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AN UV STERILIZATION ROBOT

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Abstract—Due to the COVID-19 virus, human lives and livelihoods have undergone extensive changes, and the only way to minimize the spread of the virus is to maintain social distancing and follow guidelines proposed by our respective governments. Not to mention, sanitization and sterilization have become an indistinguishable part of our daily life. Speaking of sanitization and sterilization, there is a problem: we cannot directly involve ourselves in the sterilization process because there is a chance of contracting the deadly virus from contaminated spaces. However, what we can do to solve this problem is to build a powerful, efficient, and autonomous robot capable of sterilizing a place easily without exposing ourselves. Robots are already in use for several applications where humans can be at risk of exposure. Therefore, in this tutorial, we will be building an ultraviolet sanitization robot capable of killing the coronavirus in hospitals and apartment buildings. For this purpose, we will be utilizing an Arduino, some UV LEDs, and ultrasonic sensors. The aim of this work is to contribute to the fight against the spread of COVID-19, a novel human coronavirus, in hospitals, public transport, airlines, and any enclosed areas. In this study, we have adopted the physical disinfection method using UVC light as the agent. The UVC devices are studied and classified according to their disinfectant units, complementary devices, combined disinfection agents, mobilities, and order types. Our findings show that a mobile robot is the most efficient device to inactivate microorganisms, so we have developed a robot called the UV-sterilization robot. The robot is equipped with UV LEDs capable of weakening bacteria and viruses through UVC lamp emission. Manual cleaning and disinfection vary in efficiency significantly depending on individuals and their motivation, and assessing this requires direct on-site observation.

Key Words: sterilization, Arduino, ultrasonic sensors

I. INTRODUCTION

The main aim of our project is to develop a sterilization robot with the help of UV rays to disinfect rooms. Our UV disinfection and sterilization robot kills germs in the environment by decomposing their DNA structures, thus preventing and reducing the spread of viruses, bacteria, and other harmful microorganisms. This disinfection robot sterilizes the room in 360 degrees. If anyone is within the robot's range, it automatically turns off the UV lights to prevent harmful effects. Our robot is capable of operating in both manual and fully automated modes with the help of Bluetooth.

UVC works to kill microorganisms through a specific light wavelength; the power of UV is in its ability to destroy the proteins within these microorganisms, rendering them entirely harmless. While high-end UVC technology is already used in concentrated form for sanitizing tools and materials, our technology aims to bring UVC to more extensive areas than small, contained spaces, providing higher levels of protection for all.

Since the discovery of the germicidal effects of UV, research has focused on enhancing disinfection effectiveness. Recent developments in technology have led to the creation of different types of UV sources, but UV germicidal lamps remain the most frequently used due to their relatively low cost. Complementary devices such as humidifiers and wall reflectors decrease disinfection time when used

with UV. Combining disinfectant chemical agents with UV is an emergent technology but has the disadvantage of damaging hospital materials.

In the worldwide fight against the Coronavirus pandemic, robots join medical staff on the frontline, especially UV robot disinfectors. Thanks to the robot's mobility disinfection, time is reduced for an impressive effectiveness without using any complementary devices or chemical agents. Considering previous studies, a team of Tunisian researchers and engineers has designed and produced a robot disinfector called Robot UV. Manual disinfection devices are often suboptimal; recently, several mobile and automated room disinfection devices are being tested.

Problem Specification: The COVID-19 pandemic has brought everyone under the precautions of social distancing, sanitation, and other hygiene measures. A hospital worker cleans the hospital and sanitizes it despite all the steps within a COVID patient's proximity. In this paper, a UV-C disinfection robot is developed as a replacement for humans. This robot not only replaces humans within the proximity of a COVID patient but also replaces the traditional, not-proven-efficient methods. The proposed system has a dual mode: automated and manual mode. The automatic mode is used to avoid human intervention using object detection and algorithms. Manually, humans control the robot through a camera and remote. The main distinguishing component is the UV-C light. UVC light from the sun is intercepted by the Earth's ozone, so you're not commonly exposed to it every day. However, there are different human-made versions of UVC light. UV-C can be used to sanitize surfaces, air, and liquids. UVC light kills microorganisms like viruses and bacteria by damaging atoms like nucleic acids and proteins, making the embryo incapable of performing the necessary processes to survive. As UVC light is an attractive option for disinfection, together the robot module and UV-C light make it an effective and efficient method for cleaning and sanitizing, especially against coronavirus.

