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AUVISMA: Automated UV Irradiation System for Medical Apparel

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ABSTRACT

This study focuses on an approach to sanitation in medical apparel contaminated by airborne from the hospitals. Sanitizing medical apparel helps mitigate the transmission of infections to healthcare workers and patients. Previous solutions, such as laundry, have constraints in effectively removing all contaminants. This research presents an Arduino-based UV chamber for sanitizing medical apparel with the use of UV-C light and HEPA filter. The system is designed to effectively eliminate bacteria, viruses, and other pathogens present on the apparel surface without the need for harsh chemicals. An application is also made for this machine for monitoring and to provide real-time data from the UV intensity, temperature, and humidity levels inside the chamber. This innovative solution not only ensures a higher level of protection for healthcare workers and patients but also reduces the risk of cross-contamination in medical settings. By automating the sanitization process, this process can save time and enhance efficiency in healthcare facilities.

Keywords: AUVISMA, Automated UV Irradiation, Arduino-Based UV Chamber, Medical Apparel, Sanitization, Infection Control.

I. Introduction

In healthcare environments, uniforms play a vital role, but they can also harbor harmful pathogens. Alarmingly, a study revealed that 80.3% of 366 swabbed uniforms in China were contaminated with microorganisms, with 61.5% testing positive for bacteria (Du et al., 2017). A similar study at a Washington State hospital detected methicillin-resistant Staphylococcus aureus (MRSA) on uniforms within just 48 hours (Sanon, 2012). While conventional laundry methods are common, they can be time-consuming and may not ensure complete disinfection (Shin et al., 2019).

Similarly, a national study at the University of the Philippines—Philippine General Hospital examined 22 Emergency Medicine residents, with a majority being female (54.5%) and working evening shifts (63.6%). It found increased bacterial contamination on uniforms, particularly Staphylococcus Epidermidis. The contamination was notably higher after duty shifts, with moderate growth linked to morning shifts (0700–1900 hours) (Tabunar, 2022). These studies show a significant concern regarding microbial contamination on healthcare workers' uniforms, revealing high levels of pathogenic and antibiotic-resistant bacteria.

To combat these challenges, the **Automated UV Irradiation System for Medical Apparel (AUVISMA)** has been developed. This innovative, Arduino-based system utilizes UV-C light to effectively disinfect hospital uniforms by eliminating bacteria and viruses. AUVISMA automates the sanitization process, enhancing both efficiency and safety.

Equipped with a user-friendly mobile app, AUVISMA features a switch for added safety and control. Upon activation, the system initiates a 20-second delay, allowing users to load their uniforms. An 18-minute disinfection cycle then follows, during which the UV-C light sanitizes the garments. After completion, the system automatically shuts off and notifies the user through the app.

In addition to its disinfection capabilities, the AUVISMA application includes monitoring features for UV index, temperature, and humidity, providing users with real-time data essential for maintaining optimal conditions. The system also incorporates a High-Efficiency Particulate Absorbing (HEPA) filter and a dust filter to enhance air quality and reduce airborne contaminants during operation.

Extensive research indicates that healthcare workers' (HCWs) apparel is frequently contaminated with microorganisms and pathogens, posing significant risks for infections (Mitchell et al., 2015). Similar devices have utilized Arduino microcontrollers to manage UV lamps and disinfection processes (Albayyat et al., 2024). UV-C radiation, which operates within a wavelength range of 200 to 270 nm, effectively disrupts DNA molecular bonds, rendering microorganisms inactive (Buonanno et al., 2020). Additionally, HEPA filters have demonstrated significant efficacy in removing airborne pathogens, achieving virus capture ratios of over 99.97% (Ueki et al., 2022). The Automated UV Irradiation System for Medical Apparel (AUVISMA) integrates UV-C radiation and HEPA filtration to enhance hygiene standards in healthcare by efficiently disinfecting medical uniforms, thus safeguarding both healthcare workers and patients.

