AUDI: AN AUTOMATED FOG DISINFECTING MACHINE

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***Abstract*— The Covid-19 pandemic has brought major inconvenience to the education system due to the unprecedented shift in the method of instruction. Limited physical classes to reduce close contact, strong adherence to the Covid-19 protocols, and developing ways to reinforce the educational missions of institutions must be administered to ensure a virus-free environment. Inclined to these constraints, an automated fog disinfecting machine was created. Its goal is to automatically disinfect the space by considering its occupancy variable. The effectiveness was assessed through the Petri-disk diffusion method. The results showed an overwhelming decrease in microbial growth after it undergoes the disinfection process. Many factors have contributed to achieving such results, some of which are the composition of the disinfectant liquid, the mobility of fog, and the machine's performance which added a reinforced cleaning method. The data gathered from the different tests conducted proved that the Automated Fog Disinfecting Machine is a wise choice to further reinforce the physical learning environment of academic institutions and other institutions during this time of the pandemic.**

Keywords*— *automation, disinfecting machine, liquid disinfectant, covid-19 pandemic

I. INTRODUCTION

The COVID-19 Pandemic has brought an alarming global situation which has made countries implement a widespread disruption in academic institutions [3]. Many governments have ordered institutions to cease face-to-face instruction for most of their students, requiring them to switch, almost overnight, to online teaching and virtual education [4]. Fortunately, schools across those countries that managed to flatten out the curve of infections have already reopened physical classrooms [5]. To ensure the safety of students as well as teachers and school staff in a staged fashion, face-to-face interactions must be carefully planned [3] as the viral DNA particles can land on other people, clothing, and surfaces around them, some of the smaller particles can even remain in the air. This can be achieved by maintaining a clean environment using frequent disinfecting of surfaces and shared objects [7]. Thus, frequent disinfection or frequent application of alcohol-based disinfectants shall be mandatory in all workplaces and all work areas, and frequently handled objects such as doorknobs and handles, shall be cleaned and disinfected regularly [8].

Similar products such as Dyson's air purifier, Hydrogen Peroxide-Based Fumigation, and Multi-Vector UV treatment machines do not carry out disinfection, but rather these machines use a filtration system with the utilization of carbon filters to conceal pollutants and odor [10]. In addition, these systems are constrained by the operator's responsibility for the agent's proper selection, composition, application, and contact time [18].

These electronic cleaning machines are often suboptimal compared with automated disinfection. This is often due in part to a variety of personnel issues such as exposure and technical incapability that many institutions encounter and given the efficacy of automated disinfecting machines being limited only to its variable performance and antimicrobial activity of some disinfectants against associated viruses [11]. With this, all institutions will derive benefit from the mechanisms that they have put in place to continue and reinforce their educational and training missions in a time of crisis [10].

With this, the researchers take into consideration the means of creating a room disinfection mechanism embedded with a sensor for a full-automation system. The machine will be operated through the microcontroller Arduino and implemented using the C language for a conventional and simpler programmable unit. The disinfection machine will convert the liquid disinfectant into a fog as it was found to be effective and much more efficient in reducing the number of detectable airborne and surface viruses [12]. The effectiveness of the proposed project will then be assessed by comparing the microbial and viral properties that are present in the room before and after the machine has been placed using the Petri-disk diffusion. This machine aims to create a reinforced learning environment among students in this time of the pandemic.

II. Related Works

Recent studies aim to develop disinfectant machines to reduce contact with surfaces during the disinfection process. The development of the Hydrogen Peroxide-Based Fumigation sterilization cabinet is primarily to disinfect protective equipment. Four PPRPHs were hung in the fumigation chamber to test the effectiveness of disinfection [13].

A parallel procedure using a focused Multi-Vector UV treatment machine consistently achieved comprehensive and significant decreases in microbial contamination levels on all physically clean clinical care apparatus [14]. Experiments have shown that UV-C has terrific efficacy in removing high bacterial inoculation. This device's sanitizing approach is effective against a diverse spectrum of germs and has numerous advantages over chemical-based sanitizing procedures [15].

