An Ultra-violet Disinfection Robot

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Abstract - In this pandemic, many people find it difficult to prevent the spreading of viruses. Disinfection is very difficult in crowded areas like hospitals, shopping areas, etc. So the low-cost and sustainable solution is more acceptable. We have design a robot called UV disinfection robot. It emits UV-C light that can kill pathogens such as COVID-19. UV-C rays are high-energy ultraviolet radiation that is capable of destroying DNA and RNA, but it's also very dangerous for the human body. That is why robots are relevant in such situations. This robot also contains extra safety features like collision avoidance and human exposure.

Key Words: Robot, Ultra-violet, Disinfection, Viruses, UV-C rays, Pandemic, COVID-19.

1. INTRODUCTION

Infection prevention technologies are of great challenge in this pandemic. Effective practice of daily cleaning routine and disinfection of environmental surfaces and patient care equipment is very important in reducing the transmission of pathogens to the patients. To avoid this, we have to use UV-C lights to disinfect them.

The purpose of this project is to design and implement a robot for disinfecting applications. Our UV robot disinfects small and large areas and also can significantly reduce the bacterial count in the air. Depending on the exposure time, the UV robot can kill up to 99.99% of pathogens such as covid-19. The robot's sensor will detect if someone enters a room under disinfection, and immediately stop the disinfection, it also avoids collision.

2. Literature Survey

2.1 An Ultra-violet sterilization robot for disinfection

Author- Pacharawan Chanprakon, Tapparat Sae-oung, Pimkhuan Hannanta-anan, Tressukon Treebuoachatsakul, Wibool Piyawattanametha.

In this paper, a UV bot based on an embedded system with Raspberry Pi is designed for the disinfection process. This UV bot can either manually or autonomously (using machine learning) navigate around a room including avoiding obstacles enabling it to thoroughly sterilized the entire, with or without human intervention.

2.2 Cathartic Bot for hospital applications

Author- Srividya.K, Nagaraj.S, Subramanian.M, Nithya Rani.N.

In this paper, a bot is designed which is controlled through a mobile app to avoid direct contact. When the room has been cleansed fully, the rate of light reflection will be reduced so the robot will be turned off automatically.

2.3 Programmable and low-cost ultraviolet room disinfection device

Author- Marcel Bentancor, Sabina Vidal.

This paper presents a room disinfection device based on Ultraviolet-C radiation. Initially, it was designed for the periodic conditioning of culture rooms. It offers the capacity to be remotely programmed using an Android mobile device and it has an infrared detection security system that turns off the system when triggered.

2.4 UV Disinfecting robot for tabletops

Author- Anabel Rivera, Antonio Rivera, Eros Garcia.

In this paper, a robot is designed as a cleaning solution that cleans mechanically, which can become costly if many units need to be installed and also lead to quicker failure of parts. They have designed an autonomous robot that can maneuver on a tabletop. It is more cost-effective since it can be used for multiple tables.

2.5 A human support robot for the cleaning and maintenance of door handles using a deep-learning framework

Author- Balakrishnan Ramalingam, Jia Yin, Mohan Rajesh Elara, Yokhesh Krishnasamy Tamilselvam, Madan Mohan Rayguru, M.A. Viraj J. Muthugala, Braulio Felix Gomez.

In this paper, a robot is designed using deep learning techniques. This work proposes an AI-enabled framework for automating cleaning tasks through a Human Support Robot (HSR). The overall cleaning process involves mobile base motion, door-handle detection, and control of the HSR manipulator for the completion of the cleaning tasks. The robot is safe to operate near customers and emits less than 10 uJ at 3m away from the device.

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3. Block Diagram and System Analysis

The construction of the device involves three stages:

1. Structural building
2. Electronic assembling
3. Programming of the microcontroller.

The heart of the system is a microcontroller. That is a central command center of the UV bot. It is programmed to accept inputs to sense obstacles and motion around it, and navigate the robot around the room to avoid any collisions and alert when motion is detected. Given below is the block diagram of our project.

