Design a Semi-Autonomous Fumigation Robot Using Line Tracking for COVID-19

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Abstract. The implementation of robotics has provided various solutions to the problematic caused by Covid-19 to reduce the exposure of people when alternating work, therefore the present project was designed and manufactured a semi-autonomous fumigation robot which is made using a sprinkler and a pump, to give it autonomy was incorporated line tracking that works utilizing infrared and ultrasonic sensors. For the development of the project, the V-based methodology was used, in which the 3 branches of mechatronics are integrated. As a result, the robot can be applied in commercial and industrial areas for disinfection of floors and surfaces to reduce exposure to the virus. A nozzle with an angle of 60º was used having a range of 3.2 m wide and reaches a height of 1.6 m. as a final result, it was obtained that the robot is capable of disinfecting 3.2 m2/s.

1 Introduction

The world has been greatly affected by the COVID-19 pandemic, leaving large numbers of deaths globally [1]. In Honduras, unlike other countries with higher technology and contingency plans to combat the pandemic is still traditionalist, therefore it generates greater spread of the virus [2]. The virus exposure can take place anywhere there is a conglomeration of people, given that is why people have tried to alternate human labor with new mechanical advances in robotics, especially where people can take risks at work [3]. As it has been mention the use of robots can also reduce community transmission and consumption of personal protective equipment [4]. Given this, a fumigation robot was made to be able to alternate human work, using different mechatronic systems.

One of the basic requirements regarding the movement planning of mobile robots are route plans, location and crash prevention. In many cases, route planning can be complicated due to dynamic and static environments, such as in shopping malls, markets and in automated factories or warehouses, in which autonomous mobile robots can be easily implemented for internal logistics [5]. Moreover, line tracking can be used to facilitate various problems such as medical, transportation and logistical problems, exploration and mapping problems, tracking problems and agricultural problems. [6]. For the development of autonomous mobile robots, there are various ways and tools to be carried out, like climbing robot that uses ultrasonic sensors to detect the width and height of

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the stairs to be able to climb them [7]. On the other hand, it is suggested the use of LiDAR sensors that unlike ultrasonic sensors the point of divergence is comparatively lower, so it generates greater precision in the detection of obstacles [8].

Energy consumption is a fundamental element in the autonomy of mobile robots, and this occurs in any application in which the robot carries a finite energy source [9]. One of the key factors for extended autonomy, especially when robots operate with batteries, is their ability to maintain energy sufficiency and recharge when needed [10]. For energy autonomy, the use of solar energy for a field patrol car incorporating fast charging functions is proposed, using the solar tracking algorithm to achieve maximum energy capture [11]. However, this system can only be applied in outdoor robots. Today due to scientific and technological advances several disinfectants are known, considering two methods, using chlorine or alcohol, and disinfection by UV-C light. Chlorination is an effective disinfection method that is used today for drinking water [12]. However, chlorine in low concentration disinfection of the microorganism is not effective and, if the concentration of chlorine too high, can be harmful to humans and animals [13].

In a study on various types of coronaviruses conducted by Sizun, 12 pieces of aluminum were cleaned with running water and then disinfected with 70% alcohol for 30 minutes. The results of this study suggested that the presence of the virus on the surface of materials may be the main source of hospital infections. The use of povidone iodized and alcohol at 70% showed efficacy in the elimination of the virus in all environments evaluated [14]. Studies have also been conducted to verify the effectiveness of ultraviolet light in the elimination of pathogens on surfaces, demonstrating a positive result in the elimination of pathogens being reliable and safe, other studies have corroborated that UV-C light can be adapted for different applications [15, 16]. For the development of robot, disinfectants have been integrated sprinkler mechanisms and is used to distribute air and disinfectant fluid mixture [17]. Electrostatic spraying is proposed for the part, which can improve spray deposition. This technique has already presented gains in spray deposition [18].

