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A Comparative Study and Design for Construction of An Automatic Sanitizing Floor Cleaning Robot

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Abstract - ***This research paper proposes the development and deployment of an automated sanitizing robot integrated with a camera. The paper also compares this robot for cleaning floors to a robot for cleaning floors. G power software is used to find the sample size for each group, taking into account predefined parameters and aiming for the best performance with a maximum error of 0.05. This is done to make sure the results are correct. A fixed sample size of 20 is selected for each group for analytical purposes. The design of the automatic controlled sanitizing robot incorporates various components such as Arduino, motor shield, camera, and chassis. The Arduino IDE app is employed to program the Arduino Board. The effectiveness and reliability of the proposed methods are evaluated using a 2-tailed statistical analysis. Additionally, this paper suggests that the sanitizing robot outperforms the floor cleaning robot when it comes to spraying on a flat surface.***

Keywords: **Novel sanitizing, Automation, Ultrasonic sensor, IR sensor, Floating sensor, Arduino IDE app.**

I. INTRODUCTION

The proposed work entails designing and implementing a sanitizing robot to sanitize the floor and comparing the robot's efficiency in terms of distance and area covered with respect to a floor cleaning robot. In certain pandemic conditions, such as COVID-19, it is necessary to sanitize the floor to protect ourselves from a deadly virus; however, direct contact could be dangerous [1]. Sanitizing robot can be used to sanitize the floor and prevent humans from coming into direct contact with the virus [2].

Automation has proved its efficiency in different fields by improving productivity by reducing the hazards caused to humans. Customized spray machines have attracted many researchers and several articles are published based on customizable automatic spraying robots. Barve has developed a floor cleaning robot [3] that is capable of cleaning the entire floor however the surface of the floor should be plain for better results. Milinda developed a floor cleaning robot that has good accuracy, but the robot's speed is less than the average of 500 meters per hour [3], [4]. [5] has developed a voice-controlled floor cleaning robot that has good speed but it requires human assistance throughout the process of cleaning [6] has developed an autonomous floor-cleaning robot that has good accuracy but consumes high power.

II. RESOURCES AND METHODS

Resources like robotics lab under the Department of ECE, Saveetha School of Engineering has been used to carry out the experimental work. For conducting the experiment, spraying is divided into two groups, an automatic sanitizer spraying robot is in group one, and a floor cleaning robot is in group two. For both groups 1 and 2, a total sample size of 20 is used. A power calculation is used to determine the appropriate sample size. The analysis requires a minimum of 0.8 (or 80 percent) capacity, with a maximum acceptance error of 0.2 [7].

The components shown in Table 1 are used in the construction of the automatic novel sanitizing robot, their placements are as per the CAD design represented by Fig. 1(a) and 1(b). It consists of 3 sensors, in which 2 types of sensors are used for the moment of the robot and the other one is to detect the sanitizer level in the storage tank [8] that is a floating sensor. Ultrasonic sensors and IR sensors are used in the robot's moment. Ultrasonic sensor is used to calculate the distance between the object and the robot. The direction of the robot is controlled as per the sensor's input. This robot keeps on spraying the sanitizer once it's turned on and can change its direction automatically once it detects the obstacle in front of it. Once sanitization is complete the system plays a beeping sound indicating that spraying has to be refilled [8], [9].

TABLE 1: Components Description of the automatic sanitizing robot.

Description of Components for Sanitizing robot	**specifications**
Arduino Uno	Atmega 328P
Camera	Webcam

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Motor shield	L293D
Battery	9V
Buzzer	5V
Storage tank	500 ml
sprayers	-
Float sensor	5V
Motors	Dc geared motors 5v

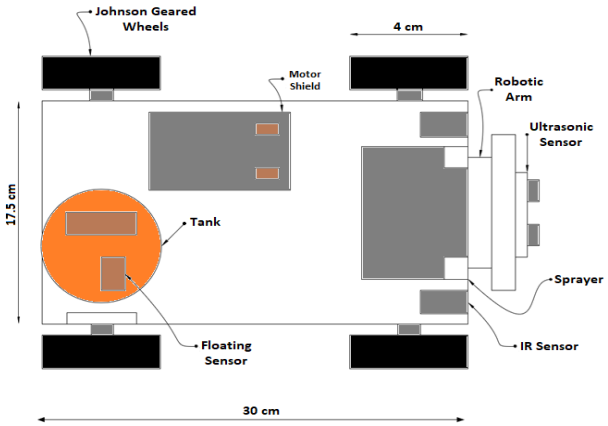

Fig. 1. (a)