Dyson’s air quality backpack is a portable air-sensing device that collects air pollution data on the move. With onboard sensors, a battery pack, and GPS, it offers insight into personal exposure to air pollution and how to avoid it. One sensor in the backpack measures temperature and humidity. The other two detect pollutants including NO2, VOCs, PM2.5, and PM10. Unique algorithms process the data, which is combined with information gathered from the onboard GPS to create reports on air quality [16].

The Last Sprayer Fogger is a hand-held machine that has wide applied fields and can be used for sanitation and epidemic prevention in hospitals, restaurants, hotels, and other public places. It also can be used in the henhouse, sheepfold, cowshed, hog pen, and so on; it is an ideal electric sprayer with reliable performance and convenient use [16].

Disinfectant fogger machines such as the marketed products of Dyson are effective and safe when used in combination with high disinfectant solutions. Disinfectant foggers don't only conceal pollutants; they also remove them at the molecular level. Most significantly, they are safe and ecologically friendly equipment that, when correctly used, can eliminate 99 percent of viruses, bacteria, fungi, mold, and mildew at the source. These machines are suitable for use in a variety of settings, including kitchens, bathrooms, and other high-touch areas [17].

Disinfection treatment by Thermal Fogging Machines has been considered for a long time as a very efficient method for hygiene maintenance. Liquid disinfectant that turns into fog was found to be effective and much more efficient in reducing the number of detectable airborne and surface viruses [12]. This method also guarantees good results in many domains such as agriculture, the food industry, and pest control. Thermal fogging has been used for the disinfection of greenhouses, shelters, or grain silos, particularly against dust mites, aphids, or other caterpillars since the 1980s. This method was also developed against bacteria and fungi, leading to new homologations for these uses [18].

III. Methods

A. Project Design and Specification

The system has a Passive Infrared (PIR) sensor to detect whether the room is occupied or not as shown in Fig. 1. The received signals from the sensor are sent to the Arduino microcontroller which will then be interpreted. Afterward, the Arduino commands the motor to pump the liquid disinfectant from the repository to the heating block to undergo the Atomization process and will be released as a fog through a nozzle.

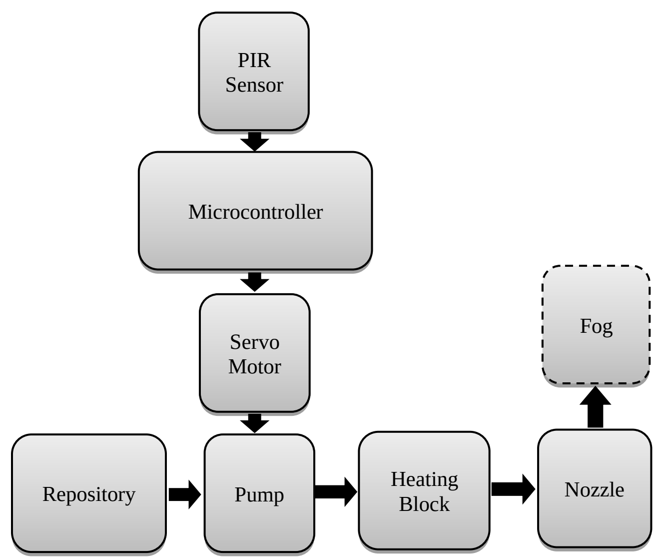

Fig. 1. Block Diagram of the System.

The flowchart of the system is shown in Fig. 2. The PIR sensor should be able to detect the presence or absence of room occupants. If the room is still occupied, the machine is on standby mode indicating a red light. Once the room is already vacant, there will be a 30-second delay before the machine starts to release disinfecting fog. The blue light will indicate that the disinfection process is ongoing. The 30-second delay is to make sure that the room is empty. The composition of the disinfectant liquid is made out of 80 % ethanol, 1.45 % glycerol, and 0.125 % hydrogen peroxide or 75 % isopropyl alcohol, 1.45 % glycerol, and 0.125 % hydrogen peroxide as per the guidelines imposed by the World Health Organization against Covid-19 virus.

