruses and bacteria. Sureka B. 2021 et al. stated that radiology equipment is disinfected only when in critical/hazardous conditions by manual means [8]. Disinfection of the medical equipment surface is not repeated after each examination. Hence, an automatic tool is needed to help medical staff disinfect the equipment surface, which is a means of transmitting the coronavirus after each chest x-ray examination [9]. This research creates an automatic disinfection tool based on the Arduino Uno microcontroller loaded with chemical disinfectant. This disinfection tool will be programmed to detect every patient who undergoes chest X-rays and automatically spray chemical disinfectant after the patient leaves the X-ray room.

1. The initial stage is to design the position of the disinfection device in compliance with the design of the X-ray room. The second stage contains the design of an automatic disinfection device, including its control system. The third stage is an automatic disinfection device prototype with an Arduino Uno microcontroller.

2. Materials and Methods

2.1. Methodology

This study aims to build an automatic disinfection system for wall bucky stand disinfection using an Arduino Uno microcontroller with a PIR (Passive Infrared Reciever) sensor. This study uses the analysis, design, development, implementation and evaluation methodology.

2.2. Design and Development of Automatic Disinfection Device.

The initial stage is made by performing the automatic disinfection device position based on the design of the x-ray room (Fig.1). The location of the disinfection device is decided on the location and height of the Wall Bucky Stand. The layout of the x-ray room is very influential in the design of the disinfection device position. The major component design comprises the disinfection device and the control system.

The location and specificity of the electric tool, tank size, sprayer type, and control system design are the critical components for building an automatic disinfection device. The disinfectant is delivered to the nozzle through a liquid pipe connected to the tank [10]. The Arduino Uno microcontroller material and PIR sensor used are proven to be easy to use, cheap and effective [11] [12] [13] [14] [15].

2.3. Design of an Automatic Disinfection System

The design of an automatic room disinfection tool based on the Arduino Uno microcontroller; this device uses the main components, which are the Arduino Uno microcontroller as a program controller of the disinfection device's work system and a PIR sensor to detect the presence of patients in the room. This device will work to spray automatically after the patient has completed the examination and left the room or if there are no people in the room. This device is equipped with other components (Fig.2), such as a PIR Sensor, Buzzer, DC Steam Pump 12V 120PSi, Nozzle, Relay Module, 5V 2A Adapter, and 12V 5A Switching Adapter. The PIR sensor's function here is to detect the patient or person in the room. The buzzer is used as an alarm or marker that the device is doing the spraying process (Table 1).