Methodologies: The UV sterilization robot has a small form factor and can be turned ON/OFF automatically when a human or animal is detected so that no damage is done. Key components of the robot are three PIR sensors, three UV lamps, a controller box, a power source (which is free of electrical wires) – battery, Arduino, two IR sensors. The main command center of the robot is the microcontroller. It is programmed to detect human beings or animals with the help of three PIR sensors or IR motion sensors mounted on top of the robot to cover a total angle of 360°. If a person is detected while the disinfection process is going on, the robot comes to a halt and the UV light gets turned OFF. Once the person leaves the room or operating area, the UV lights which were OFF get turned ON automatically, and the disinfection process goes on until complete. The robot has two IR sensors at the bottom of the base to follow the predefined path. The microcontroller controls the wheels of the robot by motor drivers in the path. Disinfection starts the moment the robot is turned ON. After the disinfection of a particular place is complete, the robot moves to the next directed position by following the marked line. This process continues until the disinfection of the entire room or place is complete. During the disinfection process, if a human or an animal approaches the operating area, then a command is sent to turn OFF the UV lights automatically. The data sensed by the PIR sensors is processed by the microcontroller, and a message is sent to the robot. The robot remains in the same position if disinfection is not completed. After a delay of a few seconds, the PIR sensors check for the presence of humans, generally detecting infrared radiation from the surrounding area within a specific range. As soon as the PIR sensors detect that there is no person or animal in its range, the robot resumes, which means the UV light gets turned ON automatically and finishes the process. After the complete disinfection of a room or place, the robot can be scheduled for disinfecting another room or can be turned off.

Calculated Time for Disinfection: As a matter of fact, all virus species of comparable kind have a similar structure and a similar RNA strand length. UV light experiments conducted in the past were used to determine the UV radiation dose required for 902.5 feet away can be calculated as: Brightness = 203(W)/4(158.49)2(cm2) = 0.00018886W/cm2 = 188.86µW/cm2. A UV dose of 10,600µW.sec/cm2 is required for 90. Hence, the time required to eliminate germs is expressed as: Time = 10,600(µW.sec/cm2) / 188.86(µW/cm2) = 56.12 sec.

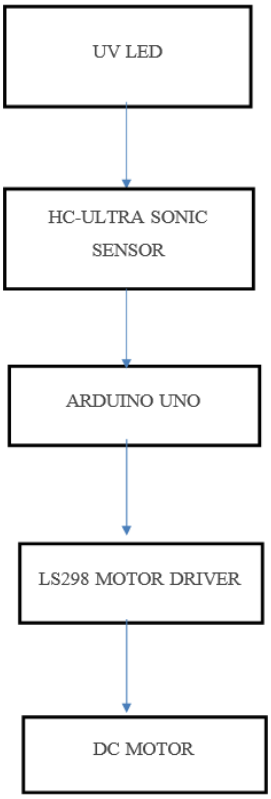

Fig.1.BlockDiagram of UV Sterilization Robot

1. A UV sterilization robot aims to sterilize and disinfect the floor.
2. The function of the robot is to disinfect a room or a flat surface using ultraviolet germicidal irradiation. The robot has ultraviolet LEDs responsible for killing the virus.
3. Bio-organisms such as bacteria and viruses are known to be deactivated when exposed to UV light.
4. This robot is completely automatic and will detect obstacles to avoid collisions. We use ultrasonic sensors for this purpose.
5. When an obstacle comes in front of any sensor at a certain distance, the robot will turn to the opposite side and avoid that obstacle. For example, if an obstacle comes in front of the left sensor, the robot moves to the right. While the robot is powered on, the UV LEDs will stay on,

and the sterilization process will continue. The robot has a total of five UV LEDs on the downside, providing comprehensive sterilization.

