DESIGN AND DEVELOPMENT OF SANITIZATION ROBOT FOR HEALTHCARE INDUSTRY

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Abstract

The purpose of this project is to demonstrate the design and development of a UV disinfection robot that is fitted with a camera for the purpose of remote monitoring and control. The robot was developed with the express purpose of providing autonomous disinfection of surfaces by the utilization of UV-C radiation, hence reducing the likelihood of contamination in a set of different situations. The incorporation of a camera enables the transmission of video in real time, which in turn enables operators to monitor the disinfection process and guarantee that it is effective. In this article, the mechanical design, control architecture, and sensor integration of the UV disinfection robot are dissected in great detail, with an emphasis placed on the robot's most important characteristics and capabilities. The results of the experiments not only reveal that the suggested system is effective in disinfection duties, but they also highlight the capabilities of the robot to operate independently and to monitor remotely. The potential applications of Realtime Agri Sprayer robots in the future are attractive. There is room for further development in areas such as autonomous navigation, intelligent spraying algorithms, and integration with sensor technologies for real-time monitoring of crop health and environmental conditions. These are just some of the areas that could benefit from further innovation. The combination of artificial intelligence and machine learning algorithms can provide the robots with the ability to assess data and make educated decisions regarding the most effective spraying patterns and the administration of substances. In addition, the incorporation of technologies that are part of the Internet of Things (IoT) can make it possible to achieve seamless connectivity, data interchange, and remote monitoring and control of several robots that are operating in various agricultural fields. It is reasonable to anticipate that agricultural spraying operations will undergo major enhancements as a result of the ongoing refinement and expansion of the capabilities of Realtime Agri Sprayer robots. This technology has the potential to significantly contribute to environmentally responsible agricultural methods, lessen the impact that chemical applications have on the environment, and eventually improve food production in order to satisfy the ever-increasing demand for food across the world.

Keywords: Smart sanitization, Disinfection robots, UV lamps, Camera module, DC-AC converter.

1. INTRODUCTION

The COVID-19 outbreak has been classified as a global public health emergency. According to a recent report from WHO [1], more than 624 million cases and over 6.57 million deaths have been reported since the start of the pandemic. COVID-19 is caused by the severe acute respiratory syndrome coronavirus 2, SARS-CoV-2. Enormous efforts have been devoted by nations world-wide to contain this disease. The virus can either be transmitted directly through respiratory droplets and aerosol particles in the air or indirectly through infectious droplets that are deposited onto surfaces [2–4]. Studies have shown that the virus can remain active and contagious on surfaces from hours to days depending on the surface material [5]. Although vaccines are being used to tackle the current pandemic, there is a need to develop more efficient decontamination procedures for the current pandemic and the post-pandemic world. Cimolai [6] presents a systematic review of environmental issues and decontamination strategies for COVID-19. The conventional method of decontamination is through manual cleaning followed by disinfection with chemicals. These procedures are labour-intensive, error-prone, could increase exposure risk for cleaning personnel, and do not provide consistent and effective results. Chemical disinfectants, including household bleach and quaternary ammonium compounds, can also be harmful to humans, leave unwanted residue, and be resisted by certain pathogens over time [7].

In recent times, the world has witnessed a growing concern for hygiene and cleanliness due to the emergence of various infectious diseases. This has sparked the need for advanced disinfection technologies that can effectively combat harmful pathogens while minimizing human intervention. One such remarkable solution is the development of UV disinfection robots equipped with cameras for remote monitoring and control. This article aims to shed light on the background, significance, and history of this cutting-edge technology. The concept of using ultraviolet (UV) light for disinfection purposes is not new. UV light has long been recognized for its ability to neutralize harmful microorganisms by damaging their DNA and inhibiting their replication. Traditionally, UV disinfection systems were operated manually by trained personnel, limiting their effectiveness and scalability. With advancements in robotics and automation, the integration of UV disinfection technology with intelligent robots became an innovative approach to enhance disinfection capabilities [8].

The journey toward the development of UV disinfection robots with camera integration began with the emergence of the COVID-19 pandemic. The urgency to find innovative disinfection solutions prompted researchers and engineers to explore the fusion of UV technology and robotics. In the initial stages, prototypes were designed and tested to evaluate their effectiveness in destroying pathogens. Researchers worked on developing precise navigation algorithms to ensure robots could maneuver autonomously while avoiding obstacles. Concurrently, camera systems were integrated to provide remote monitoring and control capabilities, allowing operators to oversee disinfection processes and make necessary adjustments. Through iterative refinements and advancements in robotics, UV disinfection robots with camera integration have evolved into highly sophisticated systems. These robots now possess advanced sensors for obstacle detection, mapping capabilities, and intelligent algorithms to optimize disinfection routes. The camera systems have also improved, providing high-definition visuals, live streaming, and the ability to capture images for analysis and audit purposes. The development of UV disinfection robots with cameras for remote monitoring and control. UV disinfection robots with integrated cameras and remote monitoring and control provide enhanced disinfection efficiency, reduced human intervention, versatility in different settings, data-driven analysis, cost efficiency, scalability, and public confidence. They play a vital role in ensuring cleanliness, hygiene standards, and the well-being of individuals by combining effective disinfection capabilities with remote monitoring and control features.

