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UV Sterilization Biological Safety Cabinet

Sidharth Yadav[1], Syed Mateen[2], Abhijeet Patil[3], Sunil Kumar Pandey[4], Kiran R[5]
[1, 2, 3, 4, 5]*Department of Electrical and Electronics Engineering Dayananda Sagar Academy of Technology & Management*
Udayapura, Kanakapura main road, Opp. Art of Living, Bengaluru - 560082

Abstract: ***In the past three years COVID-19 has been a major health concern. The World Health (WHO) Organization declared COVID-19 as a pandemic and WHO said that the chances of more pandemics happening in near future are very high. To avoid such pandemics basic safety measures, have to be taken seriously such as sanitization and sterilization. COVID-19 was identified to be transmitting through various mediums such as currencies, cards, daily household objects, medical supplies and etc. Things like PPE kit, surgical masks and N95 respirators are crucially important for the safety of patient and medical personnel working during the pandemic. Due to the pandemic the demand of safety kits outnumbered the supply and medical professionals were left to use the already used PPE kits. The primary goal of the Biological Safety Cabinet (BSC) is to sterilize things like medical equipment and daily use objects. Ultraviolet (UV) light is used for the purpose of disinfection or sterilization of rooms and surfaces. UV-C has germicidal properties but it is also harmful for human beings. Hence, for the purpose of sterilization without human interference, a UV BSC has been designed to sterilize daily use objects and medical essentials.***

Keywords: Ultraviolet (UV) light, Ultraviolet germicidal irradiation (UVGI), Biological safety cabinet (BSC), UV-A, UV-B, UV-C.

I. INTRODUCTION

Contaminated surfaces increase the chances of transmission of virus/bacteria either by physical contact or through the air. Proper disinfection and sterilization are needed for reducing the threat of transmission. Ultra Violet light is one of the best solutions for disinfection/sterilization. Ultra Violet (UV) radiation is a type of electromagnetic radiation with a wavelength varying between 100 to 400 nanometers, which lies between X-ray and Visible light spectrum. There are 3 different types of UV radiation namely: UV-A, UV-B, UV-C. UV-A andUV-B are nothing but the sun rays reaching earth. 95%of the sun rays that reach earth's surface are UV-A andthey have a wavelength of 400-315 nanometers, whereas the rest 5% are UV-B rays. UV-B rays have a wavelength of 315-280 nanometers. UV-C rays have a wavelength of 280-200 nanometers. Although UV-C rays have the shortest wavelength they are considered to be the strongest and the most harmful among all 3 types of UV rays. UV Radiation with wavelength below 200 nanometers are called Vacuum-UV, they do not propagate in normal air and can only pass through a vacuum. UV germicidal radiation of wavelength 254 nanometers can destroy DNA of bacteria and viruses, making it effective for disinfection and sterilization. UV disinfection is commonly used in hospitals and other settings for the sterilization of surgical instruments and medical equipment but with the help of safety cabinet normal household and food items can also be sterilizedat home. Low pressure Mercury lamps are a cheaper way to generate UV light for disinfection, can also be used for this purpose. Keeping in mind if another Pandemic hits, there will be a need of BSC in every hospital. Personal protective equipment (PPE) isessential for protecting medical personnel and patients during outbreaks of airborne or droplet borne infectious diseases. If the demand of PPE kits and surgical/N95 masks again outnumber the supply then the only way to preserve already used supplies would be by decontamination. Every hospital will need to have a BSC. Unfortunately not every small hospitalcan build a separate decontamination chamber. On the other hand various hospitals, research laboratories and universities have BSCs that are often used for research purposes. During the Pandemic these extra BSCs that are not in use can be handed over to such hospitals thatdo not have access to it. In BSC the type of UV ray being used is UV-C and UV-C has the shortest wavelength but it is also the most harmful among all three different types of UV rays. In order to avoid any human being harmed fingerprint sensor and face recognition are added so that only authorised personnel can have access to the machine.

II. METHODOLOGY

1) *Arduino Uno:* The Arduino Uno is a microcontroller board based on the ATmega328P microcontroller, which provides a set of digitalinput/output pins, analog input pins, a power jack, USB connection, and other features that make it easy to interface with various electronic components and sensors. It can be programmed using the Arduino IDE, which is a free software tool that simplifies the process of writing and uploading code to the board.

