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UV - C DISINFECTION ROBOTIC SYSTEM

Abstract

This chapter describes how the UV-C disinfection robotic system was created to fight COVID-19. In order to stop diseases from spreading in hospitals, environmental surface cleaning is a vital technique. However, microorganisms from contaminated surfaces could still survive manual washing and disinfection. Robotic autonomous disinfection systems, or UV-C irradiation, are being promoted more and more as a supplement to conventional decontamination techniques that also save time and effort. Although UV-C-based disinfection as a general concept has been shown, little is known about how UV-C disinfection supplied by robots actually works. We looked at the usability and efficacy of a UV-C disinfection robot as an addition to regular environmental cleaning and disinfection in order to examine its effects in a clinical context.

Keywords: UV –C disinfection systems; Robotic system; UV lamps/LEDs; No - touch disinfection technology; COVID – 19

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I. INTRODUCTION

Ultraviolet radiation (UV – C) acts as a disinfectant for air, water and non porous surfaces. Low pressure mercury lamps, excimer lamps or far UV – C lamps, pulse xenon lamps, and LEDs emit the highest energy component of the electromagnetic spectrum with the smallest wavelength range of 100 - 280 nm. UV – C radiation, commonly known as "Germicidal Lamps," can inactivate a virus by direct contact and disrupts the molecular structure of microorganisms' genetic material (DNA or RNA) by photo – dimerization, eliminating their capacity to multiply and infect. As a result, UV – C radiation has been successfully utilized to prevent the spread of virus and bacteria for decades. These radiations, on the other hand, are (extremely) detrimental to human health and skin. The disease caused by the novel corona virus SARS –CoV – 2 necessitates the development of a no-touch disinfection technique based on UV – C radiation that can destroy the corona virus and its replicates while posing no risk to human health. This chapter demonstrates the development of a revolutionary UV-C disinfection robotic system that is entirely automated and mobile, allowing the coronavirus and its duplicates to be deactivated without the need for human intervention. Traditionally, chemical agents were used to disinfect different objects, but the proposed disinfection robotic system delivers chemical-free treatment at a reasonable cost with an adequate amount of UV-C radiation. It will be remotely programmed to successfully destroy coronaviruses or other microorganisms in a certain amount of time. The device has a strong security feature thanks to its internet of things (IoT) platform, artificial intelligence, and integrated cameras and sensors. When a human enters the room, the mobile disinfection robot instantly turn off to safeguard them from hazardous UV – C radiation.The effectiveness of the device is affected by environmental parameters such as temperature and humidity, as well as pH, organic load, surface shape, hardness, and chemical compounds. The presented device is effective in disinfecting the surfaces of various things within a room of a research centre, a school, an office, a hospital, and a variety of other locations.

II. UV-C DISINFECTION INSTRUMENT DEVELOPMENT

It comprises of a UV-C tower installed to a robotic system or ground vehicle that can be controlled remotely. The UV – C tower have eight 30 Watt UV – C lamps/LEDs arranged around an aluminum cylinder constructed of aluminum sheet to reflect UV rays. It is housed in an aluminum cylinder and have its own electronic ballast unit to power the UV lamp/LEDs. The top of the tower is equipped with an FPV camera and transmitter that broadcast the video feed to a PC on a web app or it can be also accessed directly with a mobile application. In 5 minutes, the designed UV – C tower disinfect surfaces kept within 1 m of the tower. In 45 minutes, it sterilizes a floor area of around 10 m^2.

1. The UV- C disinfectant that has been designed as both the robotic and without robotic system is a valuable asset in the battle against a worldwide pandemic brought on by the spread of new corona viruses.

2. **General considerations:** (During the development of the UV – C disinfectant instrument) the general risk factors are reduced by adhering to important safety standards, which include: (1) Ozone production due to prolonged UV exposure in confined spaces. As a result, after sterilization with UV lamps, ventilation for around 20 minutes is necessary. (2) The reflection mechanism can reduce the ineffectiveness of UV radiation

in shady places. (3) UV light's effectiveness on medical equipment and pharmaceutical is recommended to be examined for usage in hospitals and medical institutions. Adjusting the amount and duration of UV radiation landing on them helps to alleviate the problem. (4) UV rays are particularly hazardous to the human eye, hence clear glass should be used to see them since UV rays are opaque to solid material.

