PSLB: Portable Sanitization Locomotive Bot

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***Abstract*—There is a need of developing portable, cost effective, handheld, low–powered, easily maneuverable, easy to use and yet very effective sanitization bot that can help disinfect indoor environments so as to act as a preventive measure in the dissemination of the virus, inclusive of COVID – 19, at a time when the number of affected individuals owing to the global pandemic is growing exponentially. We developed a bot, Portable Sanitization Locomotive Bot–PSLB, on similar grounds that can maneuver indoors as per the path laid by the user. We ran field trials in regards to how accurately it can follow the bends with respect to the speed at which it navigates and the results have been very promising so as to have a commercial deployment.**

Keywords—COVID – 19, sanitization, robot, ultraviolet light, easily maneuverable, portable, low-powered, IR sensor

I. Introduction

So far, the number of individuals affected with the Coronavirus or COVID – 19 is 25,905,876 globally and in the Indian context, the figure is 3,769,523 ever since the nascent days of 2020 when the outbreak of the pandemic gained grounds [1][2]. Among them, so far there is an appalling deaths of 861,277 individuals worldwide and 66,460 in India itself. The figures continue to be more alarming as there is hardly a sign that the pandemic is about to be on a descent. As from Fig. 1 [1], the daily reported cases in India, at present, touches almost 80,000 and the reported death rate is 2% among infected individuals in closed cases, implying they were either discharged or have left for heavenly abode, which amount to more than 1,000 deaths daily as demonstrated through Fig. 2 [1].

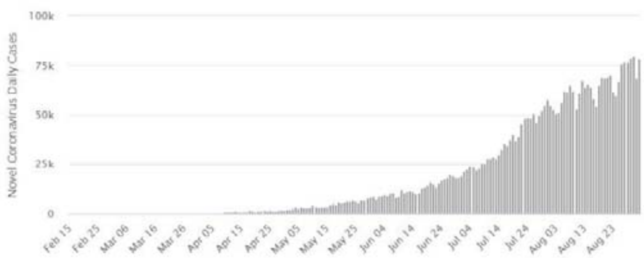

Fig. 1 Daily newly reported cases in India

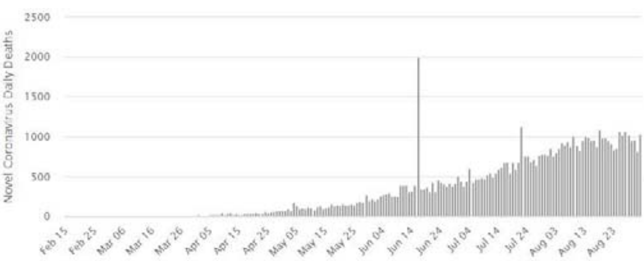

Fig. 2 Daily newly reported deaths in India

In regards to the global context, there are in total 25,905,876 people who got affected with the Coronavirus or COVID – 19. Out of the closed cases, there is a pretty high 5% death rate which amounted to 861,277 demises so far. With more than about 260,000 cases getting reported daily worldwide and the exponential fashion in which its growing, highlighted through Fig. 3 and Fig. 4, the situation is pretty alarming as the GDP of most countries have had a massive blow which that can stall the array of multifarious aspects in a country's growth and development prospects.

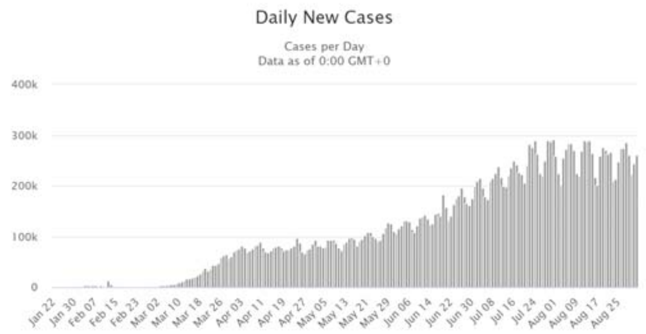

Fig. 3 Daily newly reported cases in the world

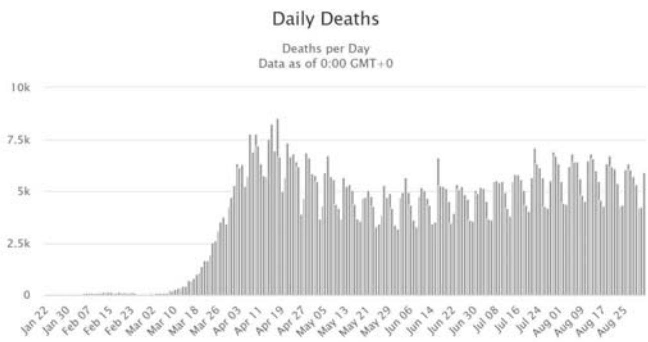

Fig. 4 Daily newly reported deaths in the world

There is an exponential rise in the number of cases both globally and in the Indian context with no signs of a publicly available vaccine or other preventive drugs or proven medical cure. The Coronavirus or COVID – 19 has an incubation period [3] of two to fourteen days, which implies that an infected person can transmit it to as many people before he himself shows signs or gets detected. With rise in asymptomatic cases in the world, where an affected person gets completely undetected, the stakes of spreading of the virus is even higher. Studies even show that one person can infect up to 406 people in 30 days [4]. Thus, we need to come up with solutions that can act as a preventive measure to help curb the spread of the infectious virus. Design and development of systems was undertaken that can help sanitize our indoors effectively and be made available to individuals across all strata.