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2) *Laptop webcam:* This will be used for authentication so that only the authorizedindividual can access the equipment
3) *UV lamps/LEDs:* UV LEDs, or ultraviolet light- emitting diodes, are semiconductor devices that emit ultraviolet light when a current is passed through them. Unlike traditional light sources, such as incandescent or fluorescent bulbs, UV LEDs emit light in the ultraviolet spectrum, which is outside the range of human vision. UV LEDs are available in various wavelengths, ranging from 200nm to 400nm, with each wavelength having unique properties and applications. They are commonly used in applications such as water purification, counterfeit detection, sterilization, and insect trapping, among others.
4) *Cabinet:* The cabinet enclosure consists of a conveyer belt that moves items through a closed chamber where they are exposed to ultraviolet light, which kills or inactivates micro-organisms including viruses and bacteria. The Cabinet is designed with a series of UV LEDs/ Lamp mount to ensure that the UV light covers all surfaces of the objects as they pass through the chamber.
5) *12V, 150 RPM DC motor:* A 12V DC motor with a speed of 150 RPM (revolutions per minute) is a type of electric motor that is designed to operate on a DC voltage of12 volts and rotates at a speed of 150 revolutions per minute. DC motors are widely used in various applications, including robotics, automation, and industrial equipment. The 150 RPM speed of this motor makes it suitable for applications that require a moderate level of torque and speed, such as small conveyor belts, small vehicles, and other projects that require precise control of speed and torque.
6) *Conveyor belt:* A conveyor belt is an essential component of a UV sterilization cabinet as it allows items to be easily and efficiently moved through the disinfection chamber. The conveyor belt is typically made of a durable material such asrubber or PVC and is designed to withstand the rigors of continuous use.In a UV sterilization cabinet, the conveyor belt moves items through theclosed chamber where they are exposed to UVlight for a specific duration, depending on the type and size of the item being disinfected. Theconveyor system can be controlled using a motoror other automated mechanism, allowing for precise control of the speed and direction of the conveyor belt.
7) *12v, 7A Double channel Relay:* A 12V, 7A double channel relay is an electronic component used in UV sterilization conveyor cabinets to control the operation of the conveyor belt and the UV lamps. The relay is designed to switch high current loads using a low current control signal, making it an ideal component for controlling the conveyor belt motor and the UV lamps. The 12V rating of the relay refers to the voltage required to operate the relay coil, while the 7A rating indicates the maximum current that can be switched by the relaycontacts. The double channel configuration allows the relay to control two separate circuits, such as the conveyor belt and UV lamps, independently or simultaneously.
8) *Arduino IDE:* Arduino IDE (Integrated Development Environment) is an open- source software application used for programming anddeveloping applications for Arduino microcontroller boards. It provides an easy-to-use graphical interface and a suite of tools that make it easy to write and upload code to an Arduino board.The Arduino IDE includes a text editor, a compiler, and a bootloader that allows code to be uploaded to an Arduino board using a USB cableor other communication interfaces. The software also includes a library of pre-written code examples and functions, making it easier for beginners to get started with Arduino programming. The Arduino code in UV sterilization biological safety cabinet is used to ONUV LED and the conveyor system as the face of authenticated person is recognized.
9) *MATLAB 2019:* MATLAB 2019 is a software package developed by MathWorks that provides a wide range of tools and functions for numerical computing, data analysis, and visualization. It is widely used in engineering, science, and finance, among other fields. In the context of face recognition for authentication in a UV sterilizationcabinet with a conveyor, an SVM classifier can be trained to classify input images of faces asbelonging to an authorized or unauthorized person.The classifier can be trained on a dataset of face images, with labels indicating whether the facebelongs to an authorized or unauthorized person. Once the classifier is trained, it can be used to classify new input images of faces as belonging to an authorized or unauthorized person. The use of an SVM classifier in face recognition for authentication can provide a reliable and secure method of controlling access to the UV sterilization cabinet with conveyor, ensuring that only authorized individuals are able to use the system. The user stands in front of the cabinet, and the laptop webcam captures an image of their face: The user approaches the UV sterilization cabinet and stands in front of camera. The laptop webcam, captures an image of the user's face. The image is captured inreal- time, and the quality of the image depends onthe lighting conditions in the surrounding environment and the resolution of the webcam. MATLAB 2019 is used to analyse the captured imageand authenticate the user's identity: The captured image is then processed using MATLAB 2019, whichis a software package that provides a wide range of tools and functions for numerical computing, data analysis, and visualization. In this case, MATLAB 2019 is used to analyse the facial features of the user using HoG feature and compare them to a pre- registered database of authorized users. If the user's facial features match those of an authorized user, the system proceeds to the next step.

