



Hand Sterilization Device with Mist Based on Microcontroller

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ABSTRACT

Maintaining cleanliness is an important aspect of a healthy lifestyle, with handwashing being one of the basic hygiene practices effective in preventing the spread of diseases and infections. However, public awareness of the importance of handwashing remains low, often due to a lack of adequate public facilities and the discomfort experienced after washing hands. Additionally, handwashing requires a substantial amount of clean water, with an average usage of about 640 ml per wash, significantly increasing the consumption of clean water. Therefore, innovation in more effective and efficient handwashing facilities is necessary. With advancements in science and technology, the development of a microcontroller-based hand sterilization device using disinfectant mist can be a solution to save water and improve hand hygiene in public places. Based on this background, this study aims to design and develop a microcontroller-based hand sterilization device using mist as an effort to enhance cleanliness and reduce the use of clean water.

INTRODUCTION

Maintaining good hygiene goes beyond merely looking presentable; it is a cornerstone of a healthy lifestyle. One of the most fundamental personal hygiene practices is handwashing, which has proven to be highly effective in preventing the spread of diseases and controlling infections. This effectiveness is due to the fact that hands frequently act as vectors for bacteria and other pathogens to enter our bodies[1]. Despite its importance, many people neglect this basic practice, often due to a lack of awareness or inadequate public facilities to support regular handwashing[2]. In public spaces such as parks, the need for handwashing facilities is particularly acute[3]. However, the implementation of handwashing stations or sinks in these areas remains inadequate and ineffective[4]. Several factors contribute to this issue, including the inconvenience of wet hands and the time required to dry them, which deters many people from washing their hands at sinks[5]. Additionally, traditional handwashing methods consume significant amounts of clean water. On average, the water usage for handwashing is approximately 0.064 liters per second, leading to a minimum of 640 ml of water per wash, which results in high water consumption[6].

To address these challenges, innovation and creativity in designing handwashing facilities are necessary. Advances in science and technology can contribute significantly to more efficient hand hygiene solutions, such as automatic mist

disinfection machines that can be integrated into sinks to prevent the spread of microorganisms and reduce water usage[7]. Previous research has explored the design of automatic handwashing stations using ultrasonic sensors, relay switches, and microcontrollers like Arduino Uno. However, these designs often lacked effective water control, leading to wastage[8]. Other designs employed proximity modules and solenoid valves but still relied heavily on substantial water supply and had separate sections for soap and water, which can be cumbersome[9].

This study proposes a novel approach to hand sterilization by designing a microcontroller-based hand sterilization device that utilizes mist spray technology[10]. This device aims to transform water into mist, significantly reducing water consumption while maintaining effective hand sanitization. By addressing the limitations of previous designs, this innovation seeks to provide a more efficient and user-friendly solution for public hygiene facilities. The following sections will discuss the design and implementation of the proposed device, evaluate its effectiveness, and explore its potential impact on public health and water conservation

Sterilization

Hand hygiene is a crucial factor in maintaining health, as hands often act as intermediaries in the transmission of diseases [1]. Approximately 98% of germ transmission occurs through unclean hands [8], highlighting the importance of proper hand sanitation practices. Common methods for cleaning hands include

washing with running water and soap, and using alcohol-based hand sanitizers [9].

Washing hands with water and soap is the most effective method for eliminating microorganisms on the hands. Additionally, it helps remove dirt, oils, and chemicals from the skin [9]. However, in situations where water and soap are not available, using hand sanitizers with an alcohol concentration above 60% is a practical alternative. Although not as effective as washing with water and soap, hand sanitizers are easy to carry and use anywhere [10].

There is no definitive threshold for determining hand cleanliness, but hands can be considered clean if they are washed with soap and water or sanitized with a hand sanitizer containing more than 60% alcohol [10].

Mist Maker

A mist maker is a device designed to convert liquids into mist. This conversion process is achieved through ultrasonic atomization using piezoelectric technology. The mist maker comprises an ultrasonic generator, a transducer (piezoelectric element), and a framework for placing the transducer in the lower water layer, which serves as the medium for transforming water into vapor. The working principle of the mist maker involves converting the liquid into mist through a piezoelectric element that transforms ultrasonic frequencies into vibrations, which are in turn synchronized with the electrical waves produced by the ultrasonic generator [7].



Figure 1 Mist Maker [5]

Table 1 Spesification of Mist Maker

Komponen	Mist Maker
Temperature limit	+5 - 40°C
Water level	500-550mL/H
Water depth limit	45~65mm
Voltage	12W
Output voltage	AC 24V
Output current	0.5A
Transformer	CE,GS, BS,UL,CSA,PSE,SAA

Microcontroller

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 microcontroller. The board features 16 analog inputs, 54 digital input/output pins, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, an ICSP (In-Circuit System Programming) header, a USB connection, a power jack, and a reset button [12].