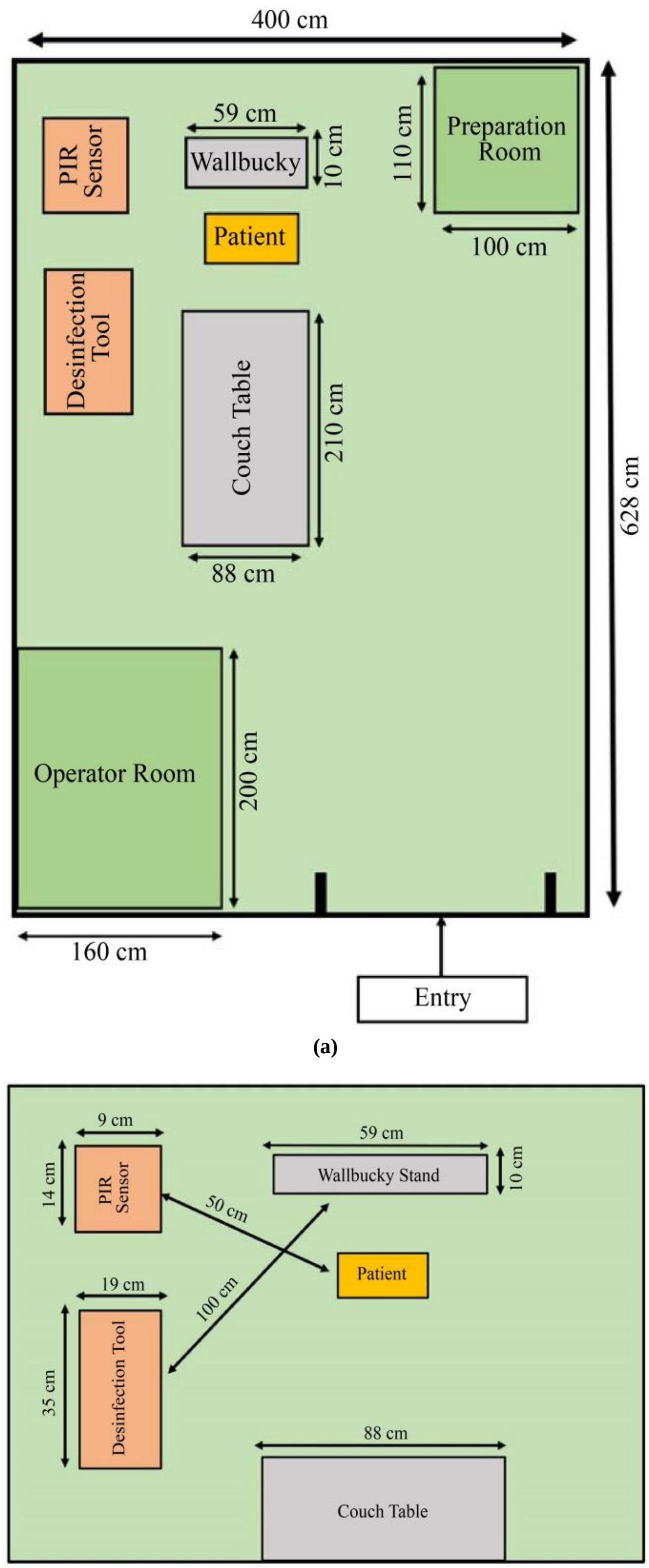
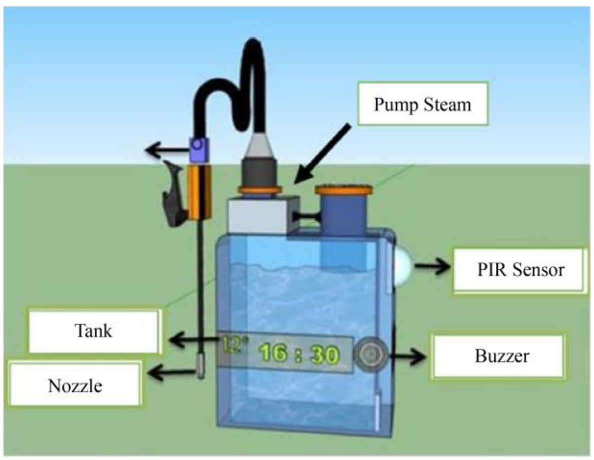


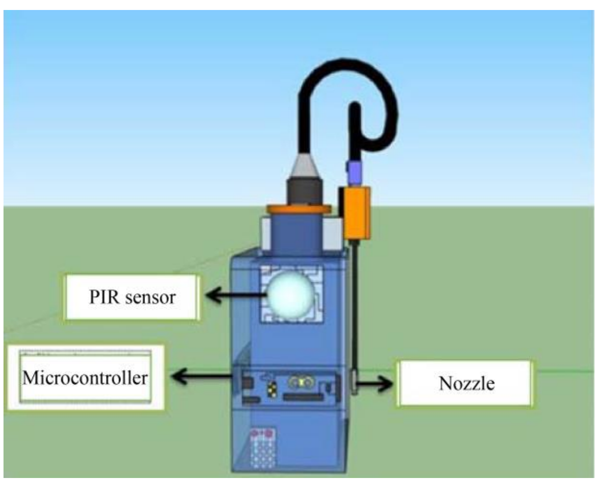
Fig. 1 Initial design of disinfection device (a) Disinfection equipment position plan based on the location of the Wall Bucky Stand in the X-ray room. (b) The distance estimation between the disinfection device and Wall Bucky Stand, PIR sensor and patient position.