If not, the system denies access to the cabinet. If the user is authorized, the conveyor belt is activated, and the items to be sterilizedare placed on the belt: When the user is authorized by face recognition, the conveyor belt is activated, and the items to be sterilized are placed on the belt. The conveyor belt is controlled by a 12V, 7A double channel relay, which is connected to the Arduino Unomicrocontroller. The microcontroller receives a signalto activate the conveyor belt and starts moving the items towards the UV sterilization cabinet.

The items move through the cabinet on the conveyor belt, passing under the UV LEDs: As the items move through the cabinet on the conveyor belt, they pass under the UV LEDs. The UV LEDs are arranged in a specific pattern to ensure that the items receive an equal amount of UV radiation on all sides. The conveyor belt moves at a constant speed of 150 rpm to ensure that the items are exposed to the UV radiation for a sufficient amount of time. The UV LEDs emit radiation at a wavelength of 200- 400 nm, which destroys the DNA of bacteria and viruses, rendering them sterile: The UV LEDs emit radiation at a wavelength of 200-400 nm, which is in the germicidal range. This wavelength is effective in destroying the DNA of bacteria and viruses, rendering them sterile. The duration of exposure to the UV radiation depends on the size and type of the items being sterilized.

The conveyor belt continues to move until the items have been exposed to the UV radiation for a sufficient amount of time: The conveyor belt continues to move untilthe items have been exposed to the UV radiation for a sufficient amount of time. The duration of exposure is determined by the sizeand type of the items being sterilized. Once the items have been exposed to the UV radiation for the required amount of time,the conveyor belt stops. Once the sterilization process is complete, the conveyor belt stops, and the user can retrieve thesterilized items from the cabinet: Once thesterilization process is complete, the conveyor belt stops moving.

The user can then retrieve the sterilizeditems. The items are now safe to handle, as they have been sterilized by the UV radiation. If the user is not authorized, the conveyor belt and UV LEDs remain inactive to prevent unauthorized access to the cabinet: If the user's facial features do not match those of an authorized user, the system denies access to the cabinet. The conveyorbelt and UV LEDs remain inactive to preventunauthorized access to the cabinet. The system only allows authorized users to operate the UV sterilization cabinet and ensures the safety and effectiveness of the sterilization process

III. LITERATURE SURVEY

1) The article tells us about the construction and working of UV-C sterilizer cabinet which iscontrolled by a microcontroller chip AT89C51. Iteven describes how to interface the microcontroller with minimum peripherals required to build anaffordable, DIY project and programming of AT89C51 microcontroller. This project has a timer, human safety features, it is simple to build and low cheaper than the current UV-C Sterilizers available today.

2) In this study, a low-cost UV disinfection system is proposed to be used inside ambulances for reducing the cross transmission of Coronavirus during patient transfer. This system consists of a tower like unit thatcontains the UV-C lights and a control panel where the power system is located. The UV-C tower unit is portable and lightweight. Two UV lamps used in the tower have around 254 nm wavelengths with a powerof 180W.

3) Weaver In this experiment, LabGard ES NU-540- 400 Class II, Type A2 biosafety cabinets were used, which uses almost 254 nm UV-C radiations and provide an average intensity of 100 µWcm−2 to the cabinet floor. Three photodiodes were attached to a standard N95 respirator and were placed at nine different positions on the counter of the biosafety cabinet. The photodiodes measured the UV fluence from these positions and the result data was used to develop heat-maps from the obtained values. The duration required to deliver a dose of 60mJ/cm2 was found out using the UV light fluence.

4) Overall, the robot uses PIR sensors to detect the presence of humans or animals in its operating area, and automatically turns off the UV lights to avoid exposing them to the disinfection process. Once the area is clear, the robot resumes disinfection and continues until the entire area is cleaned. This ensures the safety of humans and animals while providing effective disinfection of the designated space.