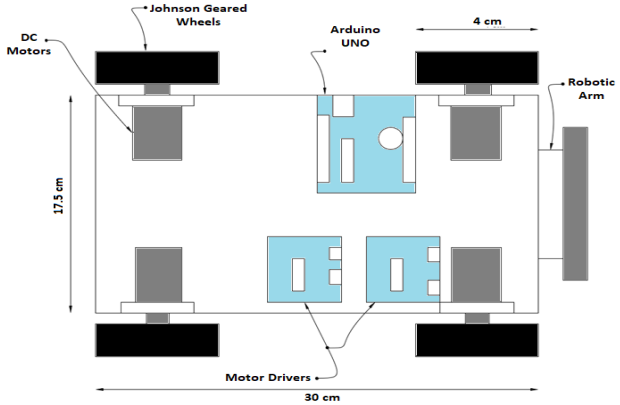

Fig. 1. (b)

Fig. 1. (a) and Fig. 1. (b) Bottom view and top view of the mobile-controlled sanitizer spraying robot.

This automated sanitizing robot is compared with a cleaning robot [10] which is considered in group 2. The components used in the cleaning robot are mentioned in Table 2. As similar to the novel sanitizing robot, the cleaning robot also uses the Arduino and motor drivers as main controllers to control the robot. But both are designed for different applications, for cleaning the floor this robot uses a rotating brush that is placed in between the floor and the chassis.

TABLE 2: Components Description of the floor cleaning robot.

Description of Components for floor cleaning robot	**specifications**
Arduino Uno	Atmega 328P

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Ultrasonic sensor	HC-05
Motor shield	L293D
Battery	9V
Buzzer	5V
Storage tank	500 ml
sprayers	-
Float sensor	5V
Motors	Dc geared motors 5v

The projected work utilizes a hardware setup to develop a mobile-controlled sanitizing robot. Arduino IDE software is run on an Intel Core i5 processor with 8 GB RAM in this prototype. To calculate the robot's distance traveled, we'll need a scale and a stopwatch. The robot is located on a reference point that has been established. At the same time as the robot is given orders to go on, the stopwatch is starting. To measure the speed and distance travelled by the robot, it has been programmed to take a pause when stop watch counts 10 seconds. After that, we can repeat the procedures as many times as required. In this work, for the calculation of precise value of distance covered by the robot process has been repeated 20 times.

Majority of resources for this work has been done in robotics lab of Saveetha School of Engineering to check Robot's behaviour and various other tests including the time taken to cover a defined distance, the robot's speed, and the distance covered in a given period.

III. STATISTICAL ANALYSIS

Statistical investigation like G graphs, T-tests, and descriptive analyses are carried out using SPSS 21 (SPSS Inc., Chicago, Illinois, USA). The standard error and standard deviation values for the sanitizer spraying robot were calculated using descriptive analysis, which was found to be lower than those for the floor cleaning robot. The significance value is 0.038 (0.05) and was calculated using T-tests. sanitizer quantity is the dependent variable, while area, speed, and distance travelled are the independent variables.

IV. RESULTS

Observations taken for the robot to complete the distance for a fixed time duration of 10 seconds and recorded its distance and the same is shown in Table 3. As per the DC motor's specifications, theoretically robot should have to cover the 2m distance in 10 seconds, but as per the tabulated results, it is very clear that robot is always travelling more than 2m. Experimental values are 7.65% more than the desired value. So, to calculate the speed of robot, it is desired to take the mean value of the distance travelled by the robot.