Designed to be cost-effective and accessible in the Philippines, AUVISMA offers a practical solution for hospital uniform sanitization, contributing to a safer and more hygienic healthcare environment.

II. Review of Related Literature

This section discusses a thorough review of the literature related to the study. This review examines the efficiency of UV-C light and HEPA filter and their effect on their potential impact on reducing airborne pathogens. This also includes studies investigating these technologies' effectiveness in sanitizing medical apparel.

Effectiveness of UV-C light in sanitizing

Sanitizing in a 254 nm hospital effectively kills bacteria and eradicates various pathogens from hard surfaces, making it a crucial tool for hospital room decontamination (Smolle et al., 2018). Temperature significantly influences pathogen control on cloth, as higher temperatures can effectively eliminate bacteria and viruses (Abney et al., 2021). In the study by Moufti et al. (2023), the efficacy of UV light cabinets for disinfecting non-sterilizable dental objects was demonstrated, highlighting that a 2.5-minute UV exposure could achieve complete disinfection, outperforming traditional disinfection solutions. This research supports the concept behind the AUVISMA project, which employs a compact UV irradiation system to sanitize medical apparel efficiently. By leveraging the findings on UV exposure time and disinfection efficacy, AUVISMA can ensure effective sanitation of hospital uniforms, ultimately enhancing safety and hygiene in healthcare settings. Moreover, the considerations regarding wavelength, intensity, and safety are critical in the design of AUVISMA, ensuring optimal performance while maintaining user safety.

Applications of UV Irradiation in Healthcare Settings

Ultraviolet germicidal irradiation (UVGI) is a widely adopted method in healthcare for disinfecting surfaces and air. Its effectiveness, particularly with UV-C light, has been demonstrated in reducing microbial contamination in both rooms and smaller items. However, safety concerns limit its use to unoccupied spaces. Emerging technologies, such as autonomous UV systems and far-UV light, show promise for broader applications, yet they remain underutilized in the field (Scott et al., 2022). This aligns with AUVISMA's objective to sanitize hospital uniforms through UV-C, utilizing an automated, controlled environment to ensure safety and efficiency, similar to clinical room disinfection protocols.

By integrating reflectors and a controlled HEPA-filtered chamber, AUVISMA adapts UVGI principles for textiles, potentially filling a niche for sterilizing non-electronic personal items in healthcare environments. For the AUVISMA project, integrating UVGI in sanitizing clothing could enhance safety and efficiency, helping to reduce microbial contamination on medical uniforms while addressing existing challenges in standardization and application across various healthcare environments.

UV-C Disinfection Technologies and Safety Features

UV-C disinfection has become a vital tool in combating pathogens, particularly during the COVID-19 pandemic. Various UV-C disinfection technologies have been developed, each with its own features and limitations. The Arduino-based UV-C disinfection box developed by Chougule et al. (2022) offers advancements such as 360-degree all-around sanitization and includes safety mechanisms like fingerprint locks and automatic locking. However, it faces limitations in terms of fixed sizing and manual disinfection settings. In contrast, the AUVISMA project enhances safety and disinfection by incorporating a safety switch and automated operation using UV-C light, ensuring thorough sanitization of medical apparel. By also monitoring UV intensity and environmental conditions, AUVISMA provides a more adaptable and user-friendly solution for healthcare settings.

Effectiveness of Reflectors in UV Chambers

In their study, De Sternberg Stojalowski and Fairfoull (2021) highlight that while microporous PTFE sheets exhibit the highest reflectivity for UV-C radiation, reflective insulation foam presents notable advantages in practical applications. This material is lightweight and cost-effective, making it suitable for various industries. When lined with aluminum foil, reflective insulation foam enhances its reflective properties, contributing positively to the efficiency of UV chambers. Although it may not achieve the same level of uniform UV scattering as PTFE, reflective insulation foam serves as a viable alternative, particularly in scenarios where budget constraints and structural flexibility are critical. Furthermore, it effectively addresses the dual need for thermal insulation and UV reflection, presenting a practical solution that balances cost and performance in UV disinfection applications.

