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Smart Disinfection Bot Using UV-C Radiation

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Abstract – *In the past year, the whole world has been suffering from the Coronavirus outbreak right now. Virus outbreaks are highly contagious and life-threatening. One of the essential steps in controlling the outbreak of infectious diseases and defeating global pandemics is the disinfection of contaminated surfaces. Maintaining safe and clean public spaces can be pretty challenging, especially if different people are frequently touching feelings. Public areas and frequently touched surfaces are disinfected manually using portable disinfection devices. Manual disinfection is labor-intensiveand increases the risk of infection by exposing cleaners to contaminated surfaces. Robots have the potential of being deployed for disinfection. Disinfecting contaminated surfaces using robots is efficient and reduces the risk of infection, and overcomes the costs involved in manual cleaning. Excessive use of strong disinfectants can also cause severe health problems. This global pandemic has encouraged us to design and build a safe, human-friendly UV-C disinfection mobile robot for public spaces as well as personal use. The UVC rays can reach tight spaces, which can be easily missed during manual cleaning. Disinfection robots provide an efficient and effective solution to disinfecting high-risk and frequently touched surfaces without the need for human intervention.*

Keywords: — Contactless, Raspberry Pi, UV-C, Servo motors, Disinfectant, Camera.

1. INTRODUCTION

Coronavirus disease (COVID-19) is caused by SARS- COV2 and is a causativeagent of a fatal illness of great globalpublic health concern. Person-to-person transmission of COVID-19 infection results in isolation of patients providing various treatments. Extensive measures to reduce person-to-person transmission of COVID-19 have been implemented tocontrol the current outbreak. Currently, early detection of the coronavirus is often done by checking a person's body temperature. Body temperature is one of the vital signs that describes a person's health status. If a person's body temperature is above normal, it is said that the person has a fever. Fever can be caused by abnormalities in the brain itself or by toxic substances that affect the body's temperature regulation center.

As we know, the whole world has been suffering from the Coronavirus outbreak right now. Virus outbreaks are highly contagious and life-threatening. One of the essential stepsin controlling the outbreak of infectious diseases and defeating global pandemics is the disinfection of contaminated surfaces. Maintaining safe and clean public spaces can be challenging, especially if surfaces are being frequently touched by different people. Public areas and frequently touched surfaces are disinfected manually using portable disinfection devices. Manual disinfection is not only labor-intensive but also increases the risk of infection by exposing cleaners to contaminated surfaces.

The current COVID-19 pandemic has promoted many innovations at the public, social and medical levels, and disinfection practices are no exception. Robots used for disinfecting are a promising tool for surface disinfection in hospitals today, but they have more significant potential in the future. A cost-effective UV robot is designed to limit the spread of bacteria and viruses. Bacteria and viruses spread along a particular route, and it can reach inaccessible areas for effective disinfection. Environmental disinfection on the surface isan essential tool to prevent the spread of infection in the hospital. However, manual cleaning and disinfection may not be sufficient to remove pathogens from contaminated surfaces.

There is increasing publicity to implement ultraviolet-C (UV-C) eradication of autonomous disinfection equipment (i.e., robots) to supplement standard decontamination procedures while reducing time and workload. Although the principle of disinfection based on UV-C has already been proven, little is known about the operation details of the UV-C disinfection provided by the robot. These robots are being increasingly touted as a simple solution for instant disinfection of room spaces and all surfaces in one process, so they appear to be attractive for hospitalmanagement, also because of automation and by a reduction in the number of cleaning staff, significant cost savingsareachieved. However, the true potential in the hospital setting requires careful evaluation. The use of UV-C light for disinfection where certain surfaces are not exposed due to obstacles or inaccessibility.

The manual cleaning and disinfection are often inappropriate and can lead to residual contamination. Robots have the potential of being deployed for disinfection. Disinfecting contaminated surfaces using robots is not only efficient, but it also reduces the risk of infection and overcomes the costs involved in manual cleaning.[1] Excessive use of strong disinfectants can also cause severe

health problems. The UVC rayscan reach tight spaces, which can be easily missed during manual cleaning. Disinfection robots provide an efficient and effective solution to disinfecting high-risk and frequently touched surfaces without the need for human intervention.[2] This global pandemic has encouraged us to design and build a safe, human-friendly UV-C disinfection mobile robot for public spaces as well as personal use. It is an environmentally friendly method as it leaves no residue behind.

