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UV-C Based Disinfectant Robot

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Abstract: UVC (ultraviolet-C) light has been proven to kill various bacteria and viruses, including the COVID-19-producing virus, which has been discovered to be a powerful disinfectant. Manual UVC disinfection, on the other hand, can be tiresome, time-consuming, and hazardous for human operators. As our senior project, we developed a UVC-based disinfection robot to address these problems. Our robot has been designed to move and clean on its own in a variety of applications including hospitals, schools, and public places. Ultrasonic sensors for navigation and obstacle avoidance, a mobile platform, a UVC light source, and an Arduino microcontroller for communication and control comprise the robot.We conducted a microbiological test to gauge the robot's performance by comparing the number of microbe cells on a surface before and after UVC disinfection. Our findings demonstrated the robot's effectiveness as a disinfection tool by showing that bacterial colonies were reduced by 93.9%. By measuring UVC radiation levels at various angles and at various distances from the light source, we were also able to assess the safety of the robot. Our findings demonstrated that the robot complied with safety requirements for UVC radiation exposure to humans.
Keywords: Sanitization, UV-C, Object Detection

I. INTRODUCTION

The pandemic has fundamentally altered the way we work and live, emphasising the significance of efficient disinfection procedures to stop the spread of dangerous diseases. Traditional disinfection techniques, including chemical sprays and wipes, can take a lot of time, need a lot of work, and may not be effective against all pathogen kinds. It has been demonstrated that ultraviolet-C (UVC) radiation is a potent disinfectant that can eliminate a variety of bacteria and viruses. However, manual UVC disinfection might be harmful to human operators' health.

We created a UVC-based disinfection robot as our senior project to address these issues. Our robot is built to move and clean on its own in a variety of settings, including hospitals, schools, and public places. Surfaces are cleaned by the robot using UVC light, which provides a quick and easy replacement for conventional disinfection techniques.

Our project's goal was to create a UVC-based disinfection robot that is reliable, effective, and safe in minimising the spread of infectious diseases.

All things considered, our UVC-based disinfectant robot presents a potential answer for automatic, effective, and secure disinfection in a variety of environments. This technology has the potential to significantly contribute to lowering the transmission of infectious illnesses and enhancing public health with more research and improvement. A helpful tool for decreasing the workload and exposure dangers for human operators, the robot's autonomy makes it another advantage.

II. RELATED WORK

Recent years have seen a substantial increase in interest in the creation of UVC-based disinfection robots, especially in reaction to the COVID-19 epidemic. The worth of UVC disinfection robots as an appealing choice for automated and effective disinfection in diverse settings has been demonstrated by a number of research papers and commercial products created in this field.

A UVC disinfection robot that used a mix of UVC and ultrasonic sensors for mapping and localization was shown in one such study by Al-Zyoud et al. (2020). The study showed the utility of UVC disinfection robots in medical facilities and other high-risk locations.

A 360-degree scanning UVC light was employed by Sun et al. (2020) in their work to present a UVC disinfection robot. The robot could move around on its own in various spaces, and a remote operator oversaw the cleaning procedure. The study proved that UVC disinfection robots might be used in public areas and busy places.

Several commercial UVC disinfection robots have been created and put into use in hospitals and other high-risk regions worldwide in addition to research projects.

One such item is the Blue Ocean Robotics-created UVD Robot, which has been utilised in hospitals and other healthcare institutions throughout Europe and Asia. The UVD Robot navigates and sanitises areas on its own using a mix of UVC and mapping sensors.

The promise of UVC disinfection robots has been shown by these studies and devices, although there are still issues and restrictions to be resolved. As UVC radiation can be hazardous to human health, maintaining the safety of human operators and spectators is a significant concern. Additionally, elements like distance and surface type can have an impact on how efficient UVC disinfection is.

Robotic UVC-based disinfection has been the subject of numerous research investigations and projects. These research have looked at a range of UVC disinfection topics, as well as robot navigation, security issues, and real-world applications. Here is a quick summary of related research in various fields:

UVC Studies on Infection:

The effectiveness of UVC disinfection in various contexts, including hospitals, public areas, and transportation networks, has been the subject of numerous research. These investigations have shown that a variety of pathogens, including bacteria and viruses, can be rendered inactive by UVC radiation.

Research has been done to determine the ideal UVC dose, exposure duration, and separation needed for efficient disinfection. The development and application of UVC-based disinfection systems are influenced by these discoveries.

Robots for UVC disinfection:

The development of UVC disinfection robots has been the subject of numerous research studies and commercial products. These robots are made to independently go through and clean different surroundings, minimising the need for manual disinfection procedures.

To navigate and identify obstacles in real-time, the robots use cutting-edge sensor technologies, such as cameras, lidar, ultrasonic sensors, or a combination of these. Algorithms for path planning allow for effective coverage of the target area.Studies have looked into integrating artificial intelligence methods like computer vision and machine learning to improve the perception and decision-making abilities of robots doing cleaning jobs.