3. UV – C disinfectant Robotic system applications is used in nursing homes, schools, hospitals, offices, factories, and other locations.

III. OUTCOME OF THE UV – C DISINFECTION ROBOTIC SYSTEM

Current situation of Covid – 19 demands the need of disinfectant resources for our society. UV-C disinfection is a type of disinfection that uses ultraviolet light to kill bacteria. With direct contact of UV light on their surfaces, a disinfection system may eliminate diseases, viruses, bacteria, and other microorganisms found in the environment by breaking down their molecular DNA/RNA structure. The robotic and non robotic disinfectant system are put to the test in a variety of settings, including hospitals, universities, public transportation, offices, and other public locations. It is developed in such a way that it may be used in public spaces at a low cost. It is a one-time cost gadget that does not require the replenishing of alcohol or chlorine liquid, as is the case with typical devices. It may be used to disinfect medical and electrical equipment, masks, suits, and other items, with a 60 percent faster disinfection time than conventional liquid-based disinfection methods.When the design of UV – C disinfection instrument is finished, it is tested in various locations to see how effective it is at tracking infection areas, and then the robotic system's disinfection plan is implemented. It is based on the 3 – T technique (test, track and treat). Following the successful operation of the UV – C Robotic system, it will be released into the market at a fair price for industrial applications. As a result, the suggested UV – C disinfection robotic system has the potential to be more effective than chemical disinfectant systems in tackling the present pandemic scenario.

IV. NOVELTY OF THE DISINFECTION SYSTEM

The UV-C disinfection instruments on both the non robotic and robotic systems are designed to identify corona viruses and then destroy them through the disinfection process. Integrated sensors and remotely programmable devices are able to track and record the detection and treatment times. In times when traditional surface disinfectants are in short supply, it will prove to be a viable alternative to solution-based products. Manual cleaning and disinfection processes in medical fields have certain disadvantages over their robotic counterparts. They heavily rely on local protocols, staff-training standards and understanding, renewal, and staff turnover, at the same time their performance needs to be monitored, whereas in case of robots, they themselves offer reproducibility by automatically recording the operational parameters of the disinfection process and thus providing quality assurance.The UV-C disinfection robot will function independently and in a standardized manner, removing any requirement for continual human presence at the disinfection site. Therefore, any dangerous UV radiation will not be reach the healthcare professionals. The usage of a UV-C robot will be a hygienic and environmentally friendly disinfection technique since it lowers cross transmission and healthcare-associated diseases while also leaving no residue. In the future, this self-contained gadget for cleaning and disinfection in hospital and public settings will acquire traction. On the other hand, the design of UV – C chamber sterilizes the edible and non edible items effectively and it is a cost effective home – home portable device.

V. REVIEW OF THE STATUS OF RESEARCH AND DEVELOPMENT IN THE SUBJECT

A new SARS-CoV-2 variant of concern (VoC), omicron, was found on November 25, 2021, only 24 months after the first recorded case of COVID-19 and after an estimated 260 million infections and more than 5 million fatalities worldwide (Figure 1). Although earlier VoCs appeared in a world where natural immunity to COVID-19 infections was frequent, this fifth VoC appears at a time when global vaccination immunity is developing. The advent of the alpha, beta, and delta SARS-CoV-2 VoCs were linked to additional waves of infections, which spread throughout the globe at times.Because of its capacity to evade natural immunity, the delta VoC's greater transmissibility was linked with, among other factors, a larger viral load, longer duration of infectiousness, and high rates of reinfection, resulting in the delta VoC fast becoming the globally prevalent variation. In a lot of countries, the delta VoC remains the main source of infection causing widespread infections and fatalities. Concerns regarding reduced vaccine effectiveness due to new variations have shifted our perspective on the COVID-19 endgame, dispelling the myth that worldwide immunisation is sufficient to suppress SARS-CoV-2 infection.Indeed, as a gateway to viral endemicity, VoCs have underlined the need of vaccination in tandem with established public health preventative measures, such as masks, disinfectant and sanitization.

