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2019 Novel Coronavirus Disease (Covid-19): Toward a Novel Design for Disinfection Robot to Combat Coronavirus (Covid-19) Using IoT Based Technology

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***Abstract* - Coronavirus Disease 19 or well known as Covid-19 is infectious disease that attack human respirator system. This virus is contagious due to its fast transmission from small droplets that come to people that sneezing, coughing, or even talking. This virus can stay in air for long time and it also can survive on the inanimate surface things. During this time, some places like hospital, mall, and station are places where crowds gathered. People in those places have possibility to spread the virus not only through close contact but also due to touching the infected surfaces. That is why device that able to clean the infected surfaces needed. The Internet of Things based robots may give big impact in combating the coronavirus that stay on inanimate surfaces. The proposed system is the robot that able to disinfect the surfaces of things using UV-C lights. The implementation of UV disinfectant robot will indeed help health authorities in reducing the transmission.**

***Keywords:* Covid-19, Coronavirus, UV Light, UV, Ultra Violet, Robot, IoT**

I. INTRODUCTION

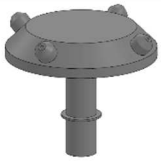
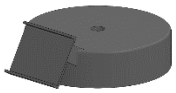
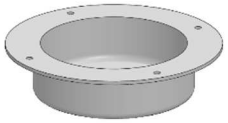
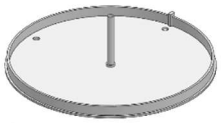
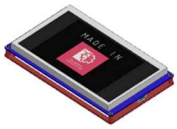
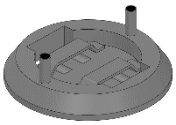
A persistent infection by an unknown severe respiratory was announced in Wuhan City, Hubei Province, China, on December 2019, discovered at the Hunan South China Seafood Market [1]. The World Health Organization (WHO) reported on January 2020 that the outbreak of such epidemic outbreak was a unique coronavirus found in 2019 (2019-nCoV) or SARS-CoV-2 and called the virus by COVID-19 [2]. Anyhow, the answer for a question of SARS-CoV-2 origin still to be determined [3]. The COVID-19 transmitted quickly to other nations involving Taiwan ,South Korea, Thailand, Japan, Singapore, Italy, Spain, Iran, UK, USA and was categorized as pandemic by the WHO on 12th March 2020 [4-6]. Coronavirus is known to survive on the surface of inanimate surface and even can survive on air (aerosol) within 3 hours and the endurance of the virus can vary according to the surface material and environmental conditions such as temperature [7]. The study [8] revealed that it was detected on copper even after 4 hours, on cardboard remain even after 24 hours, and on steel and plastic up to 72 hours. Preventing it can be done by avoiding touch with the surface that might contain virus or disinfect the surface to get rid the virus. Besides, the disinfectant

process can be done using ultraviolet (UV) [7]. Ultraviolet germicidal irradiation (UVGI) was utilized for long time ago facilities and laboratories of health care. UVGI is well known device that effectively control the course of airborne infection particles [8]. UVGI can purify the air by destroying the infectious factors within air by exposure to radiation of ultraviolet (UV) that break the nucleic acid element of viruses or bacteria to avoid reproduction [9]. The help of the UV disinfectant will indeed help health authorities in reducing the transmission in health care places like hospitals as a crucial place where patients gathered [10]. Numerous methods of infection transmission and investigations [11-14] have revealed that the main cause of contact surface is come from direct tough of door handles or cabinets, remote control, call button for assist, etc [15-18]. Internet of Things especially in health care and medical fields have been perceived by many people due to its help in monitoring, controlling, and preventing of pandemic [19-20]. The Internet of Things based robots may give big impact in combating the coronavirus. The implementation of UV disinfectant can be done using UV disinfectant robot. So using such UV Disinfectant robot would reduce the risk of hospital infections and can be attempted.