The Role of HEPA Filter in Bacterial Control

The study by Qiu et al. (2022) highlights the critical impact of ventilation, humidity, and temperature on bacterial growth, emphasizing that airtight environments with high humidity—such as storage cabinets and clothing closets—provide ideal conditions for bacterial proliferation. In the context of the AUVISMA project, the integration of a HEPA filter is crucial not only for enhancing air quality but also for complementing the UV sanitation process. While UV light effectively kills bacteria on surfaces, the HEPA filter captures airborne particles, including any bacteria and spores that may circulate in the chamber. This dual approach ensures that the sanitized medical apparel remains free from contaminants both on the surface and in the surrounding air, reinforcing the importance of maintaining a hygienic environment where infection control is paramount.

Optimal Conditions for UV Disinfection

According to Cutler et al. (2012), the Porcine Reproductive and Respiratory Syndrome (PRRS) virus exhibits increased susceptibility to ultraviolet (UV) inactivation as temperatures decrease. The virus is most effectively inactivated by UV light at relative humidity levels ranging from 25% to 79%. In contrast, it demonstrates reduced susceptibility at relative humidity levels below 24% and is least susceptible when relative humidity exceeds 80%. This information highlights the importance of environmental conditions in optimizing UV disinfection processes, particularly in applications like the AUVISMA project, where effective sanitation of medical apparel is essential.

Mathematical Models for Determining UV Exposure Time

In the study by Claytor et al. (2021), it was noted that the recommended dosages from aqueous studies do not apply to disinfecting personal protective equipment (PPE). The most common metric used in UV disinfection is dosage, typically expressed in joules per square centimeter (J/cm^2). To convert UV intensity to dosage, the time of radiation exposure must be calculated. If both the required dosage for effective disinfection and the UV-C source intensity are known, the necessary exposure time can be determined.

For calculating the UV exposure time in the AUVISMA system, the UV-C lamp has an output of 1.9 W. To determine how long the system should run, we use the formula:

$T = D/I$, where T is the exposure time in seconds, D is the required dosage (J/cm^2), and I is the UV-C intensity (mW/cm^2). Based on the calculation:

$T = 2\ J/cm^2 / 1.9\ mW/cm^2 = 2000\ mJ/cm^2 / 1.9\ mW/cm^2 \approx 1058\ s \approx 17.6$ minutes or **18 minutes.**

Thus, the required exposure time for effective disinfection in the UV chamber is approximately 18 minutes.

This calculation is highly relevant to the AUVISMA system, as it ensures that the automated UV chamber applies the correct exposure time for sanitizing hospital uniforms. By using the UV-C germicidal lamp with a known intensity, AUVISMA can precisely calculate the time needed to achieve optimal disinfection levels. This guarantees that the system meets the desired sanitation standards while protecting the fabrics from potential damage caused by excessive UV exposure. The computation provides a scientific basis for the AUVISMA system's operation, ensuring that the UV exposure time is both effective and safe for repeated use on medical apparel.

III. Methodology

Phase 1: Procurement of Materials

The researchers bought the components for the development of the device. The emphasis was the procurement of the components around Davao City from known electronic stores or online from local shops, ensuring the quality and authenticity of the components. Furthermore, sourcing locally also allowed for easier coordination with the supplies and for necessary replacements or additional parts. However, researchers encountered challenges wherein there are insufficient stock components through the local suppliers. Despite the challenges faced with stock components, the researchers were able to find alternative suppliers to complete the device. The combination of these electronic components and construction materials allowed the researchers to create a functional and efficient sanitization device that effectively eliminates germs and viruses in medical apparel.