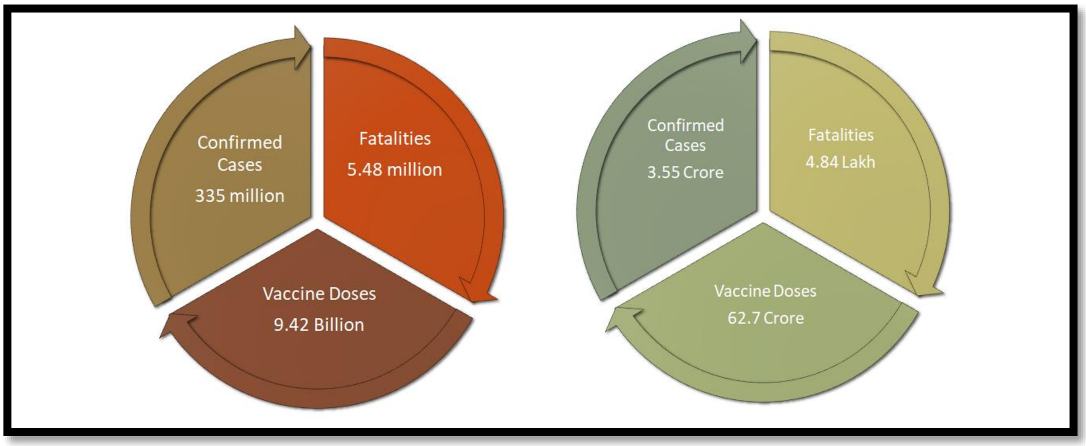

Figure 1: Global Covid – 19 Situation as of 9 January 2022 and Vaccine Doses Administered.

Several research organizations are focused towards the development of disinfection robotic systems in healthcare, the environment, and sustainable development. We'll give you a quick rundown of the worldwide and national organizations working on UV-based robotic systems for disinfection.

1. **International status:** Various groups from all around the world are working to further understand and examine UV-based disinfection robotic systems for use in the medical profession, offices, nursing homes, academic institutions, and a variety of other public

venues. A number of research have recently been undertaken on the fabrication of UV – C disinfection robotic systems for the killing of corona viruses.

The impact of UV disinfectant technology on clinical outcomes has been described by several writers. In a study in 2020, Elgujja et al. [1] examined the available research on UV surface disinfection. There are several limits to current UV surface decontamination applications, with the most important discovery being that shaded regions remain difficult to sterilize. Other drawbacks include UV's inability to remove dust or debris from surfaces, the necessity to leave the room for most UVGI uses, and expensive initial investment prices. Although the method is time-consuming, it can be employed in an inhabited space and HVAC systems must be covered during usage, HPV as a disinfection agent offers benefits over UV-C in specific situations.The absence of design against darkened regions is a major complaint about present UVGI systems. According to van Doremalen et al. [2], the SARS-CoV-2 virus may be detected on hard surfaces for up to 72 hours and in the air for up to 3 hours. Other human coronaviruses can survive on some surfaces for up to 9 days, according to Kampf et al. [3]. UVGI has been demonstrated to be effective against viruses of the coronavirus family in several investigations. UV-C irradiation inactivated three single-strand RNA viruses, including SARS-CoV-1, according to Eickmann et al. [4]. Fischer et al. [5] discovered that UV was as effective at inactivating SARS-CoV-2 on solid, non-porous surfaces as hydrogen peroxide vapour (HPV). Guettari et al. [6] developed a transportable UV-C disinfection system that was 99.99 percent effective in eradicating diseases, viruses, and other microorganisms. McGinn et al. [7] investigated the use of a UV disinfection robot in the field of radiology. The tests were carried out in two hospitals' CT and X-ray rooms to assess the Robot's germicidal capability. It was discovered that the room could be cleaned in less than 15 minutes, which is 2–4 times quicker than existing disinfection procedures.UVGI effectively inactivated all of the detectable microbial load on 22 out of 24 surfaces, according to the findings. UVGI decreased the microbial burden on the remaining two surfaces by 84 and 95 percent, respectively. The study also highlights some of the difficulties of manually sanitizing radiology suites, demonstrating significant germ loads in difficult-to-reach areas. Even if microorganisms are only exposed to brief bursts of irradiation, UVGI can efficiently inactivate them on routinely handled surfaces in radiology suites. Despite the short irradiation duration, UVGI was shown to be able to inactivate bacteria with more complex cell structures and greater UV inactivation energy than SARS-CoV-2, indicating that it is highly likely to be successful against coronavirus.Many other worldwide firms are attempting to improve the design of UV-C disinfection robots for medical and industrial use. UV D Robots®https://uvd.blue-ocean-robotics.com/about-ushttps://www.intel.in/content/www/in/en/customer spotlight/stories/akara-customer-story.html https://bluebotics.com/uvc-disinfection-robot-fights-viruses/