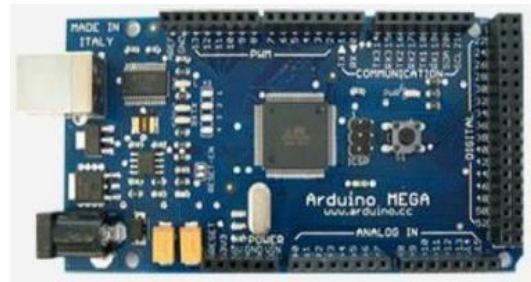


Figure 2 Arduino Mega 2560 [12]

Arduino boards are highly suitable as microcontrollers. They can be easily started by connecting to a computer via a USB cable or by using an AC-to-DC adapter or battery. Programming the Arduino Mega 2560 is done using the Arduino Software (Arduino IDE), which processes data detected by sensors.

Table 2 Spesification of Arduino Mega 2560

Microcontroller	ATMega2550
Operational Voltage	7-12 volt
GPIO	54 pin GPIO
Memory	256 KB <i>flash memory</i>
SRAM	8 KB
EEPROM	4 KB
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Programming Language	C++

Sensor

Passive Infrared Sensor (PIR)

Passive Infrared (PIR) sensors operate with the purpose of detecting infrared light emitted by an object. Their detection capability encompasses various objects since all objects emit energy radiation. As an object's temperature increases, the amount of radiant energy it emits also increases. Although the sensor itself does not emit infrared light, it can receive the radiation from its surroundings. The sensor works by comparing the infrared radiation received over a period of time; thus, if there is a change in this emission due to movement, the sensor will record the change. When an object passes by the sensor, it identifies the passive infrared radiation emitted by the object. The heat energy from this passive infrared radiation activates the pyroelectric material inside the sensor, generating an electric current. The PIR sensor consists of five components: a fresnel lens, an IR filter, a pyroelectric sensor, an amplifier, and a comparator [13].

The PIR sensor has two chambers made of special materials sensitive to radiation. When the sensor is stationary, these two chambers recognize the amount of radiation emitted by the surrounding environment, such as walls or outer areas. When a human or animal with a high body temperature passes by the PIR sensor, a positive change occurs in the differential of the two chambers. When out of the coverage area, a negative differential change occurs. The PIR sensor can detect human movement

within a range of 1 to 4 meters and can read movements from an angle of 40° [6].



Figure 3 Passive Infrared Sensor (PIR) [14]

Ultrasonic Sensor (HC-SR04)

The HC-SR04 ultrasonic sensor functions as a device capable of converting sound waves into electrical signals and vice versa. Its operating principle involves the transmission and reception of ultrasonic waves to measure the distance to an object. The sensor emits sound waves and then captures the reflected waves, noting the time difference between transmission and reception. This time difference correlates with the distance or height of the object reflecting the sound waves. The HC-SR04 sensor can measure distances ranging from 2 cm to 400 cm with a precision of approximately 3 mm. Additionally, it can detect various types of objects, including solids, liquids, and particles. To operate this sensor, four pins are essential: Vcc for positive power, Gnd for ground, Trigger for initiating the signal transmission, and Echo for capturing the reflected signal from the measured object. One practical application of this sensor is in water level measurement [6].



Figure 4 Ultrasonik Sensor [15]

Relay

A relay is a switch that operates electrically and is an electromechanical component consisting of two main parts: an electromagnetic (coil) and a mechanical part (a set of switch contacts). The relay works on the electromagnetic principle to move the switch contacts so that only a small current can conduct electricity with higher voltage [16].

Relay Characteristics [17]:

1. The impedance of the coil is usually determined by the thickness and number of turns of the wire used. Generally, 1-50KΩ is used to ensure good conductivity.
2. The power required to operate the relay is equal to the voltage value multiplied by the current.
3. The number of armature contacts can open and close more than once at a time, depending on the type of contacts and relay used. The distance between contacts determines the maximum voltage allowed between contacts.



Figure 5 Relay [17]

DC Fan

A DC fan has an iron coil in the moving part and a pair of flat magnets in the stationary part. The iron coil in the DC fan can be turned into a magnet by passing an electric current through the iron wire coil. The created magnet will have opposite poles to the flat magnets. These opposite magnetic properties will repel each other and produce a periodic rotational force on the iron coil. Therefore, the fan blades are connected to the coil shaft. By increasing the voltage on the iron coil, the airflow generated by the fan blades attached to the coil will also increase [18].