TABLE 3: different test results for distance covered by the automatic sanitizing cleaning robot

Test results while sanitizing for 10 sec	**Distance covered by Robot (m)**
1	2.18
2	2.17
3	2.13
4	2.2
5	2.09
6	2.17

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7	2.14
8	2.15
9	2.17
10	2.12
11	2.17
12	2.14
13	2.15
14	2.17
15	2.12
16	2.18
17	2.22
18	2.14
19	2.12
20	2.15

Distance covered by the robot can be calculated by using the following formula.
Mean Distance = [summation of all the distances / Total no. of test taken] (1)
=[(2.18+2.17+2.13+2.2+2.09+2.07+2.2+2.17+2.1+2.19+2.17+2.14+2.15+2.17+2.12+2.18+2.14+2.12+2.15) / 20]
Mean = 2.153
After considering all the 20 test results, mean distance covered by the sanitizing robot is 2.153.
Average speed = (average distance travelled) /(time) (2)
All the distances have been measured for 10 seconds. Average speed = (2.15/10)
= 0.2153 m/sec
= 0.2153*6*60 mph
= 775.08 mph
After the calculation using the above formula speed of the sanitizing robot was 775.08 mph.

TABLE 4: different test results for distance covered by the floor cleaning robot

Test results while cleaning for 10 sec	**Distance covered by Robot (m)**
1	1.9
2	1.3
3	1.2
4	2.2
5	1.9
6	1.3
7	1.8

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8	1.5
9	1.9
10	1.8
11	1.5
12	1.6
13	1.2
14	2
15	1.7
16	1.6
17	1.14
18	1.3
19	1.8
20	1.8

Observational data shown in Table 4 reflects that the measured distance value is not constant, just like the case of sanitizer robot shown in Table 3. Also, it shows that sanitizing robot covers more distance while floor cleaning robot covers lesser distance from the desired distance of 2m. The obtained result is 13.025 % less as compared to the desired. Distance covered by the floor cleaning robot can be calculated by using the equation (1).

Mean Distance covered by the floor cleaning robot =[(1.9+1.3+1.2+2.2+1.9+1.3+1.8+1.5+1.9+1.8+1.5+1.2+1.6+1.2+2+1.7+1.6+1.14+1.3+1.8+1.8) / 20]

= 1.622 m

All the tests have been performed for 10 seconds. Average speed can be calculated by using the equation 2.

Average speed= (1.622/10) =0.1622 m

=0.1622*60*60

= 583.92 mph

Average speed of a floor cleaning robot = 583.92 mph.

Table 5: standard deviation and standard error values for sanitizing robot and floor cleaning robot.

	N	**Mean**	**Standard deviation**	**Standard Error mean**
Sanitizing robot	20	2.1530	.03948	.00883
Floor cleaning robot	20	1.6220	.30538	.06829

From table 5 it is very clear that sanitizing spraying robot gives better performance as compared to floor cleaning robot in terms of standard deviation of 0.03 and standard error of 0.008.

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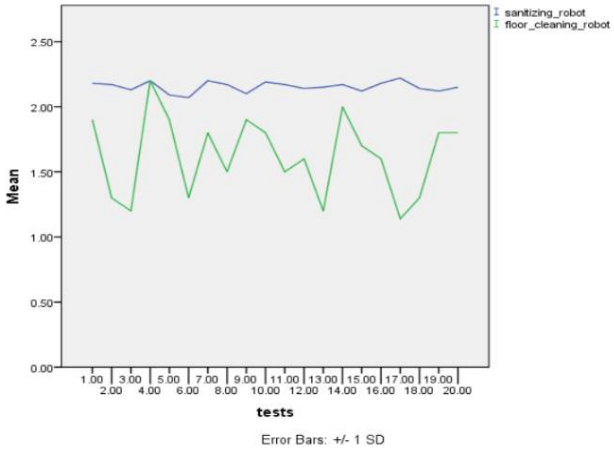

Fig. 2. Comparative analysis of the distance covered by floor cleaning and sanitizer spraying robot.

TABLE 6: comparison of Descriptive statistics of Sanitizing and Floor cleaning robot.

	N	Min	Max	Mean	Std. Deviation
Sanitizing robot	20	2.07	2.22	2.1530	.03948
Floor cleaning robot	20	1.14	2.20	1.6220	.30538

TABLE 7: T-test to compare the mobile controlled sanitizer spraying robot and Floor cleaning robot.