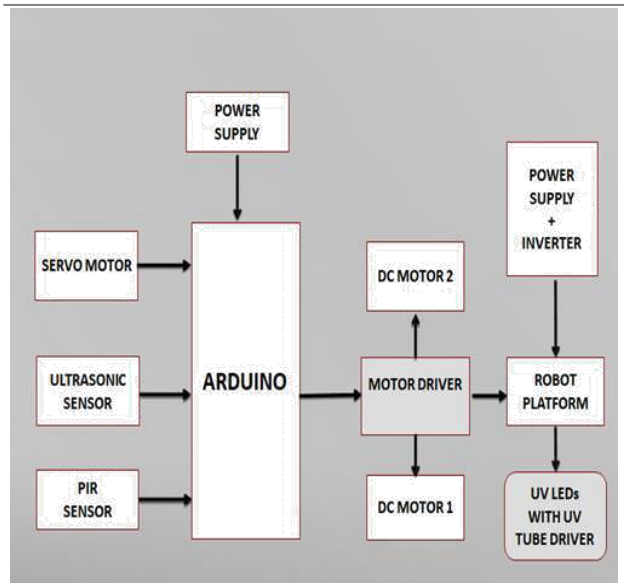

Fig 1: Block Diagram

Arduino Uno R3 is an open source microcontroller board based on ATmega328P; it has 14 input/output pins. Arduino Uno R3 is programmed such that it controls the functioning of the robot. We have interface 2 sensors i.e. HC-SR04 Ultrasonic sensor and HC-SR501 Passive infrared sensor (PIR) with Arduino Uno R3.

Ultrasonic sensor uses SONAR to determine the distance of an object (range of detection is between 2 cm to 400 cm). The ultrasonic sensor transmits a high frequency ultrasonic sound, which bounces off any nearby solid objects, and the receiver listens for any return echo, when any obstacle is encountered robot will change its direction. A servo motor is used to rotate the Ultrasonic sensor approximately 180-degrees.

Passive Infrared sensor (PIR) sense motion, it receives the infrared radiation from the human body to make an alarm (Detection range is from 25 cm to 20 m with 360-degree coverage). It uses a pair of pyro-electric sensors to detect heat energy in the surrounding environment.

We have connected 6 mm center shaft DC motors to the L298N motor driver. L298N is a dual H-Bridge motor driver which allows speed and direction control of two or four DC motors at the same time. This module consists of an L298 motor driver IC and a 78M05 5V regulator (RPM = 100).

Above a robotic platform, UV-C LEDs are placed with UV tube drivers to avoid damage of the LEDs. LED driver rectify higher voltage, alternating current to low voltage, direct current.

There are three types of UV lights i.e. UV-A (400 nm -315 nm), UV-B (315 nm -280 nm), and UV-C (280 nm – 100 nm). UV-C is a high energy ultraviolet radiation that is capable of destroying DNA and RNA. This is what allows the LEDs to kill viruses and bacteria on a surface. UV-C light is proven effective in killing micro-organisms. The nominal disinfection range is 253.7. Only UV-C has the nominal range hence the proposed system used these lights to kill the RNA and DNA of the micro-organisms.

Given below is the diagram of working of UV-C light.

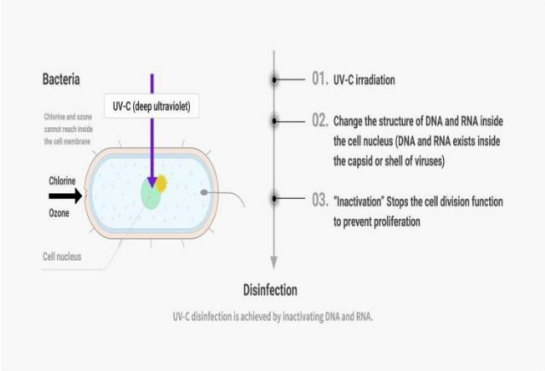

Fig 2: Working of UV-C light

4. Calculation Formula for Brightness And Time

Our UV bot utilized 3 UV lamps mounted in a circular pattern with 120 degree apart. Each lamp has a 19.3-watt output (as listed on a UV lamp datasheet). The amount of brightness in with a certain distance away can be calculated below as:

$$\text{Brightness} = \frac{Luminosity\ (w)}{4n * \text{Distance (cm)}}$$

In order to calculate the amount of exposure time to eradicate germs is expressed below:

$$\text{Time} = \frac{UV\ Dose\ (\mu M.\ sec/cm^2)}{\text{Brightness } (\omega/\text{cm})}$$