2. RELATED WORK

There is a rising interest in using autonomous disinfection systems like UV robots, due to their potential for more efficient disinfection [9] These robots have been deployed to disinfect hospital rooms against COVID-19 through the use of intense radiation [10]. Although the routine application of UV robots in public places could significantly limit the spread of infections, the intense UV radiation from these devices is hazardous to human skin, and thus human presence should be avoided. This may limit the operating time of such devices, and modifications to existing UV systems may be required to further improve the safety and performance of disinfection. With the onset of the COVID-19 pandemic, there has been an increased focus on UV disinfection technology. Abajo et al. [11] and Raeiszadeh and Adeli [12] presented critical reviews on UV disinfection, and their discussions covered a broad range of UV disinfection methods and the efficacy and safety of UV devices. Chiappa et al. [13] provided a review that demonstrated the efficacy of a variety of UV disinfection systems against different strains of coronavirus, while Martins et al. [14] explored the validity of different disinfection methods for SARS-CoV-2 in various settings. Some works have also covered the response of the robotics community [15–17]. They gave an overview of robots, including disinfection, cleaning, and COVID-19 testing robots, that are being used to address problems faced during the pandemic. Kumar et al. [18] gave a brief overview of the basics of UV disinfection, and Guettari et al. [19] provided a discussion on the efficacy of UV robots and devices. However, most of the existing reviews focused solely on classical ultraviolet germicidal irradiation (UVGI) systems, and none of these works provided discussion regarding the autonomy systems of UV robots. Although the COVID-19 pandemic has led to significant growth in UV disinfection and robotics research, their uses are not limited to the current pandemic. Other existing and future infectious diseases could also be combated with the derived research. The contagious nature of pathogens poses a problem in various public spaces. For example, Hospital-Acquired Infection (HAI) has been a major concern. HAIs may occur in hospitals, clinics, surgical centers, and long-term care facilities. It is estimated that there are more than 440,000 HAIs per year in the US [20]. UV robots can be used to combat HAIs.

3. PROPOSED METHODOLOGY

Working Operation

The UV disinfection robot operates autonomously, moving across the target area while emitting UV-C light to disinfect surfaces. The robot is equipped with a camera, mounted on a pan-tilt mechanism, to provide real-time visual feedback. This camera captures live video footage and transmits it wirelessly to a control station, allowing operators to remotely monitor the disinfection process. To achieve effective disinfection, the robot utilizes UV-C light emitters positioned in strategic locations. The emitted UV-C light destroys or inactivates microorganisms, including bacteria and viruses, present on the surfaces. UV-C light has been proven to be an effective method for disinfection in various applications.

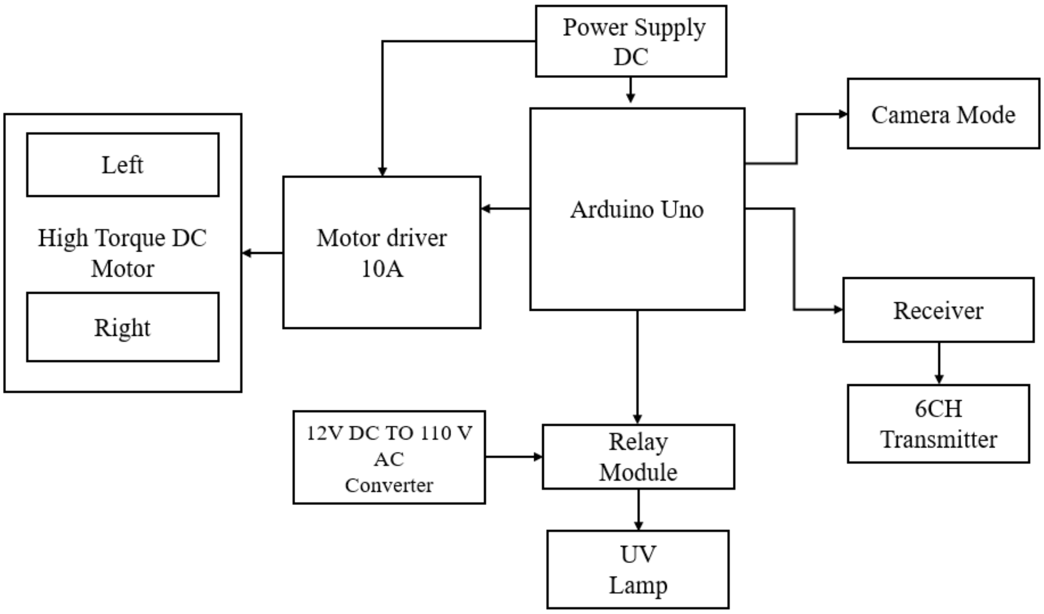


Fig. 1: Block diagram of UV disinfection robot.