The objective of this project is to successfully design and assemble a UV-C disinfection robot for public spaces like hospitals, shopping centres, offices and universities. The robot should disinfect and sanitize frequently touched surfaces by emitting condensed UV beams that will destroy the genetic structure of the microorganisms and prevent them from reproducing. The robot must be safe and human-friendly, so it must be able to detect the presence of humans and animals. The robot must detect the presence of humans and animals to protect them from the radiation while continuing to disinfect other areas. This must stop the disinfection process in their direction in optimum time to ensure safety. The robot must be fully autonomous requiring no user input except from switching the robot and on minimizing the widespread of the virus and slow down the pandemic.

2. LITERATURE REVIEW

M. Bentancor et al. in their paper named "Programmable and low-cost ultraviolet room disinfection device" 2018 discuss about a room disinfection device based on Ultraviolet-C to eliminate high bacterial inocula and how it can be remotely programmed using an Android mobile device[3]. The use of above-mentioned experimental tests showed the very sanitizing method employed by this device which affects an extensive range of microorganisms and it has several advantages with respect to chemical based-sanitizing processes. This device represents an open source, secure, 2 fast, and automatized equipment for room disinfecting. They also outline that switching toanautomated method instead of a manual helps in continuous monitoring. Their study helps in understanding the advantage of technology as well as its interfacing with the Arduino microcontroller.

A.Vyshnavi et al. in their paper named "UV Disinfection Robot with Automatic Switching on Human Detection" designed a UV Robot that has infrared sensors at the bottom of the base, which can follow a predetermined path[4]. They implemented it by using three 20W UV lamps along with PIR sensors to detect the presence of humans or animals and further interfaced it with Arduino microcontroller. The ultraviolet sterilization robot has a minorappearanceandcan automatically turn on/off when it detects a person or animal so that it will not cause damage.

D. Deepu et al. in their paper named "Robot Prototype for Disinfection of Surfaces" designed a disinfection system and implemented on a robotic platform which sanitizes the surfaces with the help of UV-C rays and further deployed it using Raspberry Pi[5].

A. Begić in his paper named "Applicationof Service Robots for Disinfection in Medical Institutions" discussed about various service robots which are used in medicine industry mainly for disinfecting surrounding[6]. This paper reviews the medical service robots, focusing on the service robots used for disinfection in medical institutions. It shows and describes how more and more disinfection service robots contribute to the very simple, fast and effectivedisinfectionof medical institutions. It also mentioned about how the use of above-mentioned technology can reduce the risk of infection and cost of cleaning and as well as security in medical fields.

P. Chanprakon et al. in their paper named "An Ultra-Violet Sterilization Robot For Disinfection" designed a UV robot for sterilization in patient room [7]. They deployedanembedded system based on a Raspberry Pi which helped in navigation. The speed and movement of the robot and UV lamp is controlled via the website by the user within the same Wi-Fi network connected.

T. Rubaek et al. in their paper named "Evaluation Of The Uv-Disinfection Robot" designed a robot using UV- C light rayswhich reduces the Hospital Acquired Infections or other types or harmful organic microorganisms [8]. Their results showed that exposure time of ten minutes could kill up to 99.9% of common bacteria. Also, their bot can move autonomously.

3. METHODOLOGY

3.1 Technology Used

The most essential aspect of the device is to cleanse surfaces of any harmful bacteria or microorganisms. The transmission rate of such organisms is very high via air as a medium, and hence it is necessary to eradicate them. UV-C radiation provides an efficient solution to this issue. It inactivates the vital components of the microorganisms and kills them. It does so using radiationwhich ruptures the DNA as well as the RNA of the microorganisms which prevents them from reproducing further and hence stops them from multiplying further which effectively means that they are dead. UV-C radiation has been used extensively for cleaning purposes, mainly in the medical sector, to cleanse operation equipment. In recent times, devices such as UV-C ovens have been produced to help clean personal belongings after coming from outdoors so as to get rid of any residual bacterias on personal stuff.

