July 2020

Autonomous Mobile Sanitization Robot

Anonymous

Autonomous Mobile Sanitization Robot

ABSTRACT

This disclosure describes an autonomous mobile robot that can be utilized for sanitization of surfaces, e.g., in indoor environments such as offices, laboratories, lavatories, hallways, entrance gates, cafeteria, etc. Per techniques of this disclosure, payloads effective to sanitize surfaces and objects, e.g., ultraviolet-C (UV-C) emitting device(s), such as UV-C lamps, are mounted on an autonomous robot that can traverse the indoor environment. The robot can autonomously navigate the indoor environment and disinfect surfaces by emitting UV-C radiation via its payload. The robot is configured to dynamically learn routes, generate a map of a route traversed, etc. and to automatically detect human presence to avoid human exposure to UV-C radiation. The robot can function autonomously without human intervention and has the capability to dock itself into a wireless charging station, thereby enabling it to operate 24/7.

KEYWORDS

- Autonomous robot
- Autonomous vehicle
- Sanitization
- Disinfection
- Workplace safety
- Environmental safety
- Coronavirus (COVID-19)
- Ultraviolet radiation

BACKGROUND

Maintaining workplace safety, and prevention and control of disease is of paramount importance and is an ongoing challenge in pandemic situations, e.g. during the COVID-19 pandemic, as employees are re-integrated into workplace environments. Since surfaces are a potential medium of transmission, strict environmental surface hygiene practices serve to prevent individuals from coming into contact with contaminated surfaces. A current approach is to clean the indoor environment and surfaces (mainly overnight) with disinfectant chemicals. Manually performing such tasks can be both costly and time consuming, and pose risks that may arise due to gaps in reliability or consistency in the performance of such tasks.

Recent coronavirus strains have demonstrated a low resistance to disinfectants. Methods such as ultraviolet (UV) disinfection, application of a hot water bath at 56°C (132.8 °F) for 30 minutes, chlorine-based disinfection, application of peracetic acid, 75% ethanol, etc. can effectively inactivate the virus.

Certain classes of ultraviolet C, e.g. UV-C 254 nm, generated commonly by low-pressure mercury vapor arc lamps, have been utilized for disinfection in medical facilities. The sanitizing effects of UV-C light has been studied in the context of other coronaviruses, including the one that causes severe acute respiratory syndrome (SARS-CoV).

Studies widely have shown that UV-C irradiation can be effective in killing the coronavirus. Generally, UV-C light damages the RNA of the coronavirus and renders them inactivated. As a result of UV-C exposure, pathogens cannot reproduce once they have entered inside their host.

Coronaviruses are sensitive to oxygen levels and application of UV-C can alter the spike protein, a surface protein used to bind to a receptor, thereby altering the genomic composition of

the coronavirus and leading to its deactivation. Laboratory research has shown that the germicidal effect of UV-C is primarily a function of two factors: the intensity of the UV-C energy and the duration of exposure. One study reported that 15 minutes of UV-C exposure was sufficient to inactivate the SARS-CoV virus, making it impossible for the virus to replicate further. Studies have shown that it can be used against other coronaviruses.

Other studies have reported that it is possible to completely inactivate coronavirus using short-wavelength UV-C irradiation. It was found that a very low dose of UV-C radiation was sufficient to inactivate coronavirus completely. Indeed, for virus concentrations typical of low level contaminated closed environment and sputum of coronavirus infected patients, a very small dose of less than 4 mJ/cm2 was enough to achieve full inactivation of the virus. Even at the highest viral input concentration (1000 moi), viral replication was totally inactivated when a dose greater than 16.9 mJ/cm2 was applied. Efficient UV-C based disinfection methods can therefore help contain the spread of coronavirus infection.

DESCRIPTION

This disclosure describes an autonomous mobile robot that can be utilized for sanitization of surfaces, e.g., in indoor environments such as offices, laboratories, lavatories, hallways, entrance gates, cafeteria, etc. Per techniques of this disclosure, payloads effective to sanitize surfaces, e.g., UV-C emitting device(s), such as UV-C lamps, are mounted on an autonomous robot that can traverse the indoor environment.