Figure 6 DC Fan [18]

LED

An LED, or Light Emitting Diode, is a component that can emit light. As a type of diode, an LED will only conduct electric current in one direction. An LED will emit light when an electric voltage is applied with a forward bias configuration. Unlike typical diodes, the current carrying capability of an LED is quite low, with a maximum of 20 mA [19].



Figure 7 LED [20]

LED

The Arduino IDE (Integrated Development Environment) is an open-source platform for physical computing. Arduino is also an integrated environment used for development, combining advanced hardware, programming language, and IDE. Arduino uses its own programming language, similar to C. In the Arduino IDE, the program code is called a sketch. The term "sketch" is used interchangeably with "program code" as they have the same meaning. The Arduino IDE consists of [21]:

1. A program editor, which is a window for writing and editing programs.

2. A compiler, which is a module for converting programs into binary code.
3. An uploader, which is a module that can upload binary code from the computer to the memory on the Arduino board.

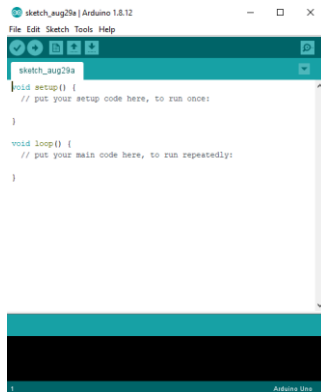


Figure 8 Arduino IDE [21]

METHOD

General Design

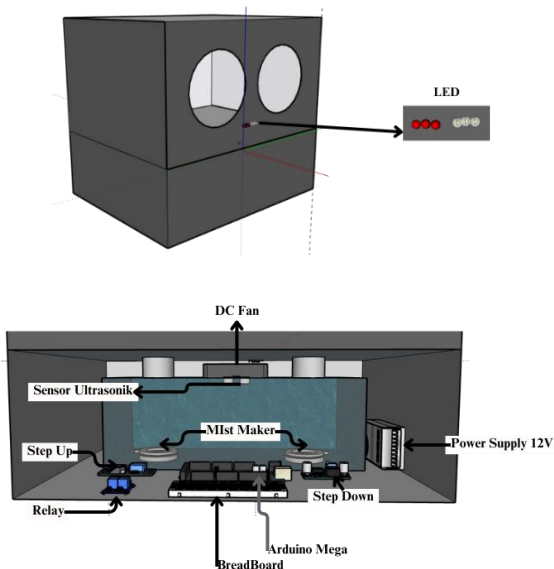


Figure 9 General System Design

In Figure 9, the hand sterilization device is designed using an Arduino Mega 2560 as the microcontroller. The PIR and ultrasonic sensors are placed inside a box to provide data input to the microcontroller. A mist maker, located in the sterilizing liquid storage, functions to convert the liquid into mist. A DC fan is used to move the created mist through a channel above the storage area. A buzzer serves as a reminder to the user, and an LED indicates the availability of the sterilizing liquid. A relay is used to control the electrical current to the mist maker.

Process Design

The software design explains the program design of the system to be created, which will be followed by data processing and the output of the completed system.

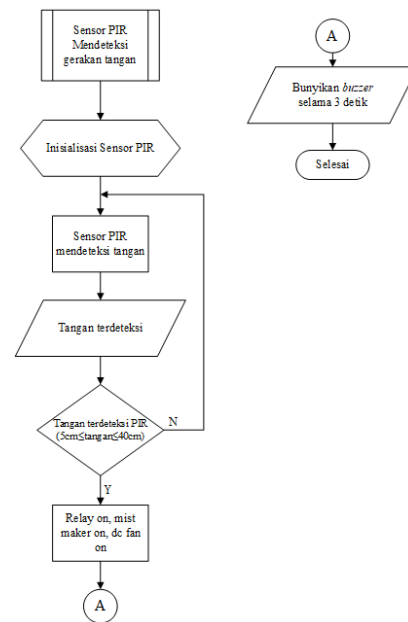


Figure 10 Flowchart of the Process Design

Figure 10 shows the flowchart of the overall system design. The process begins with the initialization of the ultrasonic sensor. The ultrasonic sensor then detects the height of the sterilizing liquid. When the liquid height is between 4.5cm and 6cm, the white LED will light up, indicating that the amount of sterilizing liquid is sufficient to be converted into mist, and the process will proceed to the next step. If the liquid height is outside this range, the red LED will light up, and the buzzer will sound every second, indicating that the sterilizing liquid does not meet the mist maker's depth conditions, thus the liquid-to-mist conversion process will not be optimal. The next process involves the system reading the output value from the PIR sensor to initiate the sterilization process. The system will always be on standby to perform its function, and it will operate as instructed.