While the same radiation can be harmful for humans as well as animals if exposed to it for extended periods. For preventing such incidents, we have used a camera module alongside raspberry pi to detect the presence of humans and animals. Now how it works is that as soon as the ultrasonic sensors detect some obstacle, the bot stops, and the camera takes a photographahead of the bot. By using deep learningthe computer has been taught to determine the objects present in front of it to be humans or animals. If it detects thesame, a shield is activated in the direction of the

human to protect it from the UV-C radiationwhile still cleaning the rest of the surroundings. In this way, the bot helps in cleaning all surfaces while still keeping the humans and animals safe from those radiations, which can be harmful successfully.

3.2 Block Diagram

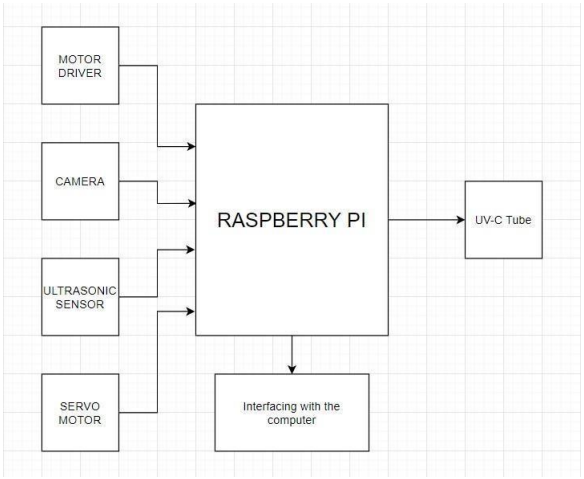

Fig -1: Block Diagram of Smart Disinfection Bot Using UV-C Radiation

To build a UV-C bot, we integrate different hardware components such as ultrasonic sensors, driver module, camera, servo motor with the Raspberry Pi, which in turn needs to be connected with the computer. The ultrasonic sensor is a transducer that converts electrical signals to acoustic wavers andacoustic waves to electrical signals. The ultrasonic sensor provides the distance between the device and the person. Raspberry Pi is used for communication and is further connected to a low-cost camera for the detectionof humans or objects.

L293D is a motor driver IC that enables us to drive a DC motor in either direction. It is a 16 pin IC through which two DC motors can be controlled simultaneously inany direction. Servo motors allow for precise control of angular or linear position, velocity for the camera, and UV-C tube to move. 7805 Voltage Regulator IC is as an adjustable output voltage regulator. LEDs will be used as an alternative to UV-C lights on the prototype. The UV-C lights can burn the skin and destroy genetic material, so all the initial testswill be carried out using LEDs

3.3 Circuit Diagram

The circuit diagram consists of 6 units which are as follows:

1. Raspberry Pi: Raspberry Pi isa series of small single-board computers. It helps in the interfacing and communication between various sensors and modules,

2. Servo Motor: A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity, and acceleration [9].

3. Ultrasonic Sensor: Thesewill be used to detect the distance and avoid obstacles as the distance of a target object is measured by emitting ultrasonic soundwavesandconverting the reflected sound into an electrical signal.

4. Low-Cost Camera: This will be used to detect the presence of humans and animals around the robot.

5. LEDs/UV-C Tube: LEDs will be used as an alternative to UV-C lights on the prototype. The UV-C lights can burn the skin and destroy genetic material, so all the initial tests will be carried out using LEDs.