2. **National status:** In India, a number of firms and organizations are working on the development of UV-C disinfection robots. At the Delhi airport, Air India Express will use robotic technology for the first time in India in January 2021 to clean and disinfect the inside of an aircraft. Inspired by the Danish business 'UVD Robots,' a team from Indian Institute of Technology (IIT) Kharagpur and All India Institute Of Medical Sciences (AIIMS) created the 'Minus Corona UV Bot' to clean hospitals as a prophylactic strategy against new coronavirus.According to DebayanSaha and ShashiRanjan, their business

PerSapien invented the technology, which is an ultraviolet light (UV C-254 nm) based robot that allows hospital halls, wards, ICUs, and patient rooms to be sterilized without exposing anybody to the polluted environment. Vanora Robots Pvt Ltd, a robotics and artificial intelligence (AI) start-up located in Mangaluru, recently unveiled an autonomous robotic platform to disinfect rooms in hospitals, schools, and other facilities. The 'Intelligent Robot,' built by Stanford IIT alumni, disinfects public spaces without the use of chemicals.With the debut of its robot, LD UVC, OMRON Asia Pacific entered the UVC disinfection market. The robot was developed in collaboration with Techmetics Robotics, a pioneer in autonomous service robots, to help organizations successfully and easily combat the spread of infectious diseases. When it senses human activity, a professor and his colleagues from Kolhapur's Shivaji University built a sanitizer robot that can produce UV rays to instantly sanitize regions surrounding it.UV 360 sanitizer module robot' is the model's name. Mahindra University in Hyderabad developed the MUDRA, a disinfecting robot (Mahindra University UV Disinfectant Robot Autonome). It was created to use ultraviolet- C (UV - C) radiation to disinfect rooms, labs, offices, shop floors, and other enclosed locations. The robot, developed by MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) in conjunction with Ava Robotics and the Greater Boston Food Bank (GBFB), features a robust disinfection mechanism that also neutralizes coronavirus aerosolized forms.

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https://www.financialexpress.com/industry/technology/mu-launches-the-disinfecting-robot-mudra/2203878/

3. **Importance of the UV – C disinfection robot in the context of current status:** The main aim of this project is to fight against the current COVID pandemic situation. On November 11, 2021, the first sequenced omicron case was reported in Botswana, and a few days later, another sequenced case was discovered in a visitor from South Africa in Hong Kong. Although there are likely unexplained examples in numerous locations throughout the world but the oldest recorded case of omicron in South Africa was a patient diagnosed with COVID-19 on November 9, 2021. The main worries concerning omicron are whether it is more contagious as compared to other VoCs, as well as if it may bypass vaccination protection. Although clear immunological and clinical evidence may still be lacking, we may generalise from whatever is known about omicron mutations to offer early leads on transmissibility, severity, and immune evasion. Omicron possesses a

few deletions and over 30 mutations, some of which (e.g., 69–70del, T95I, G142D/143–145del, K417N, T478K, N501Y, N655Y, N679K, and P681H) overlay with those found the alpha, beta, gamma, or delta VoCs. Early epidemiological data shows that cases are on the rise in South Africa, as are PCR tests that fail to detect the S-gene target. Although omicron is expected to be highly transmissible, it is still not clear if it is more transmissible than delta VoC. However, preliminary evidence suggests that it is spreading fast against a backdrop of continued delta-variant transmission and strong natural immunity to the delta variation.If the current trend continues, omicron will supplant delta as the most common variant in South Africa. Importantly, established public health preventative practices (mask use, physical separation, shunning of confined rooms, outdoor alternatives, and hand cleanliness) that have been useful in the past should also be advantageous against the omicron variant. Extrapolations based on known mutations and preliminary observations, which should be interpreted with guardedness, suggest that omicron may spread more rapidly and may escape antibodies more easily than previous variants, resulting in an increasing in cases of reinfection and mild breakthrough even in vaccinated people. People who have been vaccinated had a considerably decreased chance of serious sickness from omicron infection, according to data from prior VoCs. Vaccination along with public health initiatives is predicted to remain an effective preventative method.