RESULTS AND DISCUSSION

Hardwar Implementation

The hardware used in this research is divided into three main components: input, consisting of PIR and ultrasonic sensors; process, using an Arduino Mega as the microcontroller; and output, consisting of a mist maker, buzzer, DC fan, and LED. The hardware implementation of the system can be seen in the following figure:



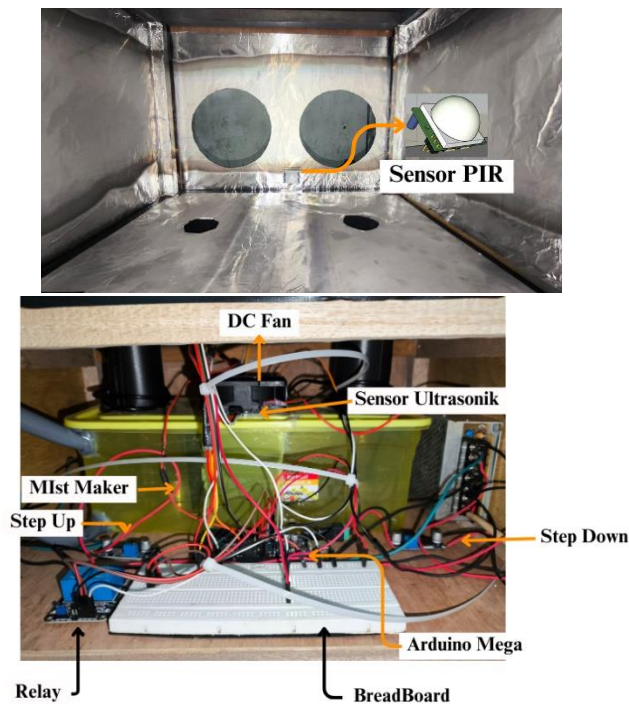


Figure 11 Hardware Implementation

Explanation of the figure 11:

- Arduino Uno: Used as the microcontroller to process the overall system operations.
- PIR Sensor: Functions to detect hand movements entering the device.
- Ultrasonic Sensor: Used to measure the height of the sterilizing liquid in the storage container.
- Mist Maker: Functions to convert the sterilizing liquid into mist.
- DC Fan: Used to transfer the mist generated by the mist maker from the storage area to the user's hands.
- LED: Provides notifications about the availability of the sterilizing liquid, with a blue LED indicating that the liquid is available and a red LED indicating that the liquid is running low.
- Relay: Functions to connect and disconnect the power supply to the mist maker and DC fan.
- Power Supply: Serves as the power source for all components, converting AC to DC with a voltage of 12V and a current of 10A.
- Step Down: Functions to reduce the voltage to 7V to power the Arduino Mega.
- Step Up: Functions to increase the voltage to 24V to power the mist maker.

Hardware Testing and Analysis

Ultrasonic Sensor Testing and Analysis

This test was conducted to evaluate the accuracy of the ultrasonic sensor by comparing its measurement accuracy against a ruler, based on the presence of an object within the defined distance range of 2 to 10 cm. The test results are presented in Table 3:

Table 3 Ultrasonic Sensor Test

Experiment No.	Ruler (cm)	Ultrasonic (cm)	Difference	Error (%)
----------------	------------	-----------------	------------	-----------

1	4	4,06	0,06	0,015
2		4,01	0,01	0,002
3		4,03	0,07	0,017
4		4,03	0,07	0,017
5	5	4,10	0,10	0,025
6		5,00	0	0
7		5,10	0,10	0,02
8		4,98	0,02	0,004
9	6	5,10	0,10	0,02
10		5,08	0,08	0,16
11		6,05	0,05	0,08
12		5,95	0,05	0,08
13	7	5,95	0,05	0,08
14		6,05	0,05	0,08
15		6,05	0,05	0,08
16		6,05	0,05	0,08
17	8	7,00	0	0
18		7,02	0,02	0,002
19		6,90	0,10	0,014
20		6,92	0,08	0,011
21	9	7,02	0,02	0,002
22		7,97	0,03	0,003
23		8,19	0,19	0,023
24		8,19	0,19	0,023
25	10	7,99	0,01	0,001
26		8,30	0,30	0,03
27		8,99	0,01	0,001
28		8,99	0,01	0,001
29	11	8,87	0,13	0,014
30		8,98	0,02	0,002
31		8,99	0,01	0,001
32		8,99	0,01	0,001
33	12	10,01	0,01	0,001
34		9,91	0,09	0,009
35		10,03	0,01	0,001

