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Disinfectant Robot

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***Abstract*--- The source of the infections in operating or patient rooms in hospitals can be difficult to identify, as patients, visitors, and physical objects can be transfer agents. Therefore, a comprehensive disinfection is necessary to minimize the risk of transmission and infection. If sanitization is done by human there is possibility that a person might get infected. Hence an Ultraviolet (UV) sterilization technology, along with sprayer, is used to aid in reduction of micro-organisms that may remain on the surfaces after a standard cleaning to the minimum number. Disinfectant Robot is used to sanitize an operating or a patient room and has UV lamps mounted on top of the robot platform covering 180° direction. The robot also has sprayers placed at the front end. The disinfectant robot is employed by an embedded system based on a Arduino UNO to aid in navigation to avoid obstacles.**

***Keywords*--- OR, UV**

I. INTRODUCTION

The goal of environmental control in the operating room (OR) or a patient room setting is to keep micro-organisms including drug-resistant bacteria to an irreducible minimum in order to provide a safe environment for the patient and healthcare worker. At present, there are as many as 14-17% of infections in operating, and 38% of hospital infections occur in patients who have surgery. Therefore, both daily preoperative and terminal cleaning of the OR environment is one of the most effective infection control methods used to accomplish the goal in minimizing the number of micro-organisms, dust and organic debris present in the environment.

Currently, fixed UV system (shown in Fig 1) has many limitations in use. For instance, a UV exposure is harmful to users if they are exposed for a long time or in a very large quantity. It can cause redness of the skin and eye infections (conjunctivitis).

A Disinfectant Robot is designed that can either manually or autonomously navigate around a room avoiding obstacles enabling it to thoroughly sanitize the entire operating room with or without human intervention.

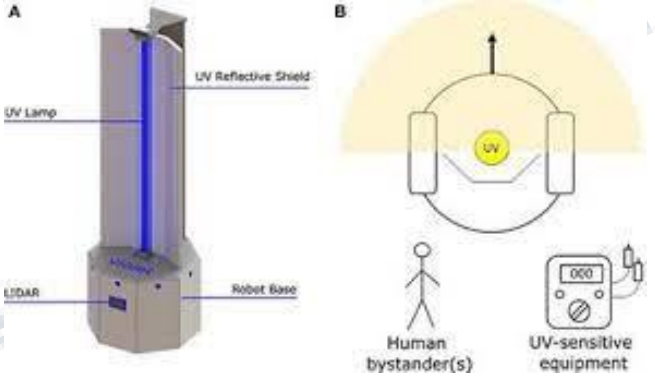

Fig 1: Applicability of Robot

II. LITERATURE REVIEW

A.M Spagnolo here discussed about the approaches to improve cleaning effectiveness that includes educational campaigns, feedback of cleaning performance and microbiological analysis of surface hygiene[1] .

Ottawa has discussed about the comparison of two different methods of operating the robot i.e., either manually or autonomously for sanitizing the entire room[2].

D.J. Anderson discusses about the use of non-manual room disinfection which reduces the chances of operator errors associated with traditional cleaning methods and offers the potential for more effective eradication of pathogens to reduce transmission of infections[3].

Curcio Katharine tells about the physical disinfection method by using sprayer and UVC light as agent. The UVC devices are studied and classified according their

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disinfectant units, complementary devices, combined disinfection agents, mobility and order types[4] .

Zeashan Hameed Khan describes the evolving role of robotics in healthcare and allied areas with special concerns relating to the management and control of the spread of the novel corona virus disease 2019 (COVID-19)[5]. The prime utilization of such robots is to minimize person-to-person contact and to ensure cleaning, sterilization and support in hospitals and similar facilities such as quarantine.

III. MOTIVATION

The threat of the spread of viruses is not something new, but the recent COVID-19 pandemic has sparked many responses, socially, medically, and technologically. The need to do more to stop the spread of viruses in these busy public spaces led to two companies that are leaders in their fields combining forces to produce a new, highly capable, "mini UVC" robot for the safe, autonomous disinfection of public buildings.

IV. PROBLEM STATEMENT

The source of the infections in operating or patient rooms in hospitals can be difficult to identify, as patients, visitors, and physical objects can be transfer agents. Therefore, a comprehensive disinfection is necessary to minimize the risk of transmission and infection. If sanitization is done by human there is possibility that a person might also get infected. A Disinfectant Robot has been proposed for sanitizing the operating or patient rooms.