In the view of current pandemic situation the study introduces unique UV–C disinfection technology. The robot's revolutionary design incorporates the robotic design onto the UV-C Tower, disinfecting the surroundings without the need for human interaction. The UV - C light has been found to be extremely effective in breaking down the pathogens' DNA and RNA beyond recovery, thus ceasing their ability to replicate. UV – C disinfection Robot moves autonomously and disinfects any type of premises including the high-touch areas by killing 99.90% of bacteria and viruses -both airborne and droplet-by delivering the correct amount of dosage of UV-C energy. Equipped with lasers and Passive Infrared (PIR) Motion Sensors, for obstacle detection & avoidance, the UV - C robot can manoeuvre through narrow corridors, elevators, and even automatic doors seamlessly. It also shuts off its UV-C light upon human detection, ensuring impeccable safety for human beings. Suitable for indoor spaces, the robot follows a mapped route, reducing the requirement of dedicated manpower for manual cleaning. Features like bumper, sonar and emergency stop render additional safety. The machine has an automatic charging and smooth touch interface for control. All this makes it an ideal gadget for facilities like hospitals, hotels, malls, event venues, airports, corporate office to name just a few. With a simple integration of software, the robot gets up and running in minimal installation time and needs no modifications inside the premises.

Elaborating more on the rationale "Given the utmost significance of sanitization and disinfection in the post COVID-19 era, we believe the robot will yield a great value to organizations who are struggling to find the right, effective, less labour-intensive and long-term solutions to ensure their premises are safe and germ-free. Driven with the mission to contribute to a better society by identifying social needs, we seek to collaborate with capable & like-minded partners to come up with innovative solutions. The integration of UV - C technology is just another example of the flexibility and adaptability inherent in Sci–Tech mobile robots. The mobile robots are deployed in thousands of domains across multiple industries such as material handling, hospitality, automotive manufacturing to name just a few.

VI. FABRICATION OF UV – C DISINFECTION INSTRUMENTS

The fabrication of UV – C disinfection instruments include the following systems

1. **UV – C Robot**: UVGI Robot (Ultraviolet Germicidal Robot) is a tele-operated robot with a UV light system. A moving robot vehicle is included in the system. While seeing the robot's camera feed, the user may manage the robot via the internet of things (IoT platform), Android smartphone or a personal computer. However, the UGV on which the lamp is mounted is itself be autonomous and can move on its own without any human guidance. For this it has an AI algorithm that would help it to find its path and avoid obstacles and at the same time make safe distance between human and itself.

   By breaking down the DNA structure of viruses, bacteria, and other sorts of hazardous organic germs in the environment, the robot may disinfect and kill them. Several nations have successfully tested these robots in hospitals, public transportation, workplace spaces, and other public venues. We used our UV robot to spread the disinfection process to public areas in a cost-effective manner.

2. **Ultraviolet germicidal irradiation (UVGI)**: UVGI is used in a multitude of applications, including the purification of food, air, and water. UVGI can help to stop the transmission of several infectious diseases. UVGI applications generally employ low-pressure mercury (Hg) discharge lamps and UV LEDs, which generate shortwave UV -C (100–280 nm) light, predominantly at 254 nm. To deactivate the functioning of each bacterium, a different dose of UV radiation is required. The necessary UV light for the sterilizing process is usually expressed in "Joule per square meter" or "Joule per square centimeter" in most research papers and publications [1]. However, the manufacturers have reported UV light intensity in terms of "Microwatt (µW) per square centimeter" at a distance of 1 meter when considering the dimensions and specifications of the UV lamp. The unit "Watt (W)" denotes the amount of energy emitted in one second. The energy travelled through a one-square-centimeter region in one second is measured in microwatts per square centimeter. The following Equation form is utilized when UV - C is employed as a disinfection treatment [8]:

   $$\frac{dN}{dt} = -ZIN \text{ ---------------------- } (1)$$

   Where, I (W/cm^2) and Z (cm^2/Ws) are the UV intensity and micro-organism susceptibility factor, respectively. Environmental factors like relative humidity affect susceptibility characteristics (RH). The efficiency of UV-C for microorganisms is also affected by room layout, lamp placement, lamp age, air movement patterns, and the degree of air mixing in the space.The dose relates, D ($\mu J/cm^2$), to the UV intensity according to Equation:

   $$D = It \text{ ------------------------------- } (2)$$

   Where, t (s) is the irradiation time.The D_{90} is the required UV - C dose for 90% inactivation of a microorganism. The SARS-CoV-2 is of about 120 nm in diameter. Its inactivation dose corresponds to D_{90} = 6.11 μJ/ cm^2 [9]. The virus is susceptible to UV - C irradiation and its vulnerability is 3 times greater than the influenza (common cold) virus. The dose received by surface unity at given distance r (cm) from the sanitizer depends on the power, P (μW), of the emitted UV - C lamp according to the following equation [10]:

$$D = \frac{Pt}{2\pi Lr} \text{ ------------------------------------- (3)}$$

Where L (cm) and t (s) are, respectively, the length of the lamp and the exposure time, so the exposure time can be estimated according to Equation:

$$t = \frac{2\pi LrD}{P} \text{ -------------------------------- (4)}$$

In order to express the relative number of living microorganisms that are inactivated, the log 10 reduction factor is calculated according to the following equation [11]:

$$Log10reduction = log\frac{N_O}{N} \text{ ------------------------------------ (5)}$$

Where, N_0 and N are, respectively, the number of microorganisms before and after exposure to UV light, so when the log 10 reduction takes the values 1, 2, 3, and 4, the percent reduced microorganisms is respectively 90%, 99%, 99.9%, and 99.99%.

3. **Understanding the functionality of the robot**: UV – C disinfection robot incorporated additional capabilities and safety elements to meet with industry norms, therefore the total system is a little complex. Before going over the implementation process, it's important to understand how the system will function. The robot is made up of three primary parts:

- **The ground vehicle:** Two DC geared motors drives two wheels that move this section (A differential drive robot). To keep the equilibrium, there are two casterwheels at the front and back. The electrical control system and the battery, a 12V 35Ah Lead Acid battery, installed within the ground vehicle. The Arduino Mega powered by a voltage regulator module, which cut the voltage from 12V to 5V. The Mega board is linked to a four-channel RC radio receiver with PWM outputs. A dual-channel H bridge motor driver is attached to the Arduino board and drives the motors.

- **The UV light tower:** To power the UV LEDs, it utilizes fluorescent UV LEDs or a light that requires a separate electrical ballast unit. The light tower has eight UV lights that are arranged around an aluminium cylinder created by rolling an aluminium sheet. UV rays are reflected by this metal cylinder. The metal cylinder houses all of the electrical ballasts. A FPV camera and an FPV transmitter are mounted on the tower's top to relay the video feed to the computer system via the IoT platform. As indicated in Figure 1, the UV tower is mounted on top of the ground vehicle.

- **Programming the microcontroller and the mobile application:** The UV-C central column is mounted on a potable base fitted with pulse air modulation to prevent overheating of the lamps. Sensors are integrated to measure physical factors like temperature, humidity as well as other factors like motion and position to avoid obstacles. The robot can predict disinfection time automatically while being monitored through a Wi-Fi connection using a phone or tablet. UV - C Robot uses ultraviolet light to disinfect rooms and other equipment, and it turns off while humans are present, to keep them safe. Through UV - C lights, the robot can eliminate up to 99.999 per cent of germs and other microorganisms.