Considerations for safety:

Utilising UVC-based disinfection systems requires special attention to safety. Studies have looked into the potential health hazards of UVC exposure for users and onlookers. To ensure safe operation and reduce potential risks, protocols and guidelines have been created.

To maintain predetermined safety requirements, research has concentrated on tracking and regulating the UVC radiation levels emitted by disinfection robots. To maintain safe operating settings, this includes the use of UVC detectors and real-time monitoring systems.

III. PROPOSED WORK

We succeeded in building a robot with sensors, an Arduino UNO board, LEDs, wheels, wires, and UV-C lights. It uses the sensors to avoid bumping into obstacles and to determine whether anything is in its path. Signals from ultrasonic sensors are supplied to dc motors once an object has been spotted, and the robot changes its direction and keeps working based on those signals. Our prototype helped us to realise our goal of developing a disinfection robot that is favourable to the environment. We were able to successfully automate and efficiently reduce radiation hazards while sanitising diseased regions.

1) *UVC Lights:* The UVC lights are the main part of the robot, and the disinfection efficiency is determined by their wavelength and intensity.The best UVC lamps for disinfection are those that emit light at a wavelength of about 200 nm to 280 nm.
2) *Motor and Wheels:* The robot can only move on its own if it has a motor and wheels. To move the robot and control it, we used wheels and DC motors.
3) *Microcontroller:* The brain of the robot, which regulates sensor readings, UVC light activation, and motor motion, is a microcontroller. Our robot's microcontroller is an Arduino.
4) *Sensors:* Sensors are necessary for the robot to autonomously move, identify impediments, and determine its location. To give the robot the information it needs, a variety of ultrasonic sensors were used.
5) *Battery:* The lights on the robot must be powered by a battery. To make sure the robot can run for a long time,we have use a battery with a high voltage and capacity.
6) *Charging Circuit:* In order to replenish the battery when it runs out of power, a charging circuit is required. To efficiently recharge the battery, we have use a charging circuit that is appropriate with your battery.
7) *Power Supply:* To power the UVC lamps, a power supply is required. we have pick a power source that works with your UVC lights and can deliver the necessary voltage and current.
8) *Chassis:* A robot's chassis is required to keep all of its parts together and give it a solid base on which to move. our robot's frame is made of aluminium chassis.

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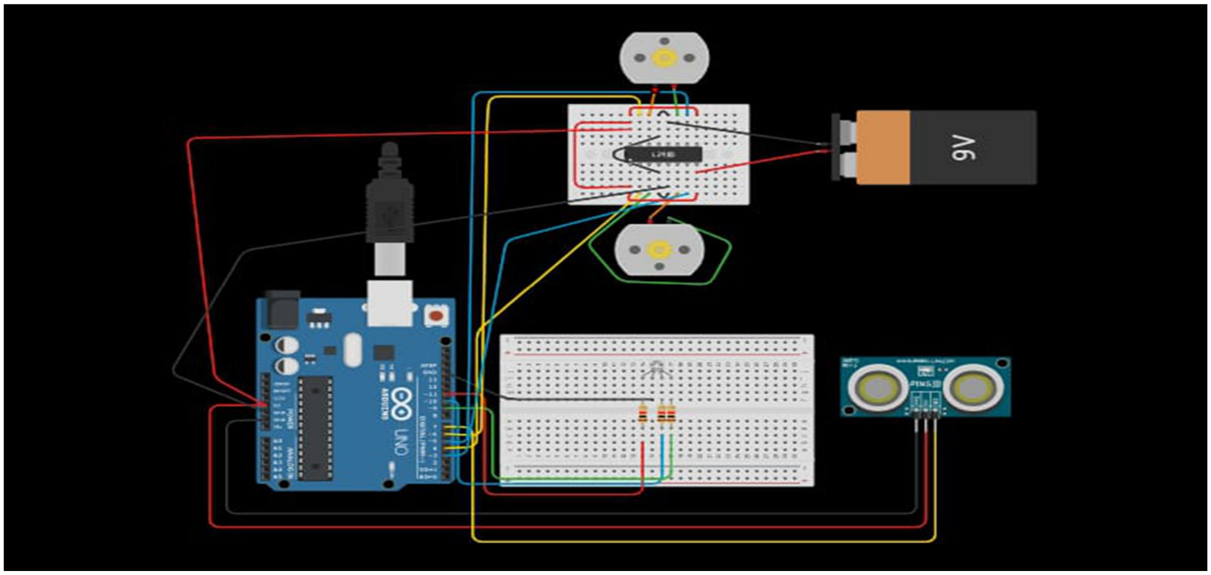
All the Components are mounted on the chassis which is powder coated with TGIC Polyester and Urethane Polyester.
Material: Metal sheet
Length: 200mm
Width: 105mm
Height: 50mm