2 Lab design

For the lab design V model [19] was developed, the mechanical part were taken into consideration the applications that will be submitted to the robot, within them, the mobility of the robot, the stability and the space to transport the different components, it was necessary that the structure of the robot comply with those characteristics since it will be in charge of performing the disinfection of an area. In the electronic systems were used two motors 12v DC, drivers and Arduino, and a lithium battery. Within the mechanical subsystems are the mechanical parts of the drive system, the tires, the axles and others, in which it was necessary the design of these parts in the SolidWorks. The CAD structure is shown in figure 1.

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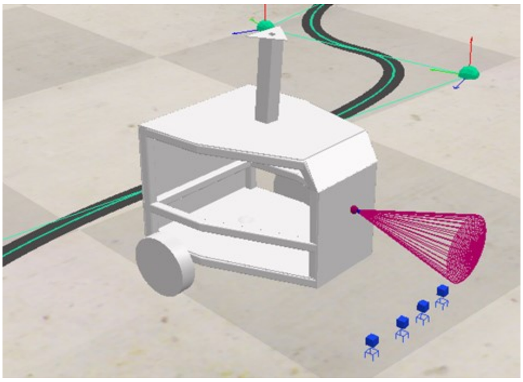

Fig. 1. Cad design for simulations.

For the line tracking it was necessary to check the programming, for them, the CoppeliaSim simulator was used. In this simulation software, it was possible to perform line tracking using 4 sensors, who simulate infrared sensors, and an ultrasonic sensor sensors. For the detection of objects, for the validation of its operation of adding the line to follow, in this case a closed circuit as shown in Figure 2.

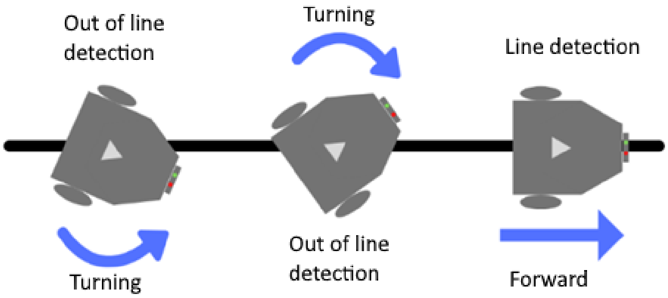

Fig. 2. Expected robot behavior.

Figure 3 shows the robot on a black line. The robot contains two drive wheels, a control camera and sensors. Since the current position of the robot is the midpoint between the two wheels, where the yellow circle is, and can be noted as Xo and Yo and denotes the robot position. In addition, the robot moves in the direction indicated by the arrow and applying the analogy in the Cartesian axes, it would be in y, and the speed of the robot can be expressed by equation 1.

$$Vy = (VLeft + VRight)/2 \tag{1}$$

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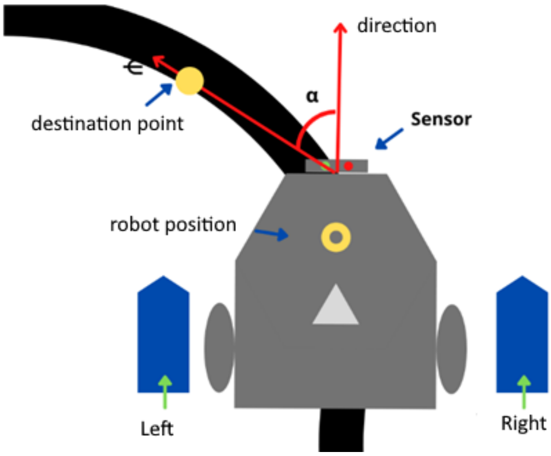

Fig. 3. Robot position.

Figure 4 shows the line tracking algorithm used for the simulations. In this algorithm, the four infrared sensors are considered as a binary number. If sensors 2 or 3 detect a line, motors will go on. The turnings will start when sensors 1 or 4 detect and the others sensors has no detection. Finally, the ultrasonic sensor can stop the process to avoid possible collisions.