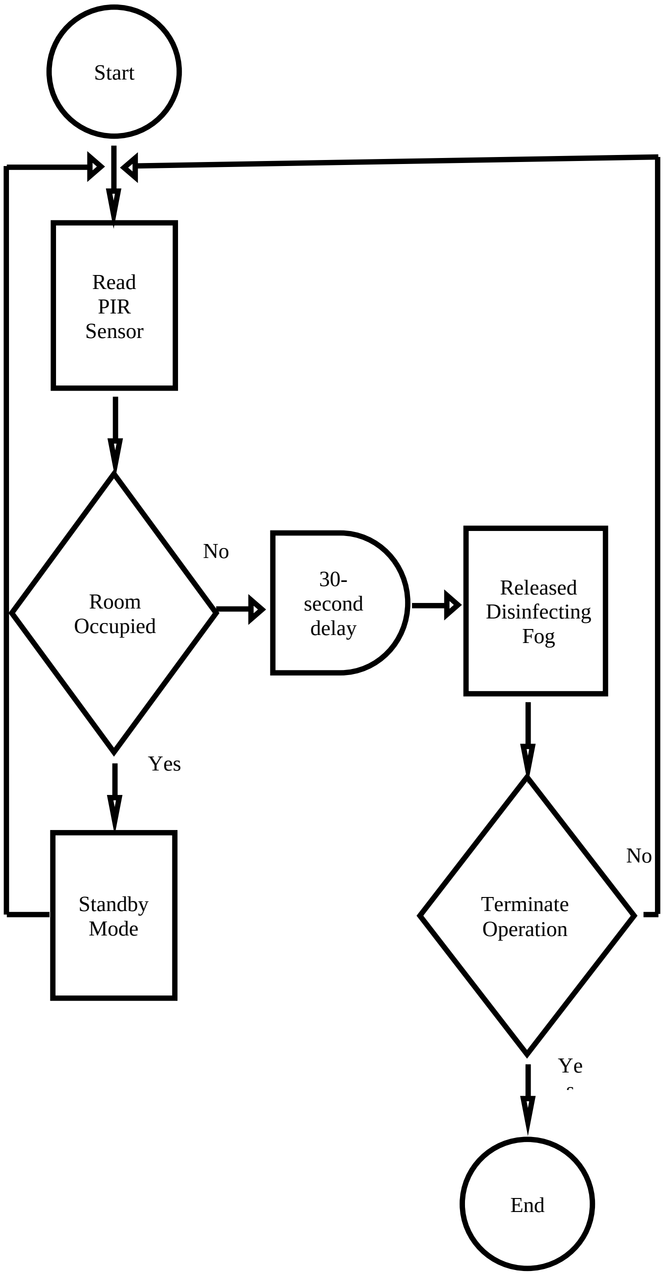

Fig. 2. Flowchart of the System.

B. *Testing and Evaluation*

Sample collection was performed before and after the machine was placed in the room. Its effectiveness was determined by using the disk-diffusion method. The surface objects within the room were swabbed and isolated using a petri dish filled with agar to accumulate the growth of such microorganisms. The samples were incubated to control the temperature and moisture for about 4-6 days to achieve visible results.

To discuss the sensor's occupancy performance with clarity, concepts that delineate basic sensor capabilities need to be defined. PIR sensors use infrared to detect motion, thereby using motion as a proxy for occupancy. These sensors do not explicitly detect or measure their intended parameter but, rather, detect or measure something related to it. Inclined to this, the sensor's efficiency in detecting humans can be made uncertain despite the different simulation models and Ad Hoc test methods done at the manufacturer's end [19].