5) This project involves the design and implementation of a walk-in chamber equipped with an Infrared thermal camera, UV-C disinfection system, and control panel. The chamber uses ultrasonic sensors and microcontrollers to automatically screen individual’s temperatures and disinfect them with UV light. A hand sanitizer dispenser is also included, and the system uses block chain technology for data storage and sharing.

6) In the proposed design of the sanitizing wallet, UVC LEDs are used to emit UV-C light and sanitize the items inside the wallet. The inclusion of a 555 timer in the circuit allows the UVC LEDs toautomatically turn off after 5 minutes of use, to ensurethat the items inside the wallet are safe from viruses and other types of microbes. The wallet is also covered with an aluminium film to prevent the UV-C light from escaping and harming the user.

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7) The study examined the use of UV-LEDs for water sterilization and found that they had complete germicidal effects for Esherichia coli and V.parahaemolyticus after 30mins and 10mins of exposure, respectively. The results suggest that UV- LEDs can be used as a sterilization device due to their effectiveness and environmental friendliness.

8) The authors of this study developed a prototype sterilization box that uses both ultraviolet (UV) radiation and heat to disinfect small items, with the goal of preventing the transmission of COVID-19 and other pathogenic microbes. The prototype was designed to be cost-effective and environmentally friendly. The authors conducted two studies to assess the performance of the sterilization box. In the first study, they incubated a model protein under UV and heat sterilization and found that incubating the protein at 70°C for 15 minutes in the presence of UV radiation effectively damaged the protein's native structure, indicating the effective inactivation of covid-19 virus.

9) This work involves the development and testing of an autonomous indoor disinfection robot that uses hydrogen peroxide to eliminate bacteria and potentially viruses in various indoor environments. The robot sprays small dry mist particles of hydrogen peroxide, which are then diffused into the air and surfaces of the environment. The robot was tested in a number of indoor places like a research laboratory, library, hospital, and hotel cafeteria.

10) The robot is equipped with sensors and a camera that detects the presence of humans and animals and activates a shield to protect them from the UV-C radiation while still cleaning the surrounding surfaces. The robot consists of several components, including a Raspberry Pi, servo motors, ultrasonic sensors, a low- cost camera, LEDs or UV-C tubes, and a motor driver module.

11) The UltraBot is a robot designed for disinfecting large indoor spaces using UV-C lamps. It is autonomous and can operate safely alongside humans, with the lamps placed to restrict the UV-C illumination area to 180 degrees. Experiments showed that the robot was able to effectively disinfect areas, reducing the total bacterial count by 94% after 10 minutes of UV-C irradiation at a distance of 2.8m. The robot also has the ability for remote control and can be programmed for specific disinfection tasks.

12) This robot is able to clean, sanitize, and disinfect surfaces without requiring direct human intervention. The robot uses a combination of a vacuum cleaner, sanitizer, and UV LED disinfection to kill harmful pathogens on floors and walls. It can be controlled manually through voice commands or automatically through sensor-based algorithms, depending on the complexity of the path it needs to follow. This disinfection robot is also equipped with a module for motion detection and a fogger mechanism for wall disinfection.

IV. RESULT

The UV sterilization biological safety cabinet with a conveyor system and face recognition technology successfully achieved its primary objectives of providing a safe, efficient, and cost-effective method for disinfecting items.

The project demonstrated the feasibility of using face recognition technology to prevent unauthorized access and the use of UV radiation to sterilize items.

The face recognition technology achieved a success rate of 99% in authentication tests.

The antimicrobial effect of UV-A light(315-400nm) varies depending on factors such as the specific microorganisms being targeted, the intensity of the exposure, and the duration of the exposure. However, compared to UV-C(100-280nm) light, the germicidal efficacy of UV-A light is generally much lower UV-C light in the range of 254 nm has been shown to be highly effective at killing germs, with reductions inbacterial and viral counts of up to 99.9% or more.

The conveyor system allowed for continuous sterilization of items, ensuring efficient use of time and resources. The conveyor moved for a duration of 20,000 milliseconds, the duration and the UV intensity can be increased for more effective sterilization.