Table 1. Materials and Equipment in Software

No.	Software Components	Amount
1	Arduino UNO	1
2	LCD I2C Blue	1
3	RobotDyn UV Sensor	1
4	Full-size breadboard	1
5	NodeMCU 1.0 (ESP-12E Module) ESP8266	1
6	DHT11 Temperature and Humidity Sensor	1
7	Passive Buzzer	1
8	NodeMcu CH340G Driver	1
9	9v Battery	2

10	9v Battery holder with PC Jack	1
11	Dupont Jumper Wires (Male to Male)	2
12	Dupont Jumper Wires (Male to Female)	2
13	Dupont Jumper Wires (Female to Female)	2

Table 2. Materials and Equipment for Hardware Components

No.	**Hardware Components**	**Amount**
1	HEPA Filter	1
2	Germicidal Lamp GL UVC F 10W T8	1
3	Push to Door Open Lock	1
4	Metallic Spray Paint	3
5	10mm Plywood	1
6	Ordinary Nails	1
7	220v Blower	1
8	5mm Insulation foam	1
9	Door handle	1
10	AOT110F Lighting Fixtures Open Type	1
11	Metal Door Frame	1
12	GE Ballast 10 W	1
13	Starter 4-40 W Only	1
14	4 Gang Unit Outlet	1
15	Dust Filter	1

Phase 2: Making a 3D Sketch of the UV chamber

A 3D design was created to showcase the AUVISMA, highlighting its innovative features and imagining how every part of the chamber comes together to ensure that they all have their function. The visual also demonstrates the versatility of the AUVISMA in various environments, from industrial settings to research facilities. The interactive model allows users to explore the product from all angles and zoom in on specific details for a closer look.

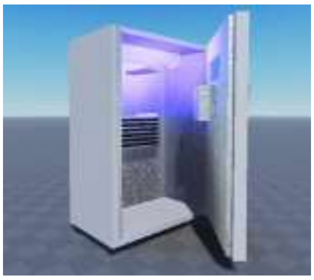

Figure 1: *3D Design of the UV chamber*

Phase 3: Hardware Development

In this phase, the researchers initiated the construction of a chamber in a rectangular frame by cutting a plywood board, serving as the foundational structure for AUVISMA. Once it was completed, a section in the center was cut for a glass panel, allowing visibility into the internal process during the sanitization. A 220 blower, mini wheels, and case for the HEPA filter were added to the structure to enhance functionality and mobility.

Figure 2: *Construction of a foundational structure*

Afterward, it was painted for visual appeal and durability, ensuring the chamber was aesthetically pleasing and a door handle for easy access to open. A Germicidal Lamp (GL UVC F 10W T8) emitting 254 nm UV light was installed inside to provide the necessary UV radiation for effective sanitization. A study showed that exposure to UV light with a wavelength of 254 nm can eliminate the virus (Singh, P., et al., 2023).

Figure 3: *Installation of fluorescent lamp*

An insulation foam was added to the chamber to improve energy efficiency and maintain a consistent temperature within the chamber. This will help bounce back the radiation from the germicidal lamp that escapes from the chamber walls, resulting in a more efficient and effective sanitization process. A control box for the components was also installed to regulate the power supply and ensure the optimum performance of AUVISMA. Additionally, a box for an I2C LCD was displayed in the glass which users can monitor the status of AUVISMA. The wiring was then carefully organized and secured in the control box to prevent interference with the system's functioning. This will help maintain the overall reliability and longevity of the chamber for continued use in sanitization processes.

Figure 4: *Final design of AUVISMA*

Phase 4: Software Development

A biomedical technician then created a detailed schematic diagram outlining the components and connections of the UV chamber. This diagram serves as a visual representation of AUVISMA's components, providing a clear and precise layout for each sensor and system involved in the project. A full-size breadboard utilizes each component to maintain organization and facilitate wiring. The schematic diagram included an illustration of where each component was located to ensure that the components are placed properly and fixed without troubleshooting any issues that may happen during the project.