6. This robot is 100% safe to operate as it detects items in the environment for its operation and safety, including obstacle avoidance.
7. The robot is fully autonomous during UV irradiation. It has a full 360-degree movement. We connect all respective ground and VCC pins. The ground pin goes to the ground of the Arduino, and the VCC pin goes to the VCC pin of the Arduino. Connect trigger and echo pins to Arduino PWM pins as shown in the circuit diagram.
8. We are using the popular L298N motor driver IC to drive the motors. Connect the two enable pins of the motor driver to 5V. Also, we need to connect the driver voltage pin to 5V because we are using 5V compatible motors.
9. All the UV LEDs are connected, tied up to VCC and ground.
10. The Arduino, ultrasonic modules, motor driver, servo motor, and DC motors work on 5 volts. Higher voltage will damage them.
11. We are using a 7.4-volt battery to convert that into 5 volts. 7805 voltage regulators are used.
12. Since we are building a moving robot, we need to make everything as compact as possible. To solder every component together, first, I took a very small dot PCB and placed every component according to the circuit diagram, and soldered everything.
13. The robot checks for obstacles in front of it. If there are obstacles, it moves in another direction and continues to sterilize the floor once the robot is on.

II. LITERATURE SURVEY

Pacharawan Chanprakon et al. developed a UV contraceptive robot to eliminate viruses. This robot utilizes ultrasonic sensors to avoid collisions, and a webcam is used to direct its movement. With three UV lamps, the robot covers a wide range for disinfection. Operators can control the robot's mobility and speed, along with UV light intensity.

Thomas Rubaek, Merima Cikotic, and Simon Falden evaluated a UV disinfection robot. Their practical robot features Bluetooth control and sanitizes surfaces through a pre-defined path without worker intervention. The UV robot requires approximately a minute to disinfect the surrounding area.

O. Hachour's work focuses on path planning for autonomous mobile robots. The paper discusses the autonomy of robots in automated fields and emphasizes optimal planning for autonomous actions based on tasks.

Jui-Hsuan Yang et al. explored the effectiveness of an Ultraviolet-C Disinfection System against healthcare-associated pathogens. The study highlights the system's impact on reducing infections caused by NTM (Non-Tuberculous Mycobacteria) and other pathogens.

Aladin Begic et al. proposed sanitizer robots for sterilization in medical institutions. These semi-automated systems reduce bacteria and MRSA on room touch surfaces, contributing to infection control measures.

Noriyuki Yagi et al. worked on a disinfection robot using high-wavelength UV-LED. Their project demonstrates the efficacy of UV-LED in eradicating microbial contaminants, suggesting its cost-effectiveness and efficiency compared to traditional mercury light.

Algorithm Design and On-Field Measurements to Improve Surface Disinfection Against SARS-CoV-2: This study evaluates the effectiveness of mobile robots for UV-C irradiation compared to static UV-C

lamps. It proposes a novel trajectory planner utilizing a genetic algorithm to optimize disinfection outcomes.

Development of Portable Sanitization Locomotive Bot: This research introduces a bot capable of maneuvering indoors for effective surface disinfection. The bot employs a PLZT pyroelectric transducer and an air-bearing system for mobility and efficient cleaning.

ROM20: An Autonomous Mobile Robot Platform for Medical Purposes: ROM20 utilizes stepper motors and UART serial communication for motion control. It integrates various subsystems, including UV-C lamp irradiation and disinfectant mist spraying, for comprehensive sanitization.

Sensor-Units for Monitoring and Controlling Sanitization: This project introduces intelligent sensor units for real-time monitoring of sanitization processes. These sensors transmit data to a centralized monitoring station for effective control and management.

Challenges in Thick-Film UV Sensors: The paper discusses challenges in ensuring the reproducibility and stability of commercial thick-film UV sensors, essential for reliable monitoring and control of UV disinfection processes.

In the context of semiconductor gas sensors, maintaining consistency in the manufacturing environment is challenging, leading to limitations in precise measurement systems. A research paper proposes an output characteristic analyzer for thick-film metal oxide semiconductor gas sensors, aiming to assess air quality in indoor spaces. The analysis categorizes the output characteristics of these sensors in normal air chambers, facilitating the creation of a characteristic table. This table helps determine the rank of sensors installed in air cleaner systems, enabling adaptive on-demand operations based on historical manual controls.

During our investigation into UV light disinfection robots, we examined various research papers and existing systems. While some UV Light Disinfection robots have been implemented in different fields, they often face limitations such as maintenance and manual operation. For instance, Aladin Begic proposed service disinfectant devices effective in medical institutions, reducing bacteria and MRSA on high-touch surfaces. Thomas Rubaek et al. developed a UV-Disinfection robot to combat the spread of diseases in hospitals and other environments. Similarly, Jui-Hsuan Yang implemented the Hyper Light Disinfection Robot, effective against multidrug-resistant bacteria and fungi commonly found in hospitals. However, the effectiveness of these devices may be limited in shadowed areas, and UV-C devices may pose risks of overexposure in crowded or open spaces.