The autonomous robot has the capability to autonomously scan and operate within an indoor environment, e.g. in the hallways and corridors of a workplace. The robot can function autonomously without human intervention and has the capability to dock itself into a wireless charging station, thereby enabling an uninterrupted operation. Additionally, the robot is designed

to operate alongside other robots and/or human personnel, e.g., with collision-avoidance capability, etc. The autonomous robot also has the capability to detect human presence, and suitably react, e.g. switch off a payload, raise an alarm, etc. when any human presence is detected.

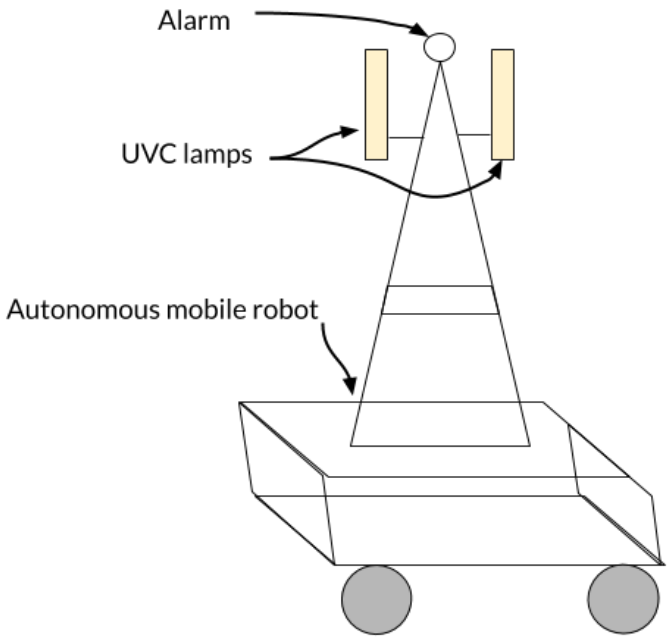

Fig. 1: An autonomous robot can disinfect surfaces using UV-C radiation

Fig. 1 illustrates an example autonomous mobile robot, per techniques of this disclosure. Only the payload components (UV-C lamps) are illustrated; other components such as navigation sensors, on-board computing hardware, power management, communication, etc. may be present in different robot configurations. The autonomous robot that carries the UV-C lamp payload can be utilized in interior spaces such as schools, office buildings, and restaurants to sanitize surfaces and help mitigate disease transmission.

In this illustrative example, UV-C emitting devices, e.g. UV-C lamps, are mounted onto the autonomous robot. The autonomous robot can be configured to navigate an indoor

environment and disinfect surfaces using UV-C radiation emitted from its payload. The UV-C radiation can be applied on each surface for a specified amount of time, e.g. between about 2-60 minutes, depending on the surface, angle, distance, and UV-C exposure dosage. The autonomous robot is configured to navigate its environment, learn its routes, generate a map of a route traversed, etc. The robot is also configured to turn the UV-C radiation off when human presence is detected in its vicinity to prevent human exposure to the UV-C radiation. The autonomous robot can also be configured to operate with other payloads effective for sanitization, e.g. electrostatic disinfection, acoustic vibration, etc.

As an instance of non-UV payload for disinfection robot, acoustic vibration may be utilized in resonance frequency therapy which has been previously tested on diseases like lung tumor, Borrelia burgdorferi pathogen responsible for Lyme disease, Rubella measles virus, E. coli etc. The therapeutic approach in such cases is based on destruction of the associated virus based on a matching resonance frequency. Example frequencies of 171.160 Hz, 174.989 Hz, 1185.131 Hz, etc. have been tested previously with encouraging results. Based on verification of its efficacy in treating COVID-19 patients, resonance frequency therapy can also be attempted using autonomous robots.

CONCLUSION

This disclosure describes an autonomous mobile robot that can be utilized for sanitization of surfaces, e.g., in indoor environments such as offices, laboratories, lavatories, hallways, entrance gates, cafeteria, etc. Per techniques of this disclosure, payloads effective to sanitize surfaces, e.g., UV-C emitting device(s), such as UV-C lamps, are mounted on an autonomous robot that can traverse the indoor environment. The robot can autonomously navigate the indoor environment and disinfect surfaces by emitting UV-C radiation via its payload. The robot is

configured to learn routes, generate a map of a route traversed, etc. and to automatically detect human presence and turn UV-C radiation off. The robot can function autonomously without human intervention and has the capability to dock itself into a wireless charging station, thereby enabling 24/7 operation.