V. OBJECTIVES

1. Ultraviolet sterilization
2. Spraying of chemicals for sanitization.
3. Detection of Ultrasonic Sensor.

VI. METHODOLOGY

The heart of the system is Arduino UNO i.e., a central command centre of the robot. It is programmed to accept inputs to sense obstacles around it and navigate the robot around the room to avoid any collisions. There are ultrasonic sensors mounted on the robot. These are located in front, left, right, and back of the robot platform. If there is an obstacle in the pathway, two controlled wheels will help steer around that obstacle according to processed signals received from ultrasonic sensors. In case of an obstacle or a potential collision, the wheels of the robot are controlled by a motor driver to avoid collision.

- The robot will move and through ultrasonic sensors identifies the object and changes its path.
- Once the robot enters the room it turns ON the UV light or sprayer to sanitize the room.
- The Ultraviolet (UV-C) rays kill the micro-organisms like bacteria and virus keeping every individual safe and happy. Thereby completes the sanitization process.
- The robot then moves to other location and keeps identifying the objects through sensors, in limited area as shown in Fig 2.

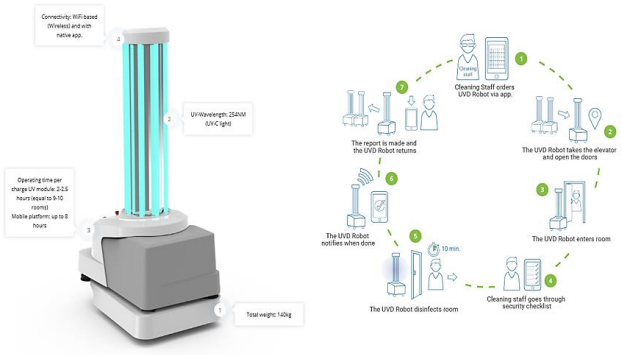

Fig 2: Disinfectant Robot saving people's life

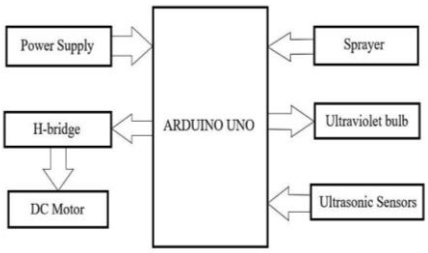

Fig 3: Block Diagram of the Disinfectant Robot

Flowchart

Working Procedure:

In order to design a mobile robot, minimum of two motors are used to propel and steer the robot. Four wheeled robots have either two or four drive motors and use skid steering. A self-balancing robot was made using four wheels and 2 DC motors, for stable platform, which is as shown in Fig 4.

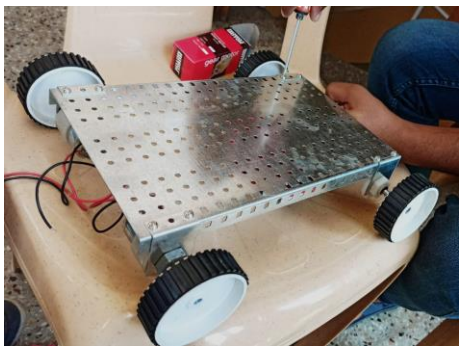

Fig 4: Fitting of Wheels and DC Motors

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The next step is to place all the components on the cardboard. Starting with Arduino (shown in Fig 3), it is a controller which consists of 28 pins out of which 14 are digital pins, 6 are analog pins and remaining pins are the supply pins. If all the digital pins are connected then analog pins can be used as digital pins for any further connections.

The operating voltage of the controller is 5V which is given to the power supply. The VIN pin of the controller is a 12V pin which is not connected. If 12V is given from the power supply, then there are chances that whole circuit may get damaged. The 7805 Voltage Regulator in the power supply reduces from 12V to 5V. This model uses two H-bridges.

One H-bridge is used to run two DC motors with the same IC (L293D), whose main purpose is to control the direction of the robot. Each motor has two input pins and one enable pin. The H-bridge also consists of 12V, GND and 5V pins. The 12V pin is connected to the power supply and the 5V is given for working of the IC.

The third DC motor is used to rotate the UV bulb which is mounted on top of the robot that covers 180° direction. The other H-bridge has been used to control this DC motor.