The percentage error is calculated using the following formula:

Percentage Error

$$\frac{(\text{sensor value} - \text{measuring instrument value})}{\text{measuring instrument value}} \times 100\% \quad \text{.....(1)}$$

The average error is calculated as follows:

$$\text{Average Error} = \frac{\sum \% \text{error}}{\text{number of data points}} \quad \text{.....(2)}$$

The average measurement difference is calculated as follows:

$$\text{Average Measurement Difference} = \frac{\sum \text{measurement differences}}{\text{number of data points}} \quad \text{.....(3)}$$

Based on the table above, from 35 experiments conducted with the ultrasonic sensor to measure water height in the system, the average measurement difference was 0.063, and the overall average error rate was 0.024%. It is concluded that the sensor has a high degree of accuracy with a success rate of 99.974%. The results from the DC-SR04 ultrasonic sensor readings are shown in the figure:

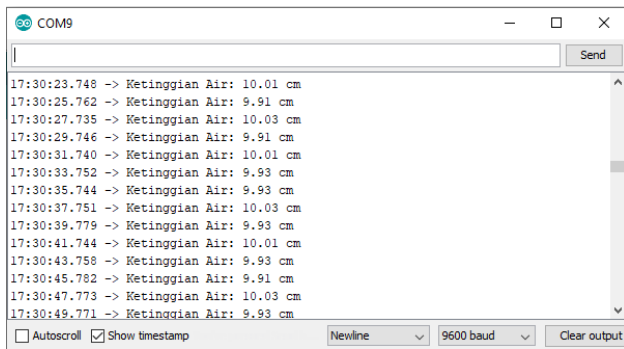


Figure 12 Ultrasonic Sensor Output

PIR Sensor Testing and Analysis

The HC-SR501 passive infrared (PIR) sensor was tested by moving a hand within the sensor's detection range to determine the distance and angle coverage that the PIR sensor can detect. The PIR sensor readings on the serial monitor are as follows:

Table 4 PIR Sensor Testing

No.	Object	Condition	Distance (cm)	Angle	Experiment Result
1	Hand	Moving	10	30°	Not Detected
				45°	Detected
				60°	Detected
				90°	Detected
				135°	Detected
				150°	Not Detected
		Still		30°	Not Detected
				45°	Not Detected
				60°	Not Detected
				90°	Not Detected
				135°	Not Detected
				150°	Not Detected
2	Hand	Moving	20	30°	Not Detected
				45°	Detected
				60°	Detected
				90°	Detected
				135°	Detected
				150°	Not Detected
		Still		30°	Not Detected
				45°	Not Detected
				60°	Not Detected
				90°	Not Detected
				135°	Not Detected
				150°	Not Detected

3	Hand	Moving	30	150°	Not Detected
				30°	Not Detected
				45°	Detected
				60°	Detected
				90°	Detected
				135°	Detected
		Still		150°	Not Detected
				30°	Not Detected
				45°	Not Detected
				60°	Not Detected
				90°	Not Detected
				135°	Not Detected
4	Hand	Moving	40	150°	Not Detected
				30°	Not Detected
				45°	Detected
				60°	Detected
				90°	Detected
				135°	Detected
		Still		150°	Not Detected
				30°	Not Detected
				45°	Not Detected
				60°	Not Detected
				90°	Not Detected
				135°	Not Detected

The table presents tests of the PIR sensor with a human hand as the object. Two conditions were tested: moving and stationary. The results indicate that the PIR sensor can detect the presence of a human hand when it is moving, as the sensor detects the infrared radiation emitted by the human body, which is converted into a voltage. Conversely, if the hand is stationary, the sensor cannot detect it. During the experiments, the PIR sensor achieved a detection range of over 40 cm with an angular coverage from 45° to 135°.