Table 1. Framework and components

Reference	Component	Purpose
Md. Rakib Ahsan et al, 2019 [16]	Adaptor	An instrument that can transform a high (AC) into a low voltage (DC).
Liengjindathaworn et al., 2002 [17]	Pump steam	A device for transporting chemical disinfectant liquid at a certain speed and pressure.
Fedak et al., 2021 [18] Ahmadi et al., 2019 [19] Chauhan et al., 2023 [10]	Nozzle	A device used to define the direction and properties of chemical disinfectant liquids when sprayed.
Adriansyah and Hidyatama, 2013[11] Toyib et al., 2019 [12] Rumengan et al., 2023 [13]	Arduino Uno	Microcontroller is programmed to disinfect the room, tools and nearby objects automatically.
Toyib et al., 2019 [12]	Buzzer	A device that converts electrical signals into sound signals. Used as an alarm during disinfection procedures.
Toyib et al., 2019 [12] Amrullah et al., 2021 [15].	Sensor PIR	The sensor used by the device to detect the patient, the device will spray disinfectant when the sensor does not detect the patient in the room for 60 seconds.



(a)



(b)

Fig. 3 Disinfection device design (a) Front and (b)Side

4. Results and Discussion

4.1. Result

This automatic disinfection device is designed with the specifications in the following table (Table 2).

The software systems, PIR sensor and Arduino Uno microcontroller, were covered with Styrofoam plastic, 14 cm x 9 cm in size. The device is placed 1 meter away from the Wall Bucky Stand. The distance between the PIR sensor and the device is 0.5 meters. Whereas the distance between the PIR sensor and the patient's position is 1 meter.

Table 2. Device components

Component	Specification
Arduino Uno microcontroller	R3 SMD CH340 ATMEGA328P
Disinfection spray	Nagata 16 L
Container size (disinfectant container)	35 cm x 19 cm x 50.5 cm
Tube length	120 cm
Nozzle type	*Hollow cone*
Pump Steam	DC 12V 120PSi
Sensor PIR	HC-SR501 PIR Motion Sensor Module
Active *Buzzer*	5V
Spray time	2 sec
Time delay (time between sensor detection and spraying time)	60 sec
Buzzer time (alarm) before spraying	5 sec

The control system is built with two paths (Fig.4). The first pathway is the device successfully spraying: In the first stage when the patient enters the room, the PIR sensor will detect the patient's movement during the patient's examination. In the second stage, after the examination is completed, the patient leaves the X-ray room until the PIR sensor discovers no motility or presence of the patient. In the last stage, there is a delay time as long as 1 minute or 60 seconds, and the device will spray disinfection for 2 seconds. The buzzer warning will be sounded during the spraying and ring 5 seconds before the spraying.