6. L293D Motor Driver Module: It is a motor driver IC which enables us to drive a DC motor in either direction.

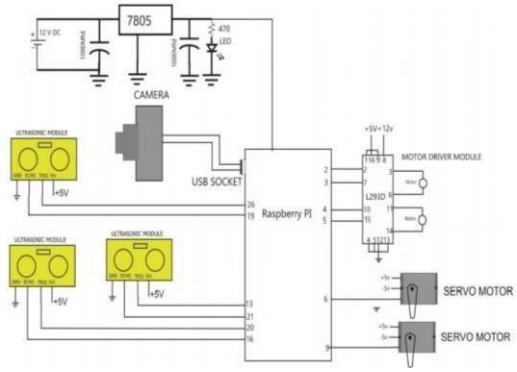

Fig-2: Circuit Diagram of Smart Disinfection Bot Using UV-C Radiation

3.4 Functioning of the Bot

The UV-C bot consists of different sensorsanda Raspberry Pi, which are interfaced together to work alongside each other and produce the desired results. And the device moves with the help of a motor driver module and servo motors which are also connected to the raspberry pi. There is an array of ultrasonic sensors which helps in navigating the device unmannedand steerclear of walls and otherobjects. It checks all the distances with the ultrasonic sensor, and then on the basis of comparison with the threshold distance, it moves. If the distance measured byany sensor is less thanthe threshold value, then stop the bot, turn the servo fitted with camera in direction pointed sensor, and takes a snapshot of the object. Also, a USB camera is connected to the deviceused to detect the presence of humans andanimals toprotectthem from radiation and steer clear of them as soon as their presence is detected. The UV tube isalso connected on top of the device to disinfect the surroundings as well as the frequently touched objects simultaneously as the device moves around. Then UV shield will disinfect the surroundings, and if it is not a human, then servo with the

shield will not be rotated. This is how the device works to sanitize or disinfect efficiently.

4. DESIGNS AND SIMULATIONS

A python code was written and compiled that can read data from the mentioned sensors, and communication will take place using Raspberry Pi.

The steps to achieve the said motive is as follows:

1. The device moves with the help of a motor driver module and an array of ultrasonic sensors, which helps navigate the device unmanned. It first checks all the distances with the ultrasonic sensor. It then makes a decision on which side to move based on the distance of the obstacle returned by the ultrasonic sensor on the basis of comparison with the threshold distance.

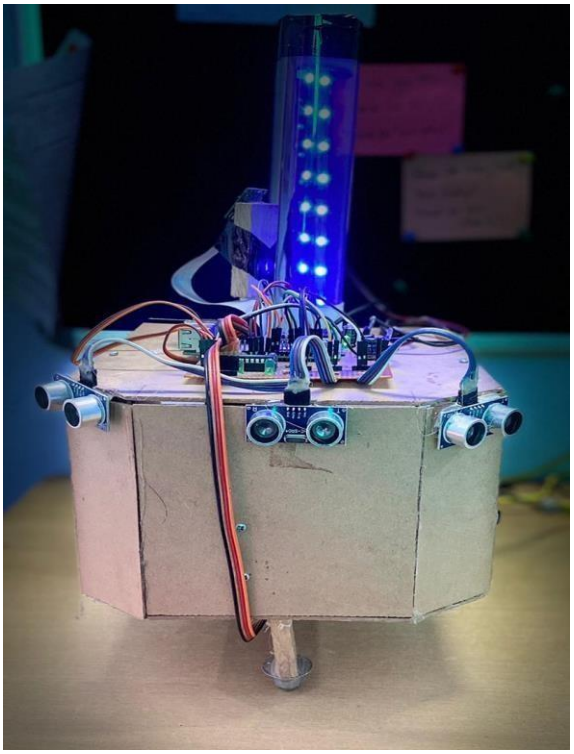

Fig-3(a): Prototype – Front View

2. If the distance measured by the front sensoris lessthanthe threshold value, then stop the bot, turn the servo fitted with the camera in the direction pointed by the front sensor and call the cam() function, which takes a snapshot of the object and through image processing returnwhether the object is a human or not, if it is a human thenanotherservo thatis fitted with UV shield will be rotated at the same angle as of the servowith the camera andif it is not a human thenservowith the shield will not be rotated.

If the front distance was not less than the threshold, then we check:

If the left distance is less than the left threshold distance, then stop the bot, take a snapshot, and with image processing, check whether the object on the left is human or not it is human then rotate to servo of the shield towards left and if not then leave it as it is. And then turn the bot towards the right for and run the next iteration.