Additionally, experiments were conducted with the PIR sensor using different objects such as a book, wood, and a water bottle, with the same distance and angles as used in the tests with the human hand. The results of these experiments are shown in the table:

Table 5 Testing of PIR Sensor with Inanimate Objects

No.	Object	Distance (cm)	Angle	Experiment Result
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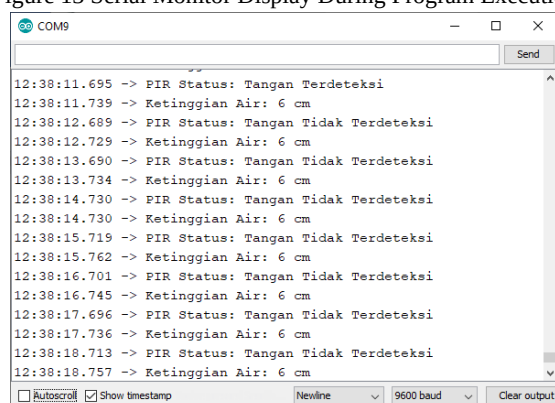
1	Book	10	30°	Not Detected
			45°	Not Detected
			60°	Not Detected
			90°	Not Detected
			135°	Not Detected
			150°	Not Detected
2	Wood	20	30°	Not Detected
			45°	Not Detected
			60°	Not Detected
			90°	Not Detected
			135°	Not Detected
			150°	Not Detected
3	Water Bottle	30	30°	Not Detected
			45°	Not Detected
			60°	Not Detected
			90°	Not Detected
			135°	Not Detected
			150°	Not Detected

From the results shown in the table, it can be observed that the PIR sensor was unable to detect the inanimate objects at the tested distances and angles. This is because these objects do not emit infrared radiation, which is typically only present in living organisms that move. The PIR sensor is designed to detect changes in infrared radiation, which is why it successfully detects moving human bodies but fails to detect inanimate objects that do not emit significant infrared radiation.

Software Testing and Analysis

The purpose of testing and analyzing the program.ino file is to determine whether the software is functioning correctly. This process displays the water height and hand detection values on the serial monitor, as shown in Figure 13:

Figure 13 Serial Monitor Display During Program Execution



From the figure 13, it can be observed that the measurements for water height and hand movement are displayed in real-time. The data is updated automatically every second, allowing for continuous monitoring and evaluation.

Functional Test

Functional Testing of Hand Detection

The functional testing of the PIR sensor detection was conducted to evaluate the system's ability to detect hand movements when inserted into the device at predetermined distances. The following table presents the results of the system testing:

Table 6 Fungsional Testing of Hand Detection

No.	Distance	Status
1.	1 cm	Detected
2.	2 cm	Detected
3.	3 cm	Detected
4.	4 cm	Detected
5.	5 cm	Detected
6.	6 cm	Detected
7.	7 cm	Detected
8.	8 cm	Detected
9.	9 cm	Detected
10.	10 cm	Detected
11.	11 cm	Detected
12.	12 cm	Detected
13.	13 cm	Detected
14.	14 cm	Detected
15.	15 cm	Detected
16.	16 cm	Detected
17.	17 cm	Detected
18.	18 cm	Detected
19.	19 cm	Detected
20.	20 cm	Detected
Succes Rate		100%

Functional testing of the PIR sensor was conducted by inserting a hand into the device at various distances from the insertion point above the PIR sensor, which was angled at 45°. A total of 20 trials were performed, with the hand being inserted into the device at

Functional Testing of Sterilization Liquid Level Detection

Functional testing of the sterilization liquid level detection was conducted to evaluate the system's ability to detect the height of the sterilization liquid in the storage container. The results of the testing are summarized in the table below.

Table 7 Functional Testing of Sterilization Liquid Level Detection

No.	Liquid Height	Liquid Height from Ultrasonic Sensor					Error	Red LED	White LED	Buzzer
		I	II	III	IV	V				
1	2,50 cm	2,45	2,45	2,45	2,45	2,45	2%	on	off	buzzin g
2	3,00 cm	3	3,02	3,04	3,04	3,03	0,8%	on	off	buzzin g
3	3,50 cm	3,56	3,44	3,54	3,38	3,48	0,5%	on	off	buzzin g
4	4,00 cm	4,1	3,96	4,04	3,98	4,02	0,5%	on	off	buzzin g
5	4,50 cm	4,44	4,37	4,44	4,48	4,44	1,5%	off	on	off
6	5,00 cm	5,13	5,06	5,06	4,99	5,06	0,9%	off	on	off
7	5,50 cm	5,4	5,4	5,4	5,43	5,48	1,5%	off	on	off
8	6,00 cm	5,95	5,91	5,99	5,89	5,95	1,1%	off	on	off
9	6,50 cm	6,53	6,59	6,49	6,51	6,53	0,5%	on	off	buzzin g
10	7,00 cm	7,05	6,98	7,05	7,05	6,98	1,6%	on	off	buzzin g
Error Rate							1,09%			

Functional testing of the sterilizing liquid level detection was conducted by measuring the distance between the liquid level and the ultrasonic sensor. The testing began with the liquid height at 2.50 cm, and the liquid level was increased by 0.50 cm increments until reaching 7.00 cm. There were 10 different height levels, with each level tested 5 times.