II. METHODOLOGY

The disinfection robot is a combination of both Ultrasonic Fog and UVC disinfection robot that is capable of sterilize the business venue autonomously with industry-leading new composite positioning and navigation technology. The disinfection robot can Sterilize the premise with ultrasonic fog during working hours and disinfect with UVC light at night can be done. It's specially designed and built for big spaces such as hospital, shopping mall, sport stadium, conventional hall etc. This robot comes with an elevator control system that enables navigation of robot to any floor autonomously. When the battery level is low, the robot automatically goes back to its home station for charging. The proposed system consist of some parts as can be seen in Table 1. Each type of microorganism requires a different dosage of UV light to inactivate its' functionality. For the Covid-19 situation, the inactivation of such virus using UV light is considered here. In most studies and published works, it has been mentioned the required UV light for the sterilization process in terms of "Joule per square meter" or "Joule per square centimeter"[21]. But when considering the parameters and specifications of the UV light, the manufacturers have given the UV light intensity in terms of "Microwatt (uW) per square centimeter" at a distance of 1 meter. The unit "Watt (W)" represents the energy emits within a period of one second. Microwatt per square centimeter stands for the energy passed through an area of one square centimeter within one second.

TABLE 1. UV DISINFECTANT ROBOT PARTS

Part	Name
	Nozzle
	Top Cover
	Liquid Storage
	Liquid Storage Cover
	Tablet
	Robot Body
	UV Light
	Lower Cover

$$Dose(J) = Intensity(W) \times Time(s) \quad (1)$$

$$Intensity\ at\ distance\ r \propto \frac{1}{r^2} \quad (2)$$

Equation **1** shows the relation between the dosage and the intensity. It can be concluded that different dosages may be achieved by varying the exposure

time to the same UV light source. The relation between the UV intensity and the distance is shown by Equation **2.** According to this equation, the UV intensity is inversely proportional to the square distance from the light source. The robot is moved by two wheels powered by a DC geared motors (A differential drive robot). There are two caster wheels at the front and back to maintain the balance. The electronic control system and the battery with a 12V 35Ah Lead Acid battery, are placed inside the ground vehicle. Arduino Mega is powered with the main battery through a voltage regulator module to reduce the voltage from 12V to 5V. A four-channel RC radio receiver with PWM outputs are connected to the Mega board. Motors are driven through a dual-channel H bridge motor driver which is connected to the Arduino board. An inverter is connected between the UV lights and the battery and controlled using a relay switch connected to the Arduino board. The used Fluorescent UV bulbs requires a separate electronic ballast unit to power up the bulb. The light tower contains 6 UV bulbs that are placed around an aluminum cylinder which is made of an aluminum sheet by rolling. This aluminum cylinder acts as a reflector for UV rays. The remote controller of the robot is using the tablet. The screen shows the camera feedback received from the robot while the joystick is used to move the robot. UV lights can be turned on and off using the UV switch. The arming switch acts as a safety switch and it cuts down all the functionalities upon turning on. Six UV bulbs are selected with the following specifications.

- Power - 55w
- Wavelength - 254nm
- length - 890mm
- tube diameter - 15mm
- type - single end 4 pin

These are not strict specifications except the wavelength. The electronic ballast unit is connected to the 4 pins of the UV bulb. UV bulbs will light up once the power is supplied to the electronic ballast. The wires of the two motors are connected to the output pins of the motor driver. This procedure can be easily found on the internet, therefore it is not intended to describe the whole procedure. Channel 1 - channel 4 PWM signal pins of the RC receiver are connected to the Arduino board from pin 18 - 21. Each channel is configured in the following way in the code. It can be changed as desired. The pins of the motor driver are connected to Arduino pin 3 - 11.

To convert the 12v to AC 230V to power up the UV lights, an inverter circuit is used here. A commercially available inverter unit with an inbuilt charger is used. This helps to avoid the complexity of the electronic system by allowing the charging of lead-acid battery using the existing power points. A modified sine wave inverter which has an efficiency of 70% is implemented. To power up all electronic ballast with the 70% efficiency, the required wattage of the inverter must be 470W.

Battery terminals are connected to the 12V input and electronic ballasts are connected to the AC output ports. There are 3 wires available in the switch which are: common wire, ground wire, and the power on wire. These 3 wires are connected to the relay switch in the following manner to control the UV lights from the Arduino board.