Fig-3(b): Prototype – Side View

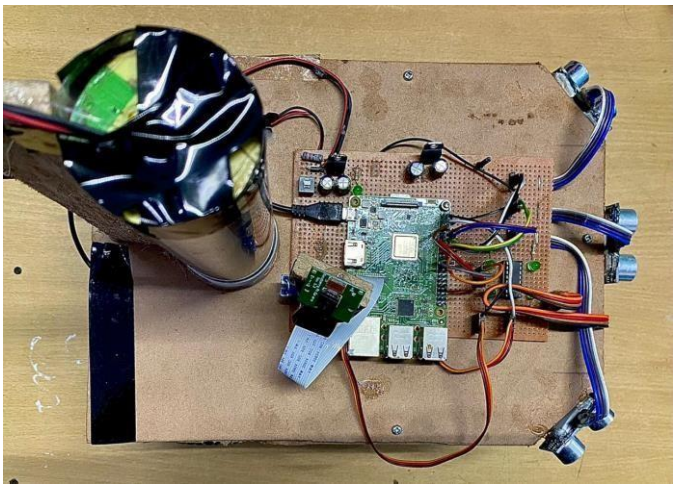

Fig-3(c): Prototype – Top View

Else If the right distance is less than right threshold distance, then stop the bot, take a snapshotandwith image processing, check whether the object on the right is human or not it is human, then rotate to the servo of the shield towards the right, andif not, then leaveit . And then, turn the bot towards the left for 0.5 sec and run the next iteration.

If none of the conditions holds true, then keep moving forward.

3. Then UV shield will disinfect the surroundings, and if it is not a human, then servo with the shield will not be rotated.

5. RESULTS AND DISCUSSIONS

We were able to combine various sensors with Raspberry Pi and interface everything with UV-C to come up with a human-friendly robot for disinfection of public as well as personal use hence made the prototype work.

A.Vyshnavi et al. have used PIR sensors, UV lamps, control box, power supply, battery, Arduino, twoinfraredsensors[4]. This system ensures the limit of the spread of bacteria and viruses; however, it follows a pre-defined path. That is, it is not flexible enough to move on its own and is not smart enough to decide whether there is an obstacle or it's a clear path to follow. In our proposed idea, our bot moves autonomously without any pre-defined path and is flexible and smart enough to determine whether there is any obstacle present or in which directionit has to movewithout any need for a pre-defined path.

D. Deepu et al. have used a raspberry pi, pi camera, android phone, and ultrasonic sensor[5]. Even though the main idea behind the present devices remains the same, i.e., to disinfect various places using UV-C radiation[4]. Thereare some key differences. Our device uses ultrasonic sensors to move around withoutany human assistance. In contrast, the other bot moves around with the help of commands provided by the operator, which means it is not able to move around autonomously and is dependent on the person operating that device. Our project, which recognizes an obstacle, disinfects the surroundings. It turns around in a different direction all on its own. Our bot was able to move around without any commands apart from the ON/OFF command.

In this way, the bot moves around continuously, disinfecting all surrounding surfaces as well as frequently touched ones without harming any humans or animals. The bot has shown great potential in replacing the manual cleaning method as well as the use of dangerous chemicals which leave residue after cleaning.

6. CONCLUSIONS

The main objective of our work was to provide an alternative for the disinfection process of public as well as personal spaces. We wanted to replace the current method of using chemical disinfectants and manual cleaning with an autonomous bot which would require minimal human assistance.

We were able to create the bot utilizing an array of ultrasonic sensors, motors, motor driver, raspberry pi, and a camera module alongside UV-C radiation. It uses the ultrasonic sensors to avoid running into obstacles as well as to detect whether some sort of object is present in front of it. After it has detected an object, the camera module takes a photograph of what is in front and decides whether it is a person or an animal. If so, then it is protected from the UV-C radiation by using a shield. If the obstacles are a human (or any other living being), the shield gets activated, blocks the UV lights in their specific direction, and changesitspath. Else if the obstacle is determined as a non-living thing, then the robot the shield is not activated, and the UV lights sterilize the surroundings and, once sterilized, will change its path.

Our aim of creating an environment friendly disinfection robot was achieved via our prototype. We successfully made the sanitization process in infected areas automated and efficient, as well as able to reduce risks of radiation.

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