Given these limitations, the integrated PIR sensors on our system are tested out from varying distances which is equivalent to that of the dimensions of a regular classroom using the test effectiveness formula for motion sensors carried under the Overall Equipment Effectivity Benchmark (OEEB). The formula and its parameters are indicated below.

$$Effectiveness = \frac{Detected}{Detected + Undetected} \times 100 \qquad (1)$$

Whereas, any percentage that yields 85% and above is considered to be world-class machines and set for long-term goals; 60% is fairly typical, and 40% is either coming on track or not working effectively.

IV. Results and Discussion

Fig. 3. The AUDI System.

The output project was made out of a galvanized iron sheet coated in ultra-thin fluid film compound paint for its anticorrosion purposes. The sensors were placed at the top of the machine to maximize its efficiency in detecting motion regardless of its position within the room. It has a vent that is directly panned over to the nozzle to ensure that the fog will not enter the system. The electrical elements and the different components such as the pump, heating block, and repository are placed inside the machine.

TABLE I. MACHINE'S OCCUPANCY PERFORMANCE

Distance	Sensor's Response
1 meter, 10º	Detected
1 meter, 50º	Detected
1 meter, 90º	Detected
1 meter, 130º	Detected
1 meter, 170º	Detected
3 meters, 10º	Detected
3 meters, 50º	Detected
3 meters, 90º	Detected
3 meters, 130º	Detected
3 meters 170º	Detected
5 meters, 10º	Detected
5 meters, 50º	Not Detected
5 meters, 90º	Detected
5 meters, 130º	Not Detected
5 meters, 170º	Detected

The reaction of the machine based on the varying distances of occupancy performed during the testing having the light indicators as a basis is shown in Table I. The data revealed that at five meters with an angle of 50º and 130º, the sensors did not detect any motion. This perhaps is due to the inability of sensors to capture the performance impacts of space characterization and obstructions or the potential of the machine for inconsistent performance characterization that results from test-method performance, especially since the room doors at located at these locations.

The total effectiveness of the machine in detecting occupancy is 86.66%. Hence, it can be interpreted that the equipment's overall performance is effective and is set for long-term objectives as it passed the OEE's Benchmarks for machines.

TABLE II. FOG RELEASED AND ROOM AREA COMPARISON

Room Number	Room area (cu. ft)	Fog released (cu. ft)
Room 1	3708.041	8237.25
Room 2	5191.258	8237.25
Room 3	6921.678	8237.25

The system was placed into three different rooms with varying dimensions to test if the programmed time of fog emission corresponds to the area's volume explicitly. The data gathered shown in Table II present that at 40 seconds of disinfecting, the room is slightly filled with a greater volume of released fog relative to the room's area. This result somehow conforms to the idea of fog being mobile and dispersing more rapidly in an unenclosed unit thus, it is just necessary to carry out over-fogging to ensure deeper penetration of surfaces and proper disinfection [20].

TABLE III. PETRI-DISK DIFFUSION METHOD RESULTS

Environment Type	Bacterial Growth
Disturbed Phase	
Traditional Method	
AUDI	

A greater number of colonies were formed in the disturbed phase as shown in Table III. This proves the idea of the Department of Health that there should be frequent disinfection of surfaces and shared objects to combat COVID-19 as the virus and other microbial organisms will continue to thrive in a fed environment. On the other hand, the traditional method undermines the idea that cleaning alone is not as effective compared with other reinforced methods. An overwhelming decrease in microbial growth after it undergoes the disinfection process using AUDI. Many factors have contributed to achieving such results, some of which are the composition of the disinfectant liquid, the mobility of fog, and the machine that added a reinforced cleaning method.

V. CONCLUSION

The data gathered from the different tests conducted proved that the Automated Fog Disinfecting Machine is a wise choice to further reinforce the physical learning environment of academic institutions and other institutions during this time of the pandemic. Aside from its effective disinfecting process, less human intervention is also needed as the system was designed to be fully autonomous which is beneficial to institutions with higher populations but having less administrative supervision such as schools.

The researchers suggest further study of the disinfecting capabilities of the system by changing prevailing factors such as the disinfectant liquid composition, fog's volume by controlling the speed and time, and the applicability to disinfect larger spaces.

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