	Test value = 0					
	t	df	Sig. (2-tailed)	Mean difference	95% confidence interval of the difference	
					Lower	Upper
Equal variances assumed	7.712	38	.000	.53100	.06885	.67039
Equal variance not assumed	7.712	19.635	.000	.53100	.06885	.67480

20 tests have been conducted and it's result has been recorded in Table 6 in terms of Minimum and Maximum distance covered by both the robots. Mean and standard deviation is also recorded. From the values tabulated in Table 6 shows that performance of sanitizing robot is significantly better than the floor cleaning robot. To compare the mean and significance values for both the robots, the T-test was taken which shows that sanitizing robot obtained a significance value of less than 0.0001 as mentioned in Table 7. Blue colored line shown in Fig 2 represents the distance covered by the sanitizing robot and the green colored line represents the distance covered by the floor cleaning robot. Based on the above parameters proposed sanitizing robot performance is 23.77% improved as compared to the floor cleaning robot in terms of distance covered.

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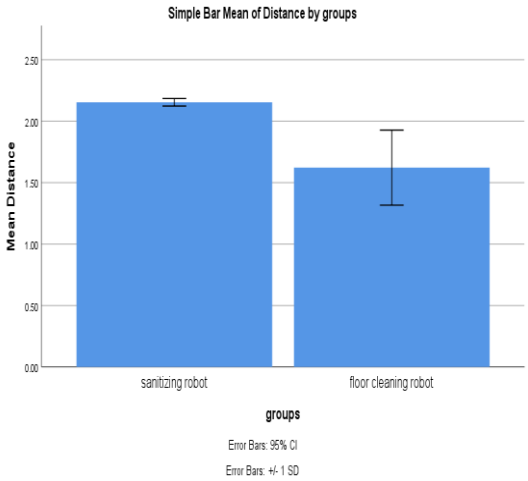

Fig.3. Comparison of sanitizer spraying robot and floor cleaning robot in terms of mean distance

Standard deviation in terms of distance for the sanitizing and floor cleaning robot is shown in Fig. 3. The mean distance of the sanitizing robot is 23.77% improved as compared to the floor cleaning robot. The standard deviation of the sanitizing robot is 0.06, while the floor cleaning robot was at 0.039. these data shows that the sanitizing robot is slightly improved as compared to floor cleaning robot. The standard deviation of total distance and spray capacity are comparatively less for sanitizing robot compared to the floor cleaning robot.

V. DISCUSSION

The proposed sanitizing robot appears to be faster than the floor cleaning robot in this study, with a 49 m/hr speed difference. The sanitizing robot performs better spraying tasks than the floor cleaning robot based on the evidence gathered. Based on the findings of this report, an automated sanitizing robot can spray sanitizer on the floor in an indoor environment. Due to difference in different applications like mode of control and spraying process of the proposed robot and floor cleaning robot, exact comparison is very difficult. But based on standard deviation, standard error, speed and coverage of area, both the robots are compared. The sanitizing robot outperforms the other robots in the above parameters. Barve has developed a floor cleaning robot [3] that is capable of cleaning the entire floor however the surface of the floor should be plain for better results. Milinda developed a floor cleaning robot that has good accuracy, but the robot's speed is less than the average of 500 meters per hour. [3], [4]. [5] has developed a voice-controlled floor cleaning robot that has good speed but it requires human assistance throughout the process of cleaning. [6] has developed an autonomous floor-cleaning robot that has good accuracy but consumes high power. From the above articles, it is observed that the spraying robots are lacking some features, such as speed, liquid level detection etc..,. In our designed model, it is found that the sanitizer spraying robot overcomes the above-mentioned problems.

The sanitizing robot's drawbacks include the fact that the prototype's battery can only provide power for 2.5 kilometres after that it needs to be recharged to take further work. The battery used in this project has a longer charging and discharging periods of 6 hours and 4 hours respectively. Maximum Tank capacity of 500 ml has been used in this work to provide maximum paint of the same amount. To make the paint at 50ml, a pumping motor is placed at the bottom of the tank along with a suction nozzle a slightly upper than the base of the painting tank. In future Raspberry Pi and a camera module can be used to program the robot to make it function more precise and allowing it to sanitize a wide area [11] – [13]

V. CONCLUSION

An automatic sanitizing robot is designed and implemented. From the result and discussion, it is clear that performance of designed robot is better than the floor cleaning robot. Results shows that automatic sanitizing robot has 32.77% faster speed and 12% less standard error as compared to floor cleaning robot. It is concluded that this system can aid in sanitizer spraying in an indoor environment.

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