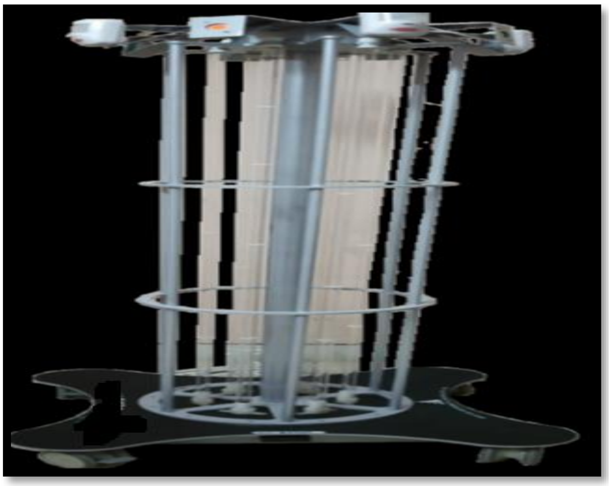

Figure 1: UV – C Disinfection Robot

- **Mobility devices:** The Tru-D transportable and automatic UV - C room decontamination system was assessed by Mahida et al. [12]. They found that when utilized at 22 J/cm^2, the device eradicates all germs with a mean log10 decrease of three to four. This includes a mean reduction of germs of 99.9 to 99.99 per cent. The robot is easy to operate and does not require any supervision while it is operational. No smoke alarms needs to be switched off and no need of any kind of ventilation is also required. When compared to hydrogen peroxide, Tru-D is faster. Cadnum et al. [13] recently evaluated the efficacy of a regular UV-C room disinfection system used in a single location to mobile robots used in a stationary or mobile position.To decrease the distance between the device and shadowing, the robot navigates around the patient room. The scientists discovered that a robotic device in a fixed posture is equally effective as a normal device against organisms within a short distance of the device, but much less effective at further distances. However, the UV-C robot device, which is configured to roam the room autonomously, is successful in minimizing contamination at various locations across the room.

A disinfection robot is a relatively new technique for deactivating bacteria, but it necessitates mastery of a number of disciplines, including robotics, electronics, mechanics, and programming. Bentancor and Vidal [14] demonstrated a remotely programmable gadget that uses an Android smartphone and an infrared detection security system. In reality, when motion is detected, the gadget switches off the lights.The robot transmits from the board using a Bluetooth device. Thanks to a mobile application, it can be operated from a wide range of Android mobile devices (tablet, cell phone, etc.). The authors have reported the device is effective to eliminate high bacterial inocula and a wide range of micro-organisms. The robot does not need any chemical agent. In order to the measure distances, detect and avoid obstacles, UV

- C Robot is fitted with ultrasound sensors. Infrared sensors help it to detect motion, so the robot operates when people are not around and turns off the UV - C lamps otherwise. The LiDAR sensor present in the robot scans the environment and creates a digital map; this permits to optimize intervention. An operator equipped with protective suit controls the robot operations from a dashboard thanks to integrated cameras.

- **Conclusion and future perspectives:** After studying the alternatives that are currently in the market, we found that there is a lot of scope for improvement. This is mostly due to the advance of Artificial Intelligence in the recent years. With new algorithms, a lot of parameters that generally needed different sensors can now be calculated with only one sensor given we have enough computation power in our microcontroller for inference during real-time and enough data for training the algorithms. The distance measured by an infrared/ultrasonic sensor, the human detection task and safety distance measurement can all done by our FPV camera only. Using an efficient object detection algorithm that is custom developed and trained for the purpose of working only in the regions that robot will encounter, we can make the robot more safe and accurate. Also this output can now be used for sorting and counting of the people so, that the robot only starts working while the room is closed or when all the humans are at a safe distance from the lamps. This same camera feed can also measure the distance from any obstacle that the robot will encounter once the disinfecting process starts. Therefore, here our Computer vision algorithm will not just be able to work as a driver for the algorithm but can also protect people near the device which increase the safety prospects of the robot manifolds. The video feed can be stored in a server for further training of the model and for other research practices. The dev board on which the algorithm is implemented can also be connected with a large number of sensors that whose values can be used for different purposes. This will help in making the whole machine more compact and portable.

For future upgrades, the machine can also be implemented with a voice-control mechanism that makes the whole setup more advance and useful in the areas where human presence is not recommended like a nuclear research lab.

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