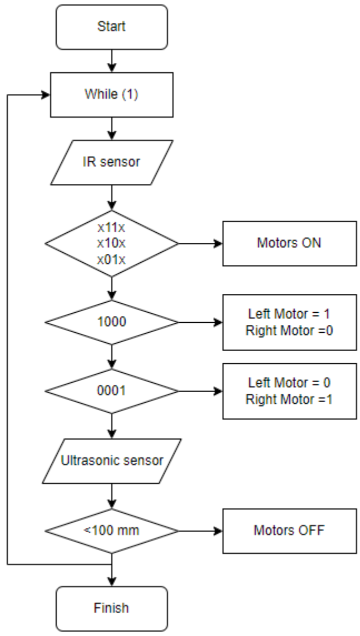

Fig. 4. Line tracking algorithm.

A test circuit was carried out, for which it was necessary to add a circular path and move the points to create a track with different curves, to validate the correct performance in line tracking. As a result of this test, it was possible to validate the correct operation of the line follower system, presenting a high fluidity in the follow-up without leaving the circuit.

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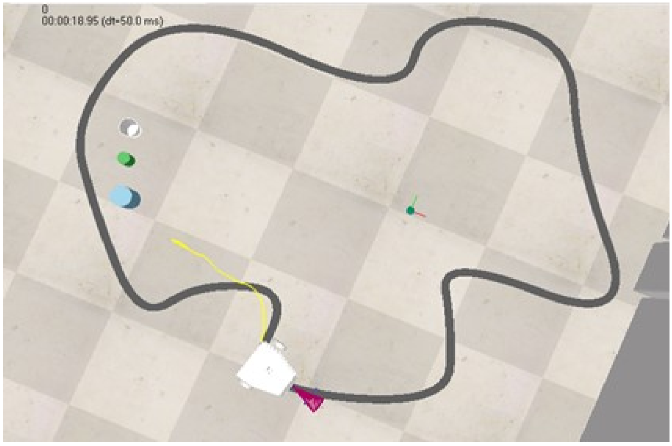

Fig. 5. Simulation test circuit.

3 Real test

The output flow of the sprinkler system was calculated, since varying this value can modify the scope of the spray. We measured the time taken to spray the liquid of 4 liters. The flow rate value was 2.35 L/min, obtained by using equation 2. Figure 6 shows the optimal sprinkler angle for the system, which gets a maximum height of 1.6 m.

$$Q = \frac{V}{T} \quad (2)$$

Fig. 6. Fumigation optimal angle.

As shown in figures 7 the angle of the exit is 60º generating a range of 3.2 m. As the robot pass in a straight line of 90 meters, the passage of the area marked by the liquid leaves a rectangular shape. Obtaining the area of 288 m2 in a time of 90 seconds, as a result, it was obtained that the robot performs a fumigation of 3.2 m2/s.

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4 Discussion and conclusion

The line tracking system was validated by simulation in CoppeliaSIM using the structure design performed and simulated in SolidWorks. It was possible to design a fumigating robot by tracking line with 4 infrared sensors TCRT500 and an ultrasonic for the detection of objects, at a speed of 1 m/s. For moving the robot, a teleoperation system was used as in logistic projects [20]. Finally, the fumigation process of the established area of the stroke line was carried out employing a pump, having an output flow of 2.35 L/min. A nozzle with an angle of 60º was used having a range of 3.2 m wide and reaches a height of 1.6 m. Finally, it was obtained that the robot is capable of disinfecting 3.2 m2/s.

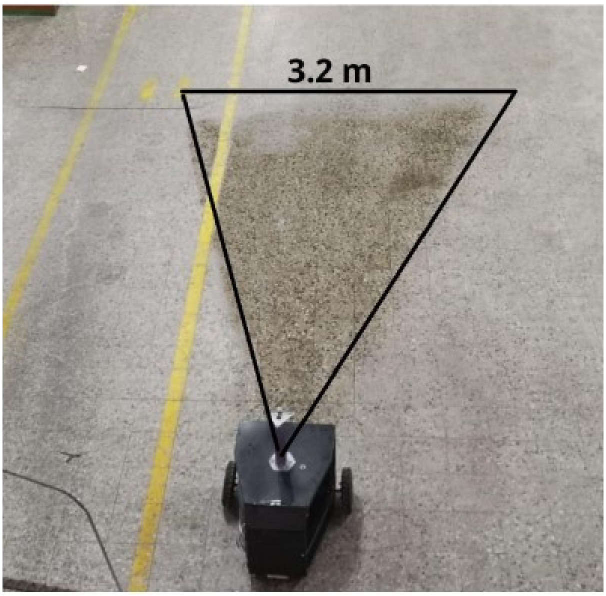

Fig. 7. Fumigation behavior with 60 degree angle.