- Common wire -> Common
- Ground wire -> NC
- Power on wire -> NO

The middle part of the tower contains an Aluminum sheet. A sheet is rolled to make a cylinder with a diameter of 15cm. Two circle-shaped cladding boards with a diameter of 30cm are placed on the top and bottom of the cylinder. They are used as UV lamp holder. Both cladding boards are drilled 19mm holes to fit the UV light. Electronic ballasts are fixed inside the Aluminum cylinder using double side sticking tapes. Following are the components required for the Ground Control Station (GCS).

- 2.4GHZ 4Ch RC Transmitter
- FPV Screen
- 2 X Toggle switches
- 1 X Power switch
- 18650 Battery Cells
- 3 Cell Batter Management System Module for 18650
- 12V, 5A Switch Mode Power Supply

Rc transmitter contains 2 joysticks and several switches. Here, the interest is only using one joystick, the circuit and LED indicator. if the transmitter is enclosure, the sensing of the joysticks by the circuit can be observed. Each joystick contains two potentiometers which are connected to the circuit board. Based on the position of the joystick, the potentiometer changes it's resistance so that the circuit can read the position of the joystick.

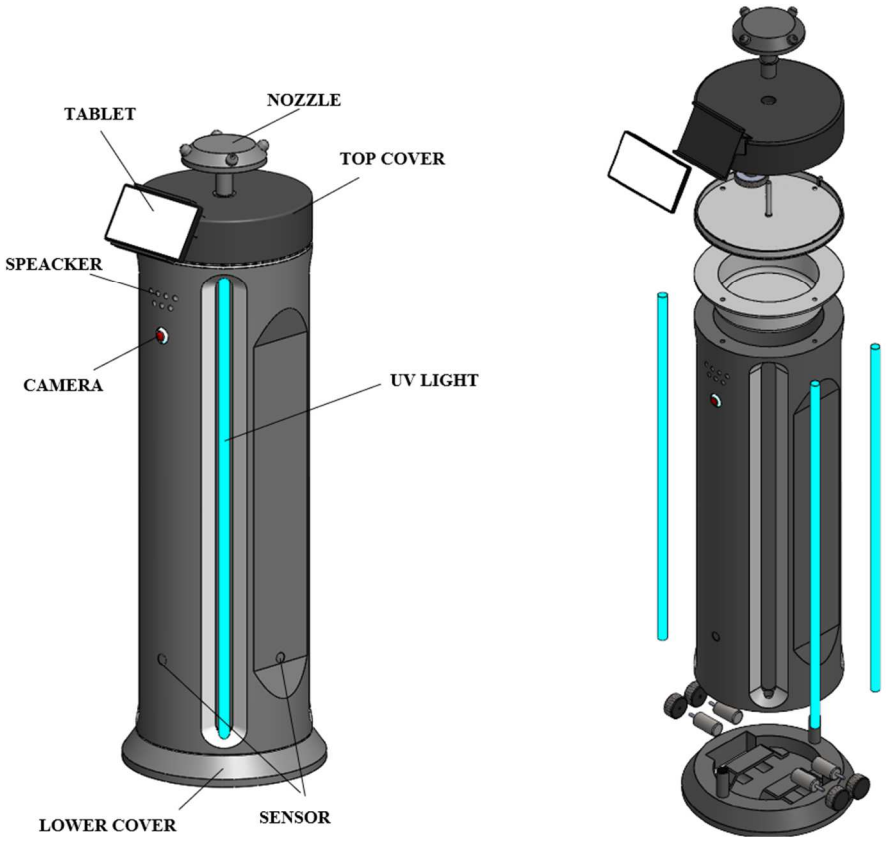


Figure 1. UV Disinfectant Robot Design

III. RESULT AND DISCUSSION

UVGI is a disinfection technique that utilizes ultraviolet light with short wavelength (UV-C) to kill or inactivate pathogens and microorganisms [7]. Basically, UVGI refers to the utilizing of UV light with adequate short wavelengths to sterilize surfaces, water, and air [8]. UVGI can purify the air by destroying the infectious factors within air by exposure to radiation of ultraviolet (UV) that break the nucleic acid element of viruses or bacteria to avoid reproduction [7]. For the sake of research security by dealing with the virus, UV can also put virus into the inactivate state. The virus state can be changed to inactive condition by treatments with 254 nm Ultraviolet light, heat treatment of 65 ◦C or greater, alkaline or acidic conditions (pH > 12, pH < 3), glutaraldehyde and formalin [22]. The derived viral stocks from inactivated cell-culture can be valuable for the production of antibodies and the investigation of their immunogenicity and safety. In other hand, many studies propose on what biocidal agent to disinfect the coronavirus. The recent study research on the efficiency of the biocidal agent like alcohols, hydrogen peroxide ,benzalkonium chloride or sodium hypochlorite to treat the coronavirus [22]. It shows that surface cleansing with sodium hypochlorite of 0.1% or ethanol of 62-71% fundamentally lessens coronavirus on surfaces within exposure time of one minute. It effectively disinfects the coronavirus (SARS-CoV-1) before and estimate a comparable impact versus the 2019-nCoV which the relate study found that the endurance of 2019-nCoV is like to SARS-CoV-1. Another study found that concentrations of ethanol in the range of 62% and 71% diminished coronavirus infectivity within one minute as exposure time by 3.0–4.0 log. 0.1-0.5% of sodium hypochlorite and 2% glutardialdehyde were additionally very successful with > 3.0 log decrease in viral titre. Interestingly, it was found also that utilizing 0.04% benzalkonium chloride, 0.55% ortho-phtalaldehyde, and 0.06% sodium hypochlorite less efficient [23]. The utilization of biocidal suspension tests with Ethanol (78-95%), the mix of 45% 2-propanol with 30% 1-propanol, 2-propanol (70-100%), formaldehyde (0.7-1%), glutardialdehyde (0.5-2.5%), and povidone iodine (0.23-7.5%) promptly inactivated coronavirus infectivity by roughly 4 log or more. It was required 0.21% of Sodium hypochlorite to be effective. The effectiveness of Hydrogen peroxide was at 0.5% concentration and one minute of incubation period.