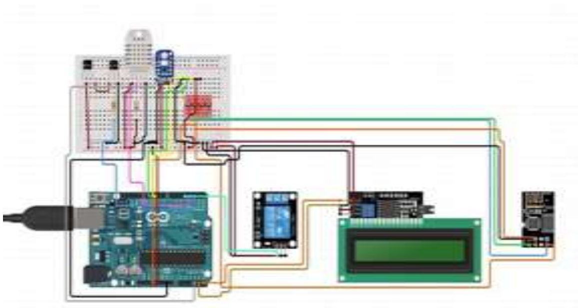

Figure 5: *Schematic diagram of the AUVISMA*

Dupont jumper wires were employed to establish secure connections, ensuring cohesive functionality among all components. The breadboard was used to easily prototype and test different circuit configurations. In the Arduino UNO, G (yellow wire) in NodeMCU is connected to GND, AD (white wire) to out in UV sensor. the G (black wire) to Temperature and Humidity Sensor (positive) and D4 (purple wire) to (out), Pin 2 (purple wire) to IN1 relay, Pin 11 (blue wire) to Out in UV sensor, A4 (yellow wire) to SDA in LCD, A5 (yellow wire) to SCL in LCD, GND (white wire) to -1 (J side, readboard), 5V (brown wire) to +1 (J side, breadboard), 3.3V (purple wire) to 28 J (breadboard). In pins, G (yellow wire) to GND UV sensor, D6 (white wire) to Out UV sensor, D5 (purple wire) to Out in Temperature and Humidity Sensor, and G (black wire) to negative (-) in Temperature and Humidity Sensor.

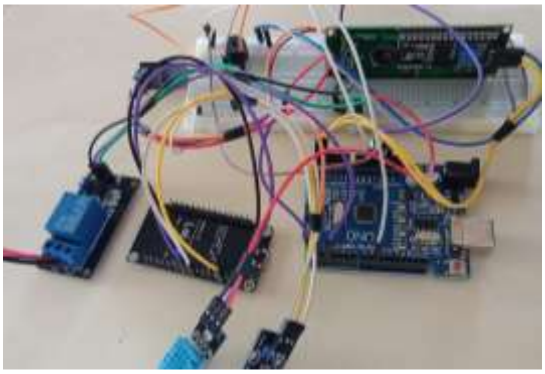

Figure 6: *Assembling of components*

Arduino IDE was used to code in the C++ programming language with an Arduino Uno on its board, to ensure proper communication between all components. In collaborating with the researchers' peers who are knowledgeable in the field of data analytics and electronics, the researchers were able to address issues that emerged during the programming process and make necessary adjustments to improve the overall functionality of the system. Various libraries were employed, such as LiquidCrystal, ALog, Adafruit Unified Sensor, DHT Sensor Library, DHT11, Firebase Arduino Client Library for ESP8266, ESP32, and RP2040 Pico, Firebase ESP32 Client, and Firebase ESP8266 Client. These libraries provided essential functions and tools that enhanced the capabilities of the system, allowing for efficient data collection, processing, and transmission. By utilizing these resources, the researchers were able to develop a robust and reliable system that met the project requirements and objectives.

Figure 7: *Coding each component in Arduino IDE*

Mobile applications have become integral tools for interfacing with various systems, enabling seamless user interaction and real-time monitoring. In response to the need for efficient monitoring of UV sterilization processes, the AUVISMA application was developed from the MIT App Inventor. This application allows users to monitor the operational status of the chamber, including humidity, temperature, and UV index. The system integrates several sensors to monitor the chamber's condition and is connected to the Arduino Uno microcontroller. A DHT11 Temperature and Humidity sensor measures both temperature and humidity, providing real-time data for environmental monitoring. A UV sensor tracks the intensity of ultraviolet light within the chamber and is used for assessing sterilization effectiveness. The ESP8266 WiFi module enables wireless communication, allowing the system to transmit sensor data to the mobile application. Each sensor is powered by Arduino and shares a common ground to ensure accurate data transmission. Blocks from MIT App Inventor were used to create the mobile application interface, allowing users to easily monitor and control the environmental conditions.