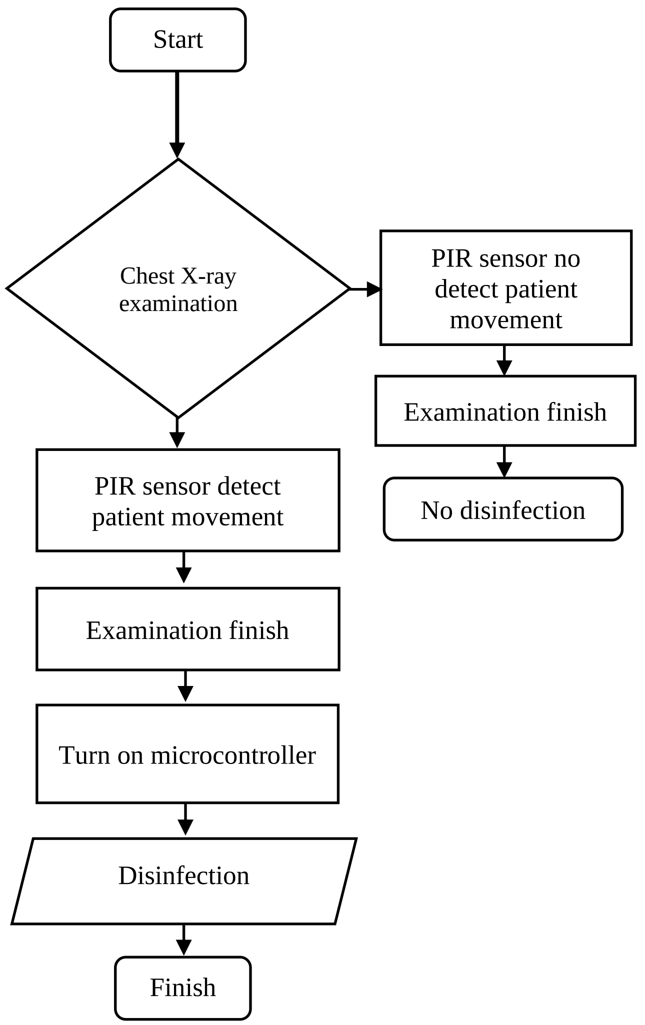


Fig. 4 Diagram block system

4.2. Discussion

This study conducted various experiments to determine the accuracy of disinfectant spraying time, the accuracy of PIR sensor time and the effectiveness of disinfection spread using various nozzles. The accuracy of the sensor time will be observed by the consistency of the sensor delay time after the sensor detects the patient's presence. The disinfection device will be set to spray disinfectant when the sensor does not detect a patient in the room for 60 seconds. The accuracy of the spraying time will be observed for its consistency in the spraying time with the accuracy of the time set in the disinfection device, which is 2 seconds. Spreadability is analyzed for the distribution of disinfectants on the entire wall bucky stand area so that the disinfection process is effective.

4.1.1. Accuracy of PIR Sensor Time

The sensor only detects the body temperature of humans; if there are other moving objects or other living things, such as animals, the sensor does not detect it because of the PIR (Passive Infrared Receiver) sensor; this sensor is very effectively used as a human detector [12]. The PIR sensor operates by trapping heat energy from each object's passive infrared rays. The human has a normal body temperature of about 32 degrees Celsius. Furthermore, the factor that affects the work of the PIR sensor is distance. Generally, a PIR sensor can read with a range of up to 5 meters [12]. PIR sensors placed in the corner of the room with a distance of 0.5-1 meter from the patient's position will be very effective in predicting the patient, so the sensor can also reach the patient's presence up to a distance of 4-5 meters when performing chest x-ray in the radiology room. A total of 31 trials for 7 days or 1 week tested the accuracy of the PIR sensor (Fig.5) in detecting movement or detecting the presence of patients up to the specified delay time with a success value of 98.71%.

4.1.2. Accuracy of Spraying Time

The Arduino Uno-based microcontroller, as a control system in an automatic room disinfection device, can respond to inputs and process them according to the program instructions made. The program instructions that have been made will work continuously so that the room disinfection process runs as expected. The microcontroller will be instructed to turn on the pump or water pump to spray or disinfect the room.

The microcontroller will give instructions to the water pump after the microcontroller receives an input signal from the PIR sensor when the sensor has finished detecting the movement of patients or patients out of the room and during 31 trials on the spraying time of disinfectant device successfully sprayed close to 2 seconds from the time setting with a success value of 99.993% (Fig.6).