II. Related Works

Research studies over the years have proved that ultraviolet lights do have the capability to disinfect the environment to which the rays are exposed given its ability to rupture biological cells. Further studies [5] have also confirmed that Far UVC.207-222 nm [6] light rays do have the capability to cause damage to COVID – 19 transmitting virus cells and could be considered to be a good one to be used for sanitization purposes.

There are several products that are slowly evolving, using Far UVC.207-222 nm rays, to disinfect the surroundings. Some are like [7][8][9] UVD Robots, TMiRob, XDBOT, Tru-D SmartUVC and Bacteria-Killer Robot Armed with Ultraviolet Light. However, there are no reported product so far to the best of our knowledge that of a portable, cost effective, handheld, low – powered, easily maneuverable, easy to use and yet very effective sanitization robot, like the one we developed [10], PSLB, that is commercially available. The ability of the bot to be able to maneuver indoors in any laden path and follow the bends in its track while sanitizing does provide an edge to sanitize the environment over other commercially available sanitization products.

III. Motivation

In regards to the global threat looming over us for the virus related pandemic, sanitization has become a key aspect in the environment and surroundings we live in. There is a need for the design and development of cost effective and efficient systems that can at large help us to stand guard in disinfecting our immediate surroundings. At the same time, there is a need that such a device must be handheld, portable, low-powered, easily maneuverable in the indoor surroundings and navigate on the laden path to disinfect the surroundings as per the choice of the user.

According to reports [11] the UV sanitization robots market is valued at $5.57 billion globally by 2027 alone in the hospitals where there is a greater degree of possibility of Hospital Acquired Infections (HAI) and our bot can also be deployed there. Apart from this, there is also a very high market value of such a product when commercial deployment is considered.

We have designed a low-cost, handheld, battery-operated, portable micro-controller based locomotive robot that uses a germicidal Far UVC.207-222 nm lamp to disinfect its immediate surroundings and is easily maneuverable in indoor surroundings as per the choice of the user. Far UVC.207-222 nm has germicidal capabilities, that is, it can help rupture the virulent cells from its immediate environment wherever the ultraviolet light gets an exposure to.

IV. Design Methodology

A. System Architecture

PSLB works on the basic principle of two Infrared Sensors (IR sensor) connected via Arduino micro-controller to two servo motors correspondingly which helps rotate their connected wheel as demonstrated in Fig. 5 and the developed system [9] in Fig. 6.

Fig. 5 System Architecture

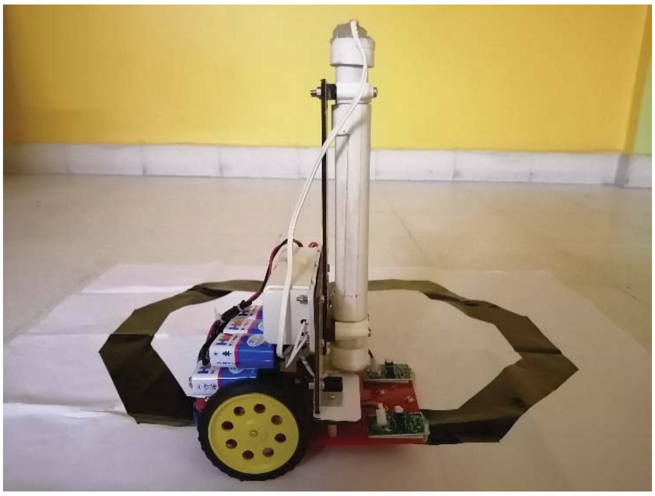
Fig. 6 Side View of the developed bot

There is a speed control switch that helps to control the speed at which PSLB would navigate on its track. In our study, we considered only 2 meters per second, 5 meters per second and 10 meters per second. We incorporated a germicidal Far UVC.207-222 nm of 4W and 6’’ in length, which was lit up using a compatible DC power choke. The whole system was powered through 24-volt rechargeable battery pack.

B. Working of IR Sensors

IR sensor comprises of an IR LED and Photo-Diode. When an IR LED falls on a reflective (or white) surface, the light is reflected back and the reflected light is sensed by the Photo-Diode which allows for an output voltage. This output voltage is sensed by the Arduino microcontroller and it generates a digital control signal to drive the motor driver and hence the servo motor operates the wheel. When the IR LED light falls on the blackened surface (non-reflective), light is not reflected back to the Photo-Diode and thus no output voltage is generated by the sensor. Then, that particular connected servo motor gets non-operational and the corresponding connected wheel stops rotating.

C. Maneuvering in the environment

A track needs to be placed by the user on the surroundings where the Portable Sanitization Locomotive Bot (PSLB) must move through. On a clean surface, like for instance a paper or floor, a black or non-reflective path of considerable width must be placed as shown in Fig. 6. The PSLB would follow that path for its motion. The speed at which the bot would maneuver would be decided upon by the user through the controls in the robotic platform.

To move across the bends that the user would lay in its path, the Infrared Red sensors comes into play. Whenever one of the sensor find a non-reflective surface on its path, then it correspondingly generates no output signal for which the connected wheel momentarily stops rotating. However, at the same time, the other wheel keeps rotating for which the robotic platform takes a turn in that direction and thus can follow the bend line. The operating speed of the platform plays an important role in how accurately it can follow the path and the accuracy also vary with the degree