Figure 8: *Developing an app in MIT App Inventor*

The researchers integrated Firebase for real-time data and storage in connecting the app to the system. This communication between the mobile application and the system by storing and syncing sensor data, including temperature, humidity, and UV index. The Arduino, via the ESP8266 WiFi module sends data to MIT App Inventor Web, which is then accessed by the app to update the user. This ensures the app remains in contact with the system, regardless of the user's location. It also gives instant updates, enhancing the responsiveness of the monitoring process.

Phase 5: Functionality Testing

A series of tests were conducted to ensure everything was functioning properly. Researchers then prepared an outline of their suggested changes for further improvements in the system. When every part could function properly under extreme conditions, such as high temperatures and the wirings to avoid potential hazards. The results showed that the chamber could withstand rigorous testing, proving its durability and reliability in harsh environments. The researchers also identified areas where some adjustments could be made to improve the performance.

Phase 6: Pilot Testing

The testing was conducted in a classroom setting to observe the condition of the medical apparel under the UV light to see if every part of the chamber can distribute the UV light's intensity, ensuring that the apparel is completely sanitized. The researchers followed strict guidelines for the testing procedure to maintain consistency and accuracy in the results, including documenting the duration of exposure and distance from the UV light source. Additionally, the researchers also monitored the measurements on every side of the chamber, confirming if every part could be sanitized. While doing this test, a ruler was measured on the UV chamber to identify how many inches away from the light source the apparel was not effectively sanitized. Sensors were also tested in regards to the temperature, humidity, and UV index to ensure that the conditions were optimal for sanitization. The testing process was listed down in detail.

Figure 9: *Testing of the chamber*

IV. Results

Overview of Findings

The primary objective of this study was to evaluate the effectiveness of the AUVISMA system in sanitizing medical apparel using UV-C light. Measurements were taken under controlled laboratory conditions and compared to outdoor UV intensity levels. The results highlight the performance of the UV chamber, emphasizing the effects of reflective insulators and the exhaust fan on the overall sanitation process.

Data Presentation

Table 3: Test of humidity, temperature, and UV intensity inside AUVISMA

Humidity (%)	
Section of AUVISMA	Relative humidity
Above (48 in)	73.00% (10 seconds) 74.00% (30 seconds) 74.00% (1 minute)
Middle (24 in)	73.00% (10 seconds) 73.00% (30 seconds) 73.00% (1 minute)
Bottom (0 in)	73.00% (10 seconds) 73.00% (30 seconds) 72.00% (1 minute)
Temperature (°C)	
Section of AUVISMA	Temperature Level

Above (48in)	29.80 °C (10 seconds) 29.90 °C (30 seconds) 30.00 °C (1 minute)
Middle (24in)	29.80 °C (10 seconds) 29.80 °C (30 seconds) 29.70 °C (1 minute)
Bottom (0 in)	29.70 °C (10 seconds) 29.70 °C (30 seconds) 29.60 °C (1 minute)
UV Sensor Effectivity (Voltage)	
Section of AUVISMA	UV Sensor Voltage Output (V)
Top (48in)	0.03V (10 seconds) 0.03V (30 seconds) 0.03V (1 minute)
Middle (24in)	0.03V (10 seconds) 0.03V (30 seconds) 0.03V (1 minute)
Bottom (0 in)	0.03V (10 seconds) 0.03V (30 seconds) 0.03V (1 minute)

Key Results

The AUVISMA project revealed stable environmental conditions within the system. Humidity levels varied slightly, with the top section (48 inches) increasing from 73.00% to 74.00%, while the middle section remained constant at 73.00%, and the bottom section decreased from 73.00% to 72.00%. Temperature measurements indicated a small increase in the top section (29.80 °C to 30.00 °C) and slight decreases in the middle (29.80 °C to 29.70 °C) and bottom sections (29.70 °C to 29.60 °C). However, the UV intensity was consistently low at 0.03 V across all sections.