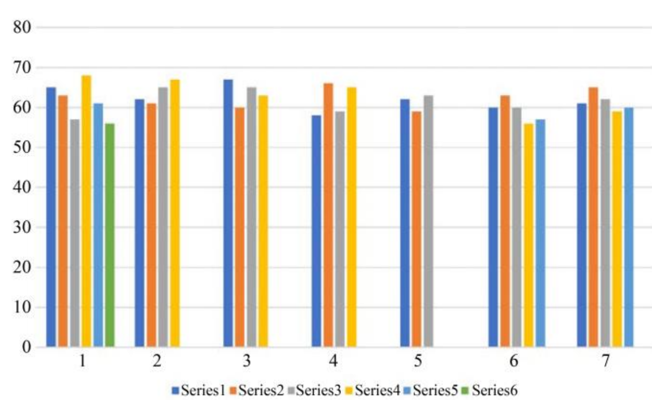


Fig. 5 Diagram of the PIR sensor time accuracy test

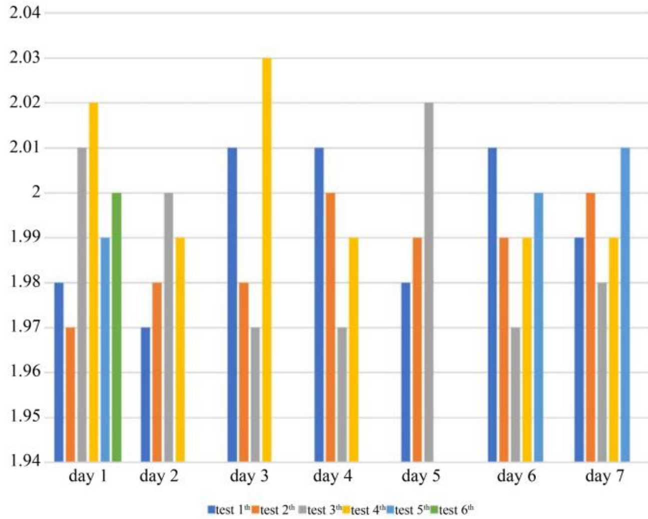


Fig. 6 Diagram of the spraying time accuracy test

4.1.3. Disinfectant Spreadibility

Disinfectant spreadibility is the ability of a disinfection device to spray disinfectant liquid onto the surface of a wall bucky stand with dimensions of 480 mm x 550 mm.

Based on the impact of the inspection results, the hollow cone nozzle is capable of being applied in the radiology room. Because of the character of the liquid granules in the hollow cone nozzle is similar to dew, in contrast to the other three nozzle variations, which have a larger liquid granule character and are much more wetting the wall bucky stand surface area.

The most important factor is that it does not interfere with patient comfort. The hollow cone nozzle is capable of producing small dew-like liquid droplets so that the patient can remain dry and clean during the examination. Wall bucky stand surfaces filled with disinfectant liquid will interfere with patient comfort because the liquid will stick to the patient's clothes and body. So, a nozzle that produces small granules and dries quickly is needed.

5. Conclusion

Based on the results and discussion above, it can be concluded that the automatic disinfection device with an Arduino Uno microcontroller is effective for disinfecting wall bucky stands in the X-ray room with inexpensive and efficient components. The specifications of the disinfection tool above spraying for 2 seconds with a delay time of 60 minutes after no patient movement is detected can produce a wide spread of disinfectant, precise sensor work and effective spraying time.