Functional Testing of Mist Maker

Functional testing of the mist maker was conducted to evaluate the system's ability to convert sterilizing liquid into mist. The test results are shown in the table below.

Table 8 Functional Testing of Mist Maker

No.	Time (minutes)	Liquid to Mist Conversion (ml)					Average (ml)	Average per minute (ml)
		I	II	III	IV	V		
1.	1	18,2	28,4	18,4	18,2	18,4	18,32	18,32
2.	2	36,8	37,0	37,0	36,8	37,0	36,92	18,46
3.	3	54,0	54,6	54,4	54,2	54,4	54,32	18,11
4.	4	72,2	72,8	72,6	72,4	72,6	72,52	18,13
5.	5	90,4	90,1	90,8	90,6	90,8	90,72	18,14
Average								18,232ml/m

Functional testing of the mist maker was performed by measuring the amount of sterilizing liquid converted into mist. The tests were conducted 5 times for durations ranging from 1 to 5 minutes using two mist makers. The average amount of sterilizing liquid converted into mist was 18.232 ml/min or approximately 1093.92 ml/hour (546.96 ml/hour per mist maker), which aligns with the mist maker's datasheet output of 500-550 ml/hour.

Functional Testing of Sterilization Notification

Functional testing of the sterilization notification was conducted to evaluate the system's ability to notify the user that the sterilization process is complete. The test was conducted 10 times, and the time before the buzzer sounded was measured using a stopwatch. The system is programmed to run the sterilization process for 15 seconds. The test results are shown in the table below.

Table 9 Functional Testing of Sterilization Notification

No.	Time Measured by Stopwatch (seconds)	Error
1.	15,65	4,3%
2.	14,86	0,9%
3.	15,04	0,2%
4.	15,10	0,6%
5.	15,35	2,3%
6.	15,21	1,1%
7.	15,12	0,8%
8.	15,29	1,9%
9.	15,41	2,7%
10.	15,51	3,4%
Average Error		1,82%

From the table obtained from 10 trials, the total or average error was 1.82%, resulting in a success rate of 100% - 1.82% = 98.28%.

CONCLUSIONS

Based on the tests and analysis conducted on the Microcontroller-Based Hand Sterilization Device with Mist, the following conclusions can be drawn:

1. The system successfully detects hand movement using the Passive Infrared (PIR) sensor within a distance of 20 cm and an angle range of 45° to 135°, achieving a success rate of 100%
2. The system can convert the sterilizing liquid into mist using the mist maker, with an average conversion rate of 182.32 ml per minute.
3. The system can measure the height of the sterilizing liquid in the storage container using an ultrasonic sensor, achieving a success rate of 98.91%
4. The system provides notifications to the user via a buzzer after the sterilization process is complete, achieving a success rate of 98.18%.

ACKNOWLEDGMENT

1. Several suggestions from this research can be considered for future development, including:
2. Adding an LCD display to show the level of the sterilizing liquid would make it easier to monitor the availability of the liquid.

REFERENCES

- [1] D. S. Dajaan *et al.*, "Hand washing knowledge and practices among public primary schools in the Kintampo Municipality of Ghana," *Int. J. Community Med. Public Heal.*, vol. 5, no. 6, p. 2205, 2018, doi: 10.18203/2394-6040.ijcmph20182146.
- [2] N. Bur and S. Septiyanti, "Perilaku Hidup Bersih Dan Sehat (PHBS) Di SD Inpres Katangka Gowa," *Celeb. Abdimas J. Pengabd. Kpd. Masy.*, vol. 2, no. 1, pp. 47–52, 2020, doi: 10.37541/celebesabdimas.v2i1.301.
- [3] F. K. Masyarakat and U. Airlangga, "Perilaku Cuci Tangan Di Kalangan Siswa-Siswi Smak Santa Agnes Surabaya," no. May, pp. 208–219, 2018, doi: 10.20473/ijph.v13il.2018.208-219.
- [4] R. S. Hendrasari, "Studi Peningkatan Kebutuhan Air Bersih Pada Masa Pandemi Covid 19 di Kota Yogyakarta," *Pros. Semin. Nas. Unimus*, vol. 3, pp. 962–966, 2020, [Online]. Available: <http://prosiding.unimus.ac.id>
- [5] M. H. Hakim, R. Irmawanto, and P. Poniman, "Rancang Bangun Wastafel dan Portal Otomatis dengan Mempertimbangkan Antropometri Guna Mencegah Penularan COVID19," *Resist. (Elektronika Kendali Telekomun. Tenaga List. Komputer)*, vol. 4, no. 1, p. 29, 2021, doi: 10.24853/resistor.4.1.29-36.
- [6] A. Nurul Fitri and D. Yendri, "Rancang Bangun Pelembab Udara Ruangan (Humidifier) berbasis Mikrokontroler," *Chipset*, vol. 4, no. 01, pp. 61–70, 2023, doi: 10.25077/chipset.4.01.61-70.2023.
- [7] M. I. Fernanda, "Rancang Bangun Mesin Desinfeksi