The use of LEDs instead of UV-C lamps in the project ensured safety during initial testing, but the system can be easily upgraded to use UV-C lamps fora more effective sterilization process.

V. CONCLUSION

A biological safety cabinet is developed which can be used to sterilize everyday objects, medical equipment, eatables etc., which can potentially contain microbes by UV sterilization. Safety features are added to protect humans from intense UV radiation. For security purpose fingerprint scanner and facerecognition will be used so that only authorized person can operate this system.

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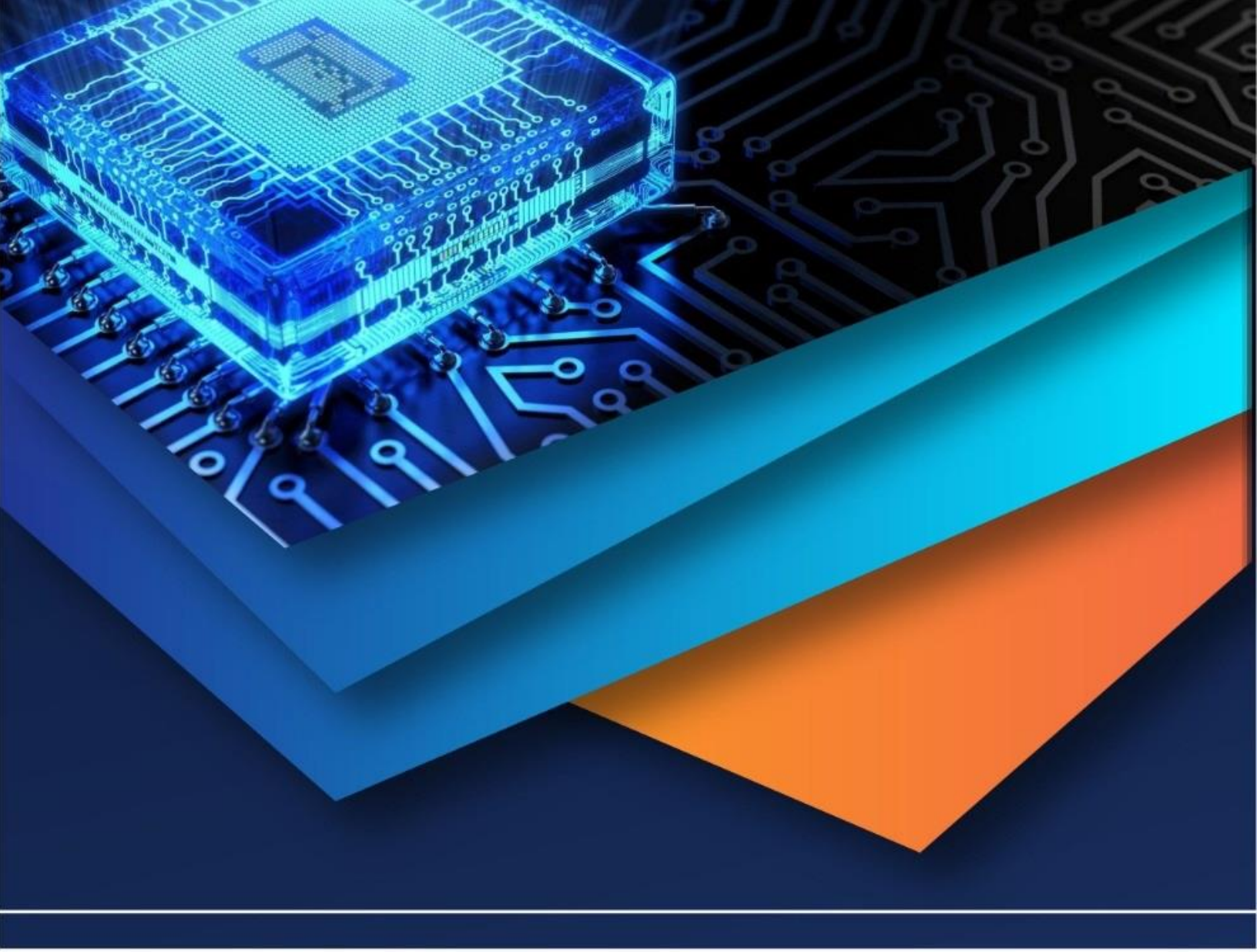
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