Methodology

The methodology of the proposed UV disinfection robot can be divided into several stages:

1. Design and Fabrication

- Design the robot chassis to accommodate the UV-C light emitters, camera module, and necessary components.

- Fabricate the chassis using suitable materials, ensuring durability and ease of movement.

- Incorporate the pan-tilt mechanism and camera mount into the design for flexible camera positioning.

2. UV-C Disinfection System Integration

- Integrate UV-C light emitters into the robot's structure, strategically positioning them for maximum coverage.

- Implement safety mechanisms to ensure operator and environment protection.

3. Camera and Monitoring System Integration

- Mount the camera module onto the pan-tilt mechanism and establish the necessary electrical connections.

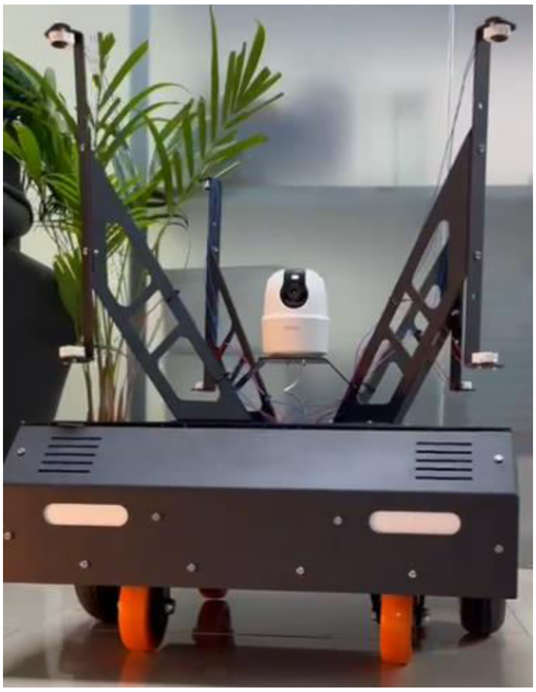
- Develop control software to enable camera movement, video streaming, and remote monitoring.

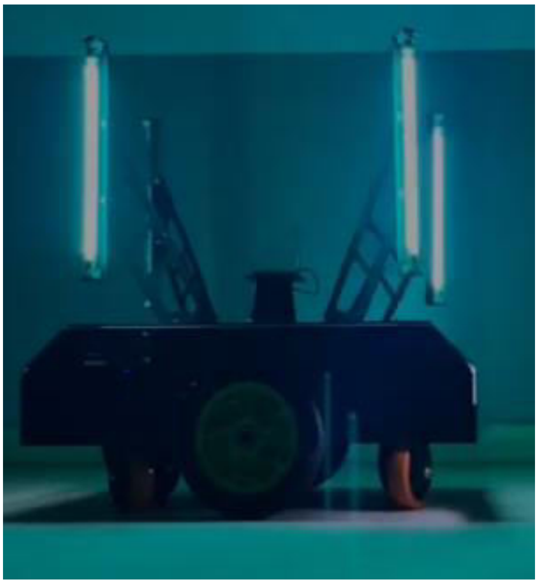
4. Control System Development

- Design and implement control software for autonomous navigation and disinfection process.

- Develop user interfaces for remote monitoring, camera control, and system status monitoring.

4. HARDWARE IMPLEMENTATION



5. CONCLUSION

The UV disinfection robot with a camera for remote monitoring and control represents a significant breakthrough in disinfection technology. By combining the power of UV light disinfection with advanced camera and remote control features, this innovative solution offers a range of benefits. It enhances the efficiency of disinfection processes, reduces the need for human involvement, and provides real-time monitoring capabilities. The ability to remotely control and monitor the robot's movements ensures precise and thorough disinfection coverage while allowing for adjustments as needed. The visuals captured by the camera offer valuable data for analysis, enabling optimization of disinfection protocols and ensuring compliance with hygiene standards. Overall, the UV disinfection robot with a camera for remote monitoring and control is a valuable tool in maintaining cleanliness, upholding hygiene standards, and safeguarding the well-being of individuals in various environments. Its implementation contributes to creating safer and healthier spaces, instilling public confidence, and driving advancements in the field of disinfection technology.

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