REFERENCES

1. Bedell, K., Buchaklian, A. H., Perlman, S. (2016). Efficacy of an Automated Multiple Emitter Whole-Room Ultraviolet-C Disinfection System Against Coronaviruses MHV and MERS-CoV. infection control & hospital epidemiology, 37(5), 598-599.
2. Bianco, A., Biasin, M., Pareschi, G., Cavalleri, A., Cavatorta, C., Fenizia, C., Clerici, M. (2020). UV-C irradiation is highly effective in inactivating and inhibiting SARS-CoV-2 replication. medRxiv, 2020.2006.2005.20123463. doi:10.1101/2020.06.05.20123463.
3. Bolashikov, Z. D., Melikov, A. K. (2009). Methods for air cleaning and protection of building occupants from airborne pathogens. Building and Environment, 44(7), 1378-1385.
4. Chang, J. C., Ossoff, S. F., Lobe, D. C., Dorfman, M. H., Dumais, C. M., Qualls, R. G., Johnson, J. D. (1985). UV inactivation of pathogenic and indicator microorganisms. Appl. Environ. Microbiol., 49(6), 1361-1365.
5. Darnell, M. E., Subbarao, K., Feinstone, S. M., Taylor, D. R. (2004). Inactivation of the coronavirus that induces severe acute respiratory syndrome, SARS-CoV. Journal of virological methods, 121(1), 85-91.
6. Dietz, L., Horve, P. F., Coil, D. A., Fretz, M., Eisen, J. A., Van Den Wymelenberg, K. (2020). 2019 novel coronavirus (COVID-19) pandemic: Built environment considerations to reduce transmission. Msystems, 5(2).

7. Masters, P. S. (2006). The molecular biology of coronaviruses. Advances in virus research, 66, 193-292.

8. Park, Y., Roth, J., Oka, D., Hirose, Y., Hasegawa, T., Paul, A., Engel-Herbert, R. (2020). SrNbO 3 as a transparent conductor in the visible and ultraviolet spectra. Communications Physics, 3(1), 1-7.

9. Shirbandi, K., Barghandan, S., Mobinfar, O., and Rahim, F., Inactivation of Coronavirus with Ultraviolet Irradiation: What? How? Why?, April 8, 2020. Available at SSRN: https://ssrn.com/abstract=3571418

10. Wu, S., Wang, Y., Jin, X., Tian, J., Liu, J., Mao, Y. (2020). Environmental contamination by SARS-CoV-2 in a designated hospital for coronavirus disease 2019. American Journal of Infection Control.

11. Yan, Y., Chen, H., Chen, L., Cheng, B., Diao, P., Dong, L., Ji, C. (2020). Consensus of Chinese experts on protection of skin and mucous membrane barrier for health-care workers fighting against coronavirus disease 2019. Dermatologic Therapy, e13310.

12. Kalter, Lindsay, "Coronavirus Puts UV in the Disinfectant Spotlight," WebMD, accessed July 17, 2020. https://www.webmd.com/lung/news/20200519/coronavirus-puts-uv-in-the-disinfectant-spotlight

13. SteriPro UVC disinfection. "SteriPro UVC disinfection robot." *YouTube* video, 1:37, Nov 14, 2019, 2020. https://www.youtube.com/watch?v=CZ3NTaUZhpo

14. Xenex Disinfection Services. "Intense pathogen killing power in just 5 minutes," accessed July 17, 2020. https://www.xenex.com/our-solution/lightstrike/

15. U.S. Department of Health and Human Services, Food and Drug Administration, Center for Devices and Radiological Health. "Enforcement Policy for Sterilizers, Disinfectant

Devices, and Air Purifiers During the Coronavirus Disease 2019 (COVID-19) Public Health Emergency: Guidance for Industry and Food and Drug Administration Staff," March 2020, accessed July 17, 2020. https://www.fda.gov/media/136533/download

16. Peterson, Hayley. "Amazon builds UV-light robot to kill coronavirus on surfaces," Business Insider, accessed July 13, 2020. https://www.businessinsider.com/amazon-builds-uv-light-robot-to-kill-coronavirus-on-surfaces-2020-5

17. Casini B, Tuvo B, Cristina ML, et al. Evaluation of an Ultraviolet C (UVC) Light-Emitting Device for Disinfection of High Touch Surfaces in Hospital Critical Areas. Int J Environ Res Public Health. 2019;16(19):3572. Published 24 Sep 2019. Available at doi:10.3390/ijerph16193572