5. Hardware

1. Arduino Uno R3
2. UV-C tube with UV tube driver
3. Robot platform
4. L298N motor driver
5. Centre shaft DC motor and wheels
6. PIR sensor
7. Ultrasonic Sensor
8. Battery and inverter
9. Servo motor
10. Connecting wires

6. Software

1. Arduino IDE
2. Proteus
3. Embedded C language

7. Flowchart

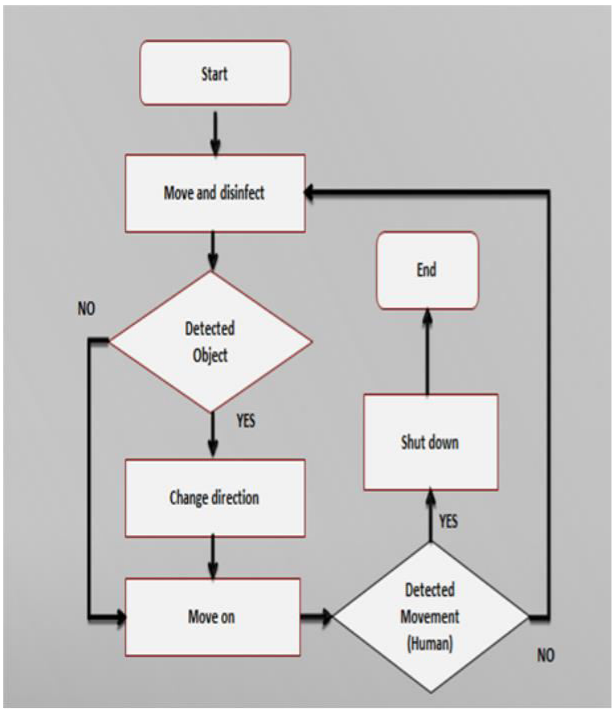

Fig 3: Flowchart

Above figure is the flowchart of our project.
When the robot is turned on, it starts moving and disinfecting the area. The transmitter of ultrasonic sensor emit a high frequency ultrasonic sound, which bounce off any nearby solid objects, and the receiver listens for any return echo. If it detects an object it will change its direction and continue to disinfect the area. In this way it will avoid collision by changing its direction, if it gets contact with an obstacle.
PIR sensor can detect human/motion in a requirement range. It detects infrared radiation from the human body particle with temperature, focusing on the optical system causes the pyro-electric device to generate a sudden electrical signal. This causes a positive differential change. If human or any motion is detected during the disinfection process, UV robot will get turn off automatically. When a human body leaves the sensing area, the sensor generates a negative differential change between the two bisects.
Likewise, it will cover the entire area and disinfect. We can turn off the robot as per the time calculated for disinfection from the above formula. Disinfection time depends on the area to be covered as well as the brightness of our UV-C tube. To spread light over a wide area we can cover the robot platform as well as stand on which the tubes are mounted with aluminum foil so, that light gets reflected and more area can get cover in short time.

8. Hardware Design and Implementation

Fig 4: Design of the UV-C robot

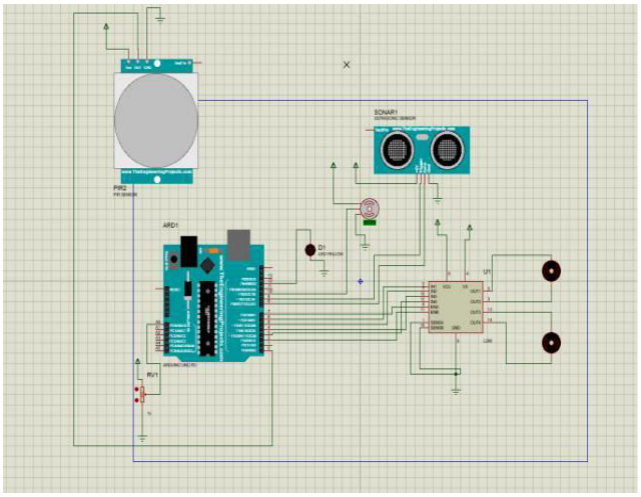

Fig 5: Circuit diagram

9. Conclusion

The aim of the present work is to contribute in the fight against the spread of Covid-19. This work proposed an open source UV-C room disinfection robot. This project gives about 80-85% of efficiency of UV disinfection. It saves money as well as reduces risk to get infected.

10. ACKNOWLEDGMENT

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