Data Analysis

The stable humidity and temperature levels suggest that the AUVISMA system effectively maintains controlled environmental conditions. However, the consistently low UV intensity raises concerns about its efficacy for disinfection purposes. This finding highlights the need for further calibration and optimization of the UV source to ensure adequate microbial inactivation within the system. Overall, while the environmental parameters are stable, the low UV output necessitates further investigation to assess its effectiveness in sanitizing materials.

V. Discussions

Interpretation of Results

The results from the AUVISMA project indicate generally stable environmental conditions, with consistent humidity and temperature levels across the system. Humidity readings were relatively stable, particularly in the middle section, where it remained constant at 73.00%. This effective regulation of moisture is essential for preventing mold growth and ensuring the integrity of the medical apparel being sanitized. The bottom section showed a slight decrease in humidity to 72.00%, but overall, the moisture levels remained conducive to a controlled environment.

Temperature measurements displayed a slight increase in the upper section, rising from 29.80 °C to 30.00 °C, while the middle section remained stable at 29.80 °C and the bottom section showed a small decrease to 29.60 °C. These temperature variations are acceptable and indicate that the system maintains a warm environment, which may be beneficial for certain disinfection processes. The generally warm conditions suggest that the AUVISMA system is functioning properly in maintaining an appropriate operational range.

The consistent voltage reading of 0.03 V across all sections confirms that the reflectors are effectively distributing UV light evenly throughout the chamber. While the readings may appear low, this does not indicate insufficient UV intensity, as we measured voltage rather than direct UV output. The uniform distribution suggests that the system is functioning as intended, ensuring even exposure for effective microbial inactivation.

In conclusion, while the AUVISMA system demonstrates effective environmental control with stable humidity and temperature levels, the consistently low UV intensity readings necessitate further investigation into the sensor's accuracy and the UV lamp's output. Ensuring adequate UV intensity, along with effective distribution from the reflectors, is critical for the system's efficacy in sanitizing medical apparel.

Limitations of the Study

The AUVISMA project faced several limitations that may impact the generalizability of its findings. Firstly, the study did not include extensive lab testing to quantify the effectiveness of the UV light in reducing microbial contamination. Instead, the focus was on evaluating the functionality of the sensors and HEPA filtration system. As a result, while the system is designed for efficiency, its actual performance in real-world settings remains to be validated. Secondly, the system is tailored specifically for medical uniforms, which may limit its applicability to other fabrics or materials. Additionally, external environmental factors, such as varying humidity and temperature levels, were monitored but not controlled, potentially influencing the overall sanitization process. Lastly, the project's affordability constraints restricted the incorporation of advanced features that could enhance the system's capabilities.

Implications for Practice

The AUVISMA system presents several practical implications for healthcare settings. By automating the sanitization of medical apparel within a controlled chamber, it can enhance infection control measures, contributing to safer hospital environments. The use of UV light, combined with HEPA filtration, effectively reduces airborne contaminants within the chamber, helping to minimize the risk of spreading pathogens. Healthcare facilities can benefit from the system's user-friendly app interface, allowing for real-time monitoring and control of the sanitization process. Furthermore, the cost-effective design makes AUVISMA accessible for smaller healthcare providers, promoting widespread adoption of effective sanitation practices. Ultimately, implementing AUVISMA could lead to improved patient safety and reduced healthcare-associated infections.

V. Recommendations

To enhance the effectiveness and applicability of the AUVISMA system, several recommendations are proposed. First, it is crucial to conduct comprehensive testing of the system in various real-world healthcare settings to assess its effectiveness in reducing microbial contamination. This could involve quantitative studies measuring the reduction of specific pathogens and evaluating performance over extended periods. Additionally, investigating the system's effectiveness on a broader range of fabrics and materials will determine its versatility beyond medical uniforms, potentially expanding its application to other types of protective clothing used in healthcare. Enhancing the system with advanced features such as automatic fabric recognition, multi-cycle programming, and improved environmental monitoring capabilities could further increase its usability and efficiency. Furthermore, developing comprehensive training programs and operational guidelines for healthcare staff will maximize the system’s effectiveness and ensure safe usage. Long-term monitoring of the AUVISMA unit's performance, particularly the effectiveness of the HEPA filtration system in maintaining air quality within the chamber, is also recommended. Conducting a cost-benefit analysis will provide insights into the economic impact of adopting the AUVISMA system in various healthcare facilities, emphasizing its potential to reduce healthcare-associated infections and improve patient outcomes. Finally, collaboration with healthcare institutions to gather feedback and insights from end-users will facilitate continuous improvement and adaptation of the AUVISMA system to meet the needs of diverse healthcare environments.