An Ultrasonic Sensor is placed at the front-end of the model. It has 4 pins namely, VCC, TRIG, ECHO and GND. This sensor is used to measure the distance between robot and the obstacle in its path (To know the presence or absence of the obstacle we use IR sensors). When an obstacle is detected the robot takes a diversion. The TRIG is an input pin which sends the signal and is received by the ECHO pin. This works on the principle of sound waves.

A 2-channel relay (shown in Fig 5) has been used which acts as an automatic switch. The input is 5V and it can withstand up-to 270V at the output side. This relay consists of four pins, one input pin for one relay and the other input pin for another relay. The other two pins are VCC (5V DC) and GND. When the relay is triggered UV light turns ON and when disconnected the UV light turns OFF.

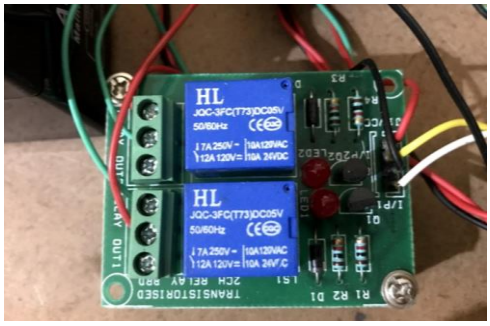

Fig 5: 2-channel Relay

As mentioned earlier, the half progress of the model is shown in Fig 6 in which the components are connected to each other by the soldering process.

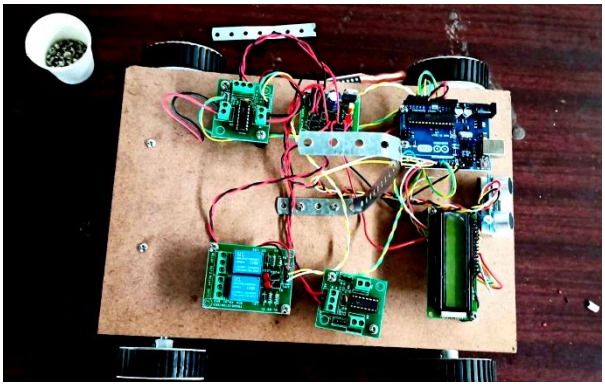

Fig 6: First stage of implementation of the robot

The UV LED is a two - terminal device. The positive terminal is connected to one end of the resistor (100Ω) and the other end is connected to relay and the negative terminal is grounded. The LEDs (shown in Fig 7) emit UV rays of wavelength 100nm – 315nm. Once the robot is switched ON (either manually or automatically), it starts moving in forward direction and the LEDs are turned ON for the sanitizing the room. These LEDs cover 180°. The robot takes the left turn when an object is detected at a distance of >40m.

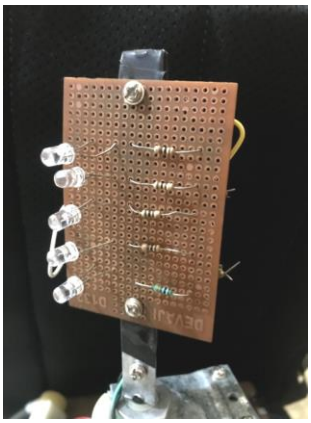

Fig 7: UV LEDs mounted on top of the Robot

In automatic mode, the robot can operate either by reading the inputs/commands given by the user through the Telegram application (as shown in Fig 8) or by a DC battery.

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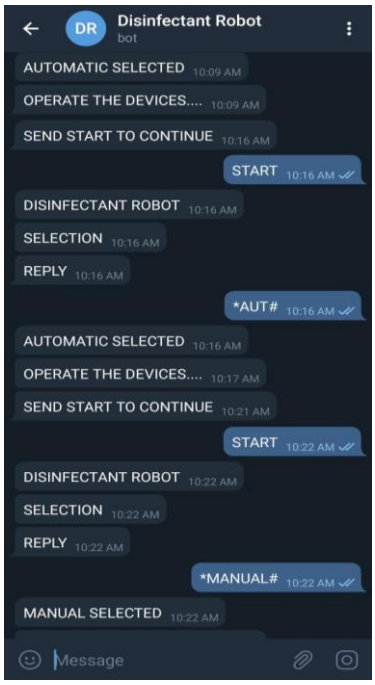

Fig 8: Commands to operate in automatic mode

In manual mode, the robot and the user has to converse in the Telegram application by providing the inputs/commands as shown in Fig 9.