- Kabut Otomatis Untuk Menghemat Air,” Universitas Andalas, 2022.
- [8] “98 Persen Penyebaran Kuman di Tubuh Bersumber dari Tangan – RSUD dr. TJITROWARDOJO KELAS B PURWOREJO.” <https://rsud.purworejokab.go.id/berita/?p=2125> (accessed Aug. 22, 2023).
- [9] F. A. Desiyanto and S. N. Djannah, “Efektivitas Mencuci Tangan Menggunakan Cairan Pembersih Tangan Antiseptik (Hand Sanitizer) Terhadap Jumlah Angka Kuman,” *J. Kesehat. Masy. (Journal Public Heal.*, vol. 7, no. 2, pp. 75–82, 2013, doi: 10.12928/kesmas.v7i2.1041.
- [10] “Chemical Disinfectants | Disinfection & Sterilization Guidelines | Guidelines Library | Infection Control | CDC.” <https://www.cdc.gov/infectioncontrol/guidelines/disinfection/disinfection-methods/chemical.html> (accessed Aug. 22, 2023).
- [11] M. Maker, T. Data, and O. Process, “Mist Maker Manual,” no. 2, 2017, [Online]. Available: <https://images-na.ssl-images-amazon.com/images/I/61bQ10U043L.pdf>
- [12] C. Nisa and R. Eka Putri, “Rancang Bangun Alat Pembuat Minuman Kawa Daun Otomatis Berbasis Mikrokontroler,” *Chipset*, vol. 3, no. 02, pp. 120–130, 2022, doi: 10.25077/chipset.3.02.120-130.2022.
- [13] R. Toyib, I. Bustami, D. Abdullah, and O. Onsardi, “Penggunaan Sensor Passive Infrared Receiver (PIR) Untuk Mendeteksi Gerak Berbasis Short Message Service Gateway,” *Pseudocode*, vol. 6, no. 2, pp. 114–124, 2019, doi: 10.33369/pseudocode.6.2.114-124.
- [14] Adafruit Industries, “PIR Motion Sensor,” *Adafruit*, vol. 1, no. 2021-11–15, p. 25, 2018, [Online]. Available: <https://learn.adafruit.com/pir-passive-infrared-proximity-motion-sensor>
- [15] Indoware, “Ultrasonic Ranging Module HC - SR04,” *Datasheet*, pp. 1–4, 2013, [Online]. Available: <http://www.micropik.com/PDF/HCSR04.pdf>
- [16] R. D. Risanty and L. Arianto, “Rancang Bangun Sistem Pengendalian Listrik Ruangan Dengan Menggunakan Atmega 328 Dan Sms Gateway Sebagai Media Informasi,” *Sist. Informfile///C/Users/Portege/Desktop/TUGAS AKHIR/Judul Baru/DAPUS/[19].pdf*, vol. 7, no. 2, pp. 1–10, 2017.
- [17] F. A. T. Utami, W. Kasoep, and N. P. Novani, “Prototype Sistem Pendeteksi dan Penetralisir Asap Rokok pada Ruangan dengan Fitur Monitoring Suhu dan Kelembaban,” *Chipset*, vol. 3, no. 01, pp. 32–44, 2022, doi: 10.25077/chipset.3.01.32-44.2022.
- [18] L. Rahmadani, “Rancang Bangun Inkubator Fermentasi Tempe Berbasis Internet of Things,” 2022.
- [19] D. Suryana, “Analisa Penggunaan Lampu LED Pada Penerangan Dalam Rumah,” *UNDIP Tembalang, Semarang*, pp. 1–7, 2013.
- [20] Everlight, “Technical Data Sheet 5 mm Round White LED (T-1 3/4),” pp. 1–10, 2007, [Online]. Available: www.everlight.com
- [21] V. Rahmadani, “Sistem Monitoring Kualitas Air Laut dan Kontrol Kadar Oksigen untuk Penangkaran Tukik Penyu Sisik Berbasis Internet of Things (IoT),” 2022.

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