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References

[1] V.C.C. Cheng et al., "Escalating Infection Control Response to the Rapidly Evolving Epidemiology of the Coronavirus Disease 2019 (COVID-19) due to SARS-Cov-2 in Hong Kong," *Infection Control & Hospital Epidemiology*, vol. 41, no. 5, pp. 493–498, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[2] Luluk Windra Yuliana, "Characteristics of Clinical Symptoms of Pregnancy with Coronavirus Disease (COVID-19)," *Sandi Husada Health Scientific Journal*, vol. 9, no. 2, pp. 726–734, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[3] Annisa Lazuardi Larasati, and Chandra Haribowo, "Use of Disinfectants and Antiseptics to Prevent Covid-19 Transmission in the Community," *Pharmaceutical Magazine*, vol. 5, no. 3, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[4] A. Athena, Eva Laelasari, and Tities Puspita, "Implementation of Disifection in Prevention of Covid-19 Transmission and Its Potential Health Risk in Indonesia," *Journal of Health Ecology*, vol. 19, no. 1, pp. 1–20, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[5] Jin-Hong Yoo, "Review of Disinfection and Sterilization – Back to the Basics," *Infection and Chemotherapy*, vol. 50, no. 2, pp. 101-109, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[6] Conor McGinn et al., "Rapid Disinfection of Radiology Treatment Rooms using an Autonomous Ultraviolet Germicidal Irradiation Robot," *American Journal of Infection Control*, vol. 50, no. 8, pp. 947–953, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[7] J.A. Otter et al., "An Overview of Automated Room Disinfection Systems: When to Use Them and How to Choose Them," *Decontamination in Hospitals and Healthcare*, pp. 323–369, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[8] Binit Sureka et al., "COVID-19 Pandemic: Cleaning and Disinfection – What Should the Radiologist Know?," *Indian Journal of Radiology and Imaging*, vol. 31, no. S 01, pp. S207–S211, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[9] Siyao Shao et al., "Risk Assessment of Airborne Transmission of COVID-19 by Asymptomatic Individuals under Different Practical Settings," *Journal of Aerosol Science*, vol. 151, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[10] Aarti Chauhan et al., "Chargeability Study of Disinfectants and the Optimization of Design Parameters of a Handheld Electrostatic Disinfection Device for Small Scale Applications," *PLoS One*, vol. 18, no. 6, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[11] Andi Adriansyah, and Oka Hidyatama, "Elevator Prototype Design Using Arduino Atmega 328P Microcontroller," *Journal of Electrical Technology*, vol. 4, no. 3, 2013. [CrossRef] [Google Scholar] [Publisher Link]

[12] Rozali Toyib et al., "Use of Passive Infrared Receiver (PIR) Sensors to Detect Short Message Service Gateway-Based Motion," *Pseudocode*, vol. 6, no. 2, pp. 114–124, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[13] Y. Rumengan, A.Z. Patiran, and E. Bevin, "Arduino-Based Automatic Disinfectant Sprayer for New Normal Era Classrooms," *JISTECH: Journal of Information Science and Technology*, vol. 11, no. 2, pp. 1–10, 2023. [Google Scholar]

[14] A. Vyshnavi et al., "UV Disinfection Robot with Automatic Switching on Human Detection," *EAI Endorsed Transactions on Internet of Things*, vol. 6, no. 23, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[15] Faiq Fawwaz Amrullah, Dewi Khairani, and Siti Ummi Masruroh, "Design of an Automatic Sterilization Gate Tool using Pir Motion Sensor," *Pilar Nusa Mandiri Journal*, vol. 17, no. 1, pp. 25–30, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[16] Md. Rakib Ahsan et al., "Implementation of IOT based Smart Security and Home Automation System," *International Journal of Engineering Research and*, vol. 8, no. 6, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[17] S. Liengjindathaworn et al., "Parametric Studies of a Pulsating-Steam Water Pump," *International Journal of Ambient Energy*, vol. 23, no. 1, pp. 37–46, 2002. [CrossRef] [Google Scholar] [Publisher Link]

[18] Waldemar Fedak et al., "Influence of Spray Nozzle Operating Parameters on the Fogging Process Implemented to Prevent the Spread of SARS-CoV-2 Virus," *Energies*, vol. 14, no. 14, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[19] Mahdi Ahmadi et al., "Experimental Study of Converging-Diverging Nozzle to Generate Power by Trilateral Flash Cycle (TFC)," *Applied Thermal Engineering*, vol. 147, pp. 675–683, 2019. [CrossRef] [Google Scholar] [Publisher Link]