Fig 9: Commands to operate in manual mode

NodeMCU (Node Micro Controller Unit) is a small controller that works like an Arduino. It consists of only 1 analog pin and remaining pins are digital pins. Due to the deficiency of analog pins Arduino UNO has been used as the heart of the robot. The NodeMCU also has an in-built Wi-Fi Module (ESP8266) which can be connected to our phones so that the model can be operated manually.

For automated operation of the robot a rechargeable DC battery is also used whose operating voltage is 12V. The positive terminal is connected to 12V and negative is grounded so that there is a continuous loop to get a power supply.

An alphanumeric LCD has been placed to display the robot direction as well as its operation, for example, FORWARD, LEFT, REVERSE, LED_ON, LED_OFF, SPRAYER_ON, SPRAYER_OFF. The distance measured by the Ultrasonic sensor is also displayed on the LCD.

The brightness/contrast can be adjusted by 10K pot at pin 3 (VEE) of LCD. The Disinfectant Robot is now ready to take its action on micro-organisms by sanitizing the rooms. The Ultraviolet (UV) rays kill the micro-organisms like bacteria and virus keeping every individual safe and happy. Thereby completes the sanitization process.
The complete model is shown in Fig 10.

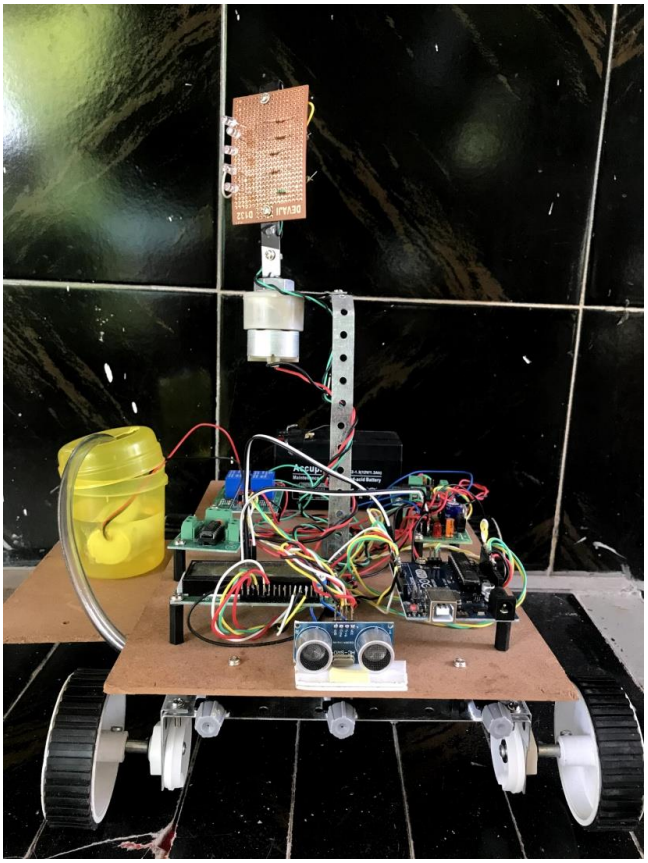

Fig 10: Final implementation of the Disinfectant Robot

VII. OUTCOMES

- **Quick and Effective for Room De-contamination**

The system consists of 5 UV LEDS and patented rotational (180°) reflector technology to effectively distribute UV-C to the surroundings to inactivate and kill microorganisms. The technology provides an easy, fast, environmentally-safe and low maintenance operation for the operator throughout the lifetime of the product.

- **Kills Bacteria and Viruses even Fungus**

The robot is capable of eradicating 99.99% of micro-organisms (such as MDRO, bacterial spores, fungus, viruses) in 5 to 15 minutes.

- **Environmental Safety and Quality Care**

The robot not only improves the environmental hygiene but also protects patients and healthcare workers from cross infection. Ultimately, reducing healthcare-associated infection can result in better quality of care.

VIII. CONCLUSIONS AND FUTURE SCOPE

Disinfectant Robot has demonstrated a great potential to aid sterilization by keeping micro-organisms including drug-resistant bacteria to an irreducible minimum in order to provide a safe environment for the patient and healthcare worker. In addition, the robot will be able to move around a room and avoiding obstacles by using a wireless control system to thoroughly sanitize the entire operating rooms. They might in the future provide validated, reproducible and documented disinfection processes.

- Camera can be attached to robot to get live streaming of disinfection process.
- System can be modified to send report about disinfection to required authorities along with footages.
- The device can be re-designed using highly advanced future technologies.

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