References

1. F. Ridwan, S. Syamsuddin, & A. Fathan, A. A. Ananta, G. A. Bintang, A. Jordan, *Andalas medical robots assistance (AMIRA) serves Covid-19 isolation patients* (2021).
2. A. Sorto, T. Marquez, J. L. Ordonez Avila, *Face recognition and temperature data aquisition for Covid-19 patients in Handuras* (2020).
3. R. J. Ong, & Azir, *Low cost autonomous robot cleaber using mapping algorithm based on internet of things* (2020).
4. V. Seethalakshmi, V. S. K. Varshani, R. Madhumitha et. al., *Tele-presence robot for medical assistance in hospitals* (2018).
5. S. Oswal, D. Saravanakumar, Line following robots on factory floors: Significance and Simulation study using CoppeliaSim, IOP Conf Ser Mater Sci Eng (2021).
6. T. T. Harmanda, M. Hazim, Wulandari, A. R. Akbar, S. Wahjuni and K. Priandana, Development of a seed-planter wheeled robot prototype, IOP Conf Ser Earth Environ Sci (2019).
7. J. D. G. Stephen, V. Das C, Khanna, V. Negi, IOP Conf Ser Mater Sci Eng (2020).

https://doi.org/10.1051/bioconf/20235708003

8. K. Nandakumar, S. R. Surya, K. Karthick, N. Raviraj, B. Cheran, V. Poovizhi et al., Autonomous Vehicle for Drug Delivery, IOP Conf Ser Mater Sci Eng (2020).
9. M. F. J. Morales, J. B. G. Mendoza, *Mixed Energy Model for a Differential Guide Mobile Robot* (2018).
10. H. Fouad, G. Beltrame, *Energy Autonomy for Resource-Constrained Multi Robot Missions* (2020).
11. W. Wenlan, B. Xionghuai, W. Xiuling, Research on energy autonomy system design of field patrol car based on solar energy, IOP Conf Ser Earth Environ Sci (2021).
12. D. Wang, H. Xiang, Composite Control of Post-Chlorine Dosage During Drinking Water Treatment, IEEE Access (2019).
13. K. Mopoung, P. Suwanyangyaun, R. Odanaka et al., A Real-Time Free Chlorine Monitoring by Graphene Field-Effect Transistor (2019).
14. L. Xiong, G. Jiang, Y. Guo, H. Liu, Experimental Research on Sensing Characteristics of Adhesive-Encapsulated FBG Under Alcohol-Disinfection Environment. IEEE Sens J. (2019).
15. L. Alvarado-Miranda, M. Zea-Palomino, M. Cabanillas-Carbonell, *Analysis of UV technologies for disinfection of public areas: a systematic literature review* (2020).
16. J. L. Ordoñez-Ávila, F. Danilo Bonilla, E. D. García, Development of a teleoperated robot based on an experimental design for sterilization in Honduras, IEEE International Conference on Machine Learning and Applied Network Technologies (ICMLANT) (2021).
17. G. S. Raju, K. Sivakumar, A. Ramakrishnan, D. Selvamuthukumaran, E. S. Murugan, Design and fabrication of sanitizer sprinkler robot for covid- 19 hospitals, IOP Conf Ser Mater Sci Eng (2021).
18. S. M. Silva et al., *Spray deposition on maize using an electrostatic sprayer* (2020).
19. T. Gabrie, A. M. Carrasco, J. L. O. Avila, *Low-cost Robot Assistance Design for Health Area to Help Prevent COVID-19 in Honduras* (2020).
20. J. L. O. Avila et al., Study Case: Teleoperated Voice Picking Robots prototype as a logistic solution in Honduras, 5th International Conference on Control and Robotics Engineering (2020).