VI. Conclusion

In conclusion, the risk of pathogen transmission in hospitals is significant, particularly through contact with contaminated surfaces and medical apparel worn by healthcare workers. These pathogens can spread through the air, posing a heightened threat to patients, staff, and visitors, especially those with weakened immune systems. Implementing stringent infection control measures is essential to mitigate this risk. The effectiveness of UV-C light at 254 nm and HEPA filters in sanitizing medical apparel has been well-documented, proving crucial in reducing airborne and surface-borne pathogens.

AUVISMA, with its automated UV irradiation system for sanitizing medical apparel, represents an innovative approach to enhance infection control measures. By utilizing UV-C light and incorporating HEPA filtration in its design, AUVISMA can significantly diminish the presence of harmful pathogens on medical uniforms, thereby protecting both patients and healthcare workers. Furthermore, AUVISMA complements existing protocols by offering a reliable and efficient means of ensuring that medical apparel is thoroughly sanitized between uses.

In addition to employing advanced technologies like AUVISMA, hospitals must also adhere to strict protocols for cleaning and disinfecting high-touch surfaces. This comprehensive strategy not only helps reduce the risk of infections but also contributes to improved patient outcomes and overall safety within healthcare facilities. By integrating such technologies and practices, hospitals can create a safer environment that minimizes the spread of infectious diseases, ultimately enhancing the quality of care provided to patients.

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Appendices

Material Procurement Checklist:

Place	**Software Components**	**Price (PHP)**	**Date**
Create Labz Store	Arduino Uno	459	Sat ,24, August 2024
	LCD 12C Blue	215	
	RobotDyn UV Sensor	265	
	Full-size breadboard	75	
	ESP866 Wifi Module	105	
	Passive Buzzer	30	
	Dupont Jumper Wires (Male to Female)	12	
	Dupont Jumper Wires (Male to Male)	12	
	Dupont Jumper Wires (Female to Female)	12	
UNITOP	9V Battery	30	Sun,6,Oct 2024
Create Labz Store	Node MCU CH349 G Driver	195	Wed,9,Oct 2024
	9V battery Holder with PC Jack	50	

Place	**Hardware Components**	**Price (PHP)**	**Date**
Shopee	HEPA Filter	198	Sun, 25, Aug 2024
Davao Everflex Electrical & Glassware	Germicidal Lamp GL UVC 10W T8	250	Tue ,3 ,Sep 2024
	3-10 W Electronic Ballast 220 V Universal Ballast	195	
Jim Qi Xiang Ventures,Inc.	220 V Blower	125	

MR.DIY	Metallic Spray Paint	360	Fri, 6, Sep 2024
Cromlech Hardware Trading	10 mm Plywood	620	
ASA Marketing Co. Incorporated Bajada Branch	Ordinary Nails	28	
	5mm Insulation foam	120	
Donation	Door handle	49	
Davao Everflex Electrical & Glassware	AOT11OFLighting Fixtures Open Type	75	
	GE Ballast 10 W	195	
	Starter 4-40W Only	10	
	Push to Door Open Lock	Donated	Sat, 28, Sep 2024
	Metal Door Frame	Donated	
	4 Gang Uni Outlet	85	
	Light Switch	Donated	

Total cost of software components: PHP 1,545.00	**Total cost of hardware components: PHP 2, 315.00**	**Total cost:** **PHP 3,860.00**