9) *Arduino UNO:* Based on the ATmega328 processor, the Arduino Uno R3 is an opensource microcontroller board. This board contains a 16 MHz ceramic resonator on board, a USB port, an onboard DC power jack, an ICSP header, and a microcontroller reset button. It also has 14 digital input/output pins and 6 analogue input pins. Everything required to support the microcontroller is included. The board is also incredibly simple to use; to get started, just connect it to a computer using a USB cable, or power it using a DC converter or battery. Either a battery or an AC-to-DC adapter (wall wart) can provide external (non-USB) power. A 2.1mm center-positive plug can be used to connect the adapter by inserting it into the board's power connector. Additionally, battery leads may be plugged into the Power connector's Gnd and Vin pin connectors. The board can be powered by a 6 to 20 volt external supply. The 5V pin, however, may deliver less than five volts if supplied with less than seven volts, and the board may become unstable. The voltage regulator could overheat and harm the board if more than 12V is used. For Arduino Uno, a voltage range of 5 to 12 volts is advised.
10) *L293D:* A medium power motor driver ideal for operating DC Motors and Stepper Motors is the L293D driver module. The well-known L293D motor driver IC is employed. It is capable of driving two DC motors in each direction or four DC motors in one direction.

IV. SYSTEM COMPARISON

Research Paper	Objective	Methodology	Key Findings
Paper 1: "Effectiveness of UVC Disinfection in Hospital Settings"	To evaluate the effectiveness of UVC disinfection in reducing hospital-acquired infections	Quantitative analysis of bacterial colony counts before and after UVC disinfection in hospital rooms	UVC disinfection resulted in a significant reduction (90%) in bacterial colony counts, indicating its effectiveness in reducing hospital-acquired infections
Paper 2: "Comparison of UVC Lamp Types for Disinfection Efficiency"	To compare the disinfection efficiency of different types of UVC lamps	Laboratory experiment with controlled surfaces and varying UVC lamp types	High-pressure mercury lamps demonstrated the highest disinfection efficiency, achieving a 99.9% reduction in bacterial colony counts compared to low-pressure mercury lamps (95% reduction)

Paper 3: "Evaluation of UVC Robot Navigation Systems for Autonomous Disinfection"	To evaluate different navigation systems for UVC disinfection robots	Field study using UVC disinfection robots equipped with different navigation systems	Laser-based navigation system outperformed vision-based and ultrasonic-based systems in terms of accuracy and efficiency, enabling precise robot movement and effective disinfection
Paper 4: "Safety Assessment of UVC Disinfection Robots for Human Exposure"	To assess the safety of UVC disinfection robots in terms of human exposure to UVC radiation	Measurement of UVC radiation levels at different distances and angles from the robot's UVC lamps	The UVC disinfection robot maintained UVC radiation levels within safety standards at all tested distances and angles, ensuring minimal risk to human operators and bystanders
Paper 5: "Cost-Benefit Analysis of UVC Disinfection Robots in Healthcare Facilities"	To conduct a cost-benefit analysis of implementing UVC disinfection robots in healthcare facilities	Economic analysis considering initial investment, operational costs, and potential reduction in hospital-acquired infections	The implementation of UVC disinfection robots led to significant cost savings due to reduced infection rates, shorter patient stays, and decreased need for manual disinfection, outweighing the initial investment and operational costs

V. CONCLUSION

To sum up, the creation of UVC-based disinfection robots has become a potential development for automated and effective disinfection in a variety of contexts. The related research in this area has examined a variety of UVC disinfection, robot navigation, safety issues, and use-case scenarios.The efficiency of UVC disinfection in lowering bacterial and virus contamination has been shown in numerous research. In order to obtain the desired disinfection results, research has also concentrated on optimising UVC dosage, exposure period, and distance. The development and application of UVC-based disinfection systems have been influenced by this understanding.Robots that can autonomously navigate and disinfect a variety of surroundings have been a primary focus of research and commercial endeavours in the development of UVC disinfection robots. These robots use sophisticated sensor systems and path-planning algorithms to effectively cover the intended areas. Their ability to perceive and make decisions is further improved by the incorporation of artificial intelligence systems.When using UVC disinfection equipment, safety must always come first. Studies have looked at the possible health dangers linked to UVC exposure and have created measures to guarantee the security of both operators and spectators. It has been crucial to monitor and regulate the UVC radiation levels that robots release in order to uphold established safety regulations.Hospitals, schools, airports, and public transit networks have all successfully adopted practical UVC disinfection robot applications. These programmes are designed to reduce the spread of infectious diseases, increase cleanliness, and promote public health. It has been demonstrated that integrating UVC disinfection robots into current disinfection protocols can increase efficiency, be more cost-effective, and need less labour.

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