The achieved result with benzalkonium chloride at sensible contact periods were clashing. It was revealed that 0.2% concentration for 10 minutes had no efficacy versus coronavirus while 0.05% was very efficient [23]. In contrast, 0.02% chlorhexidine digluconate was fundamentally inadequate [24-27]. The proposed system of UV disinfectant robot can be controlled by tablet to instruct it what it should do and it will follow the command like self-controlled robot. There are 3 disinfection mode that this robot could offer that are:

Ultraviolet (UVC) mode

It is well known that UV-C radiation is a great disinfector of water, air, as well as surfaces where it can assist mitigating the threat of involvement an infection and it was utilized widely many years. All the tested bacteria and viruses right now revealed good response to disinfection by UV-C [22].

Ultrasonic Dry Fog mode

The ultrasonic fog system is compatible with most disinfectant agent in the market. By using a suitable agent, disinfection can be carry out anytime. A capacity of 15-liter large tank enable disinfection continuous for 8 hours. Built in low level disinfectant alarm and dry burning prevention sensors making the robot working safely and smoothly.

Deep disinfection mode

Combination of both Ultraviolet and Ultrasonic Dry Fog enable detail disinfection on vertical and horizontal surfaces as well as airborne gems.

From all the process developing all the features and design of the machine, it can easily say that there was a successful design maybe it's not perfect but this machine can actually be built in real life. With the respect to the objective a good conceptual machine was produced. There are still many things or features could potentially be improved for the overall design. However, it's already good enough to satisfy having a design of a disinfection robot even though there still a lot of things that can be done better. Figure 1 shows the UV Disinfectant Robot Design.

IV. CONCLUSION

The proposed design is Ultraviolet-C-based disinfection robot. The UVC radiation has higher energy compared to other UV rays. Due to this fact, this ray is more reactive with ozone in the atmosphere and does not getting down the ground that make it not a risky issue for skin cancer. However, the UVC rays can be produced from other sources like man-made one such as mercury lamps, arc welding torches, and UV-based sanitizing bulbs utilized to remove bacteria and other germs that may exist in food, air, water, or surfaces. The mobile UV-C-based system was utilized since last years for disinfecting and cleaning hospitals. The radiations of UV-C make inactivation for microorganisms resulting damage for the DNA by generating cyclobutane pyrimidine dimers (CPDs) that change its structure, and thus involving with replication of DNA. The carrying out such robot can minimize the infectious with virus that may still exist on the inanimate surface for some period.

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