In summary, UV-light plays a crucial role in the medical field, but existing systems have limitations, including manual operation and safety concerns regarding UV exposure. To address these limitations, we propose a completely automated UV-light disinfection robot operated via an android application. Equipped with PIR sensors and Ultrasonic sensors for human and animal detection, this robot ensures safety, especially during pandemics.

Proposed Method:

We have designed an intelligent prototype module for disinfection robots using IoT technology to overcome existing limitations. This system enables automated and manual control of sanitizing mechanisms through a small electronics unit comprising a Microcontroller, Ultrasonic sensor, UV light, Robot mechanism, and IoT module. Ultrasonic sensors monitor obstacles in front of the robot, while UV light is utilized in the sanitization process. Manual mode control is facilitated by two switches, while

automated mode control is achieved through IoT technology. The UV LED effectively weakens bacteria, enhancing the disinfection process.

The COVID-19 pandemic has underscored the importance of social distancing, sanitization, and hygiene measures. Despite precautions, hospital workers face challenges in cleaning and sanitizing areas near COVID-19 patients. To address this, a UV-C disinfection robot is proposed as a replacement for humans. This robot not only mitigates the risks associated with traditional sanitation methods but also operates in a dual mode—automatic and manual. While the automatic mode employs object detection and algorithms to avoid human intervention, the manual mode allows control through a camera and remote. The UV-C light, a distinguishing component, is effective in sanitizing surfaces, air, and liquids by destroying microorganisms' genetic material, rendering them incapable of survival. Combining the robot module with UV-C light offers an efficient solution for cleaning and sanitizing, especially in combating the coronavirus.

IV. SYSTEM DESIGN

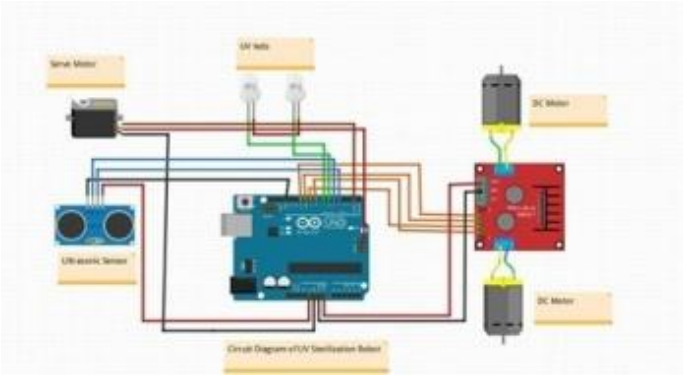

Fig.2.Circuit Diagram of UV Sterilization Robot

The UV sterilization robot offers 360°+ downside sterilization, operates quietly, and has a compact, aesthetically pleasing design. It ensures 100% safety during operation and can be controlled via a mobile application or autonomous navigation. Equipped with obstacle detection sensors, the robot operates autonomously during UV irradiation, providing full 360-degree movement while avoiding collisions. With a runtime of up to 4 hours, the robot features robust collision avoidance, durability, and low maintenance requirements. Its design prioritizes the use of readily available components and software for manufacturing.

V. IMPLEMENTATION

The Arduino IDE is used for uploading code onto the Arduino board. The IDE provides a streamlined development environment for writing Arduino code, which is similar to C++. Libraries simplify connectivity to sensors, displays, and other modules, enhancing the functionality of Arduino boards. The process of connecting and uploading programs to Arduino boards is straightforward, involving simple

steps such as connecting the board via USB, selecting the appropriate board and serial port, and clicking the upload button.

HARDWARE COMPONENTS

The Arduino Uno board serves as the core component, offering digital and analog inputs/outputs, voltage regulation, and a microcontroller for program execution. Additional hardware components include the HC-SR04 Ultrasonic Sensor, which enables obstacle detection, and the ATmega328 microcontroller, providing processing capabilities for the system.

VI. CONCLUSION

In conclusion, the UV sterilization robot addresses the challenges posed by hospital-acquired infections by providing an automated and efficient sanitization solution. By leveraging UV-C light technology and advanced hardware components, the robot ensures thorough disinfection of surfaces, reducing the risk of pathogen transmission. The integration of various hardware modules and careful design considerations contribute to the successful implementation of the project, offering a reliable solution for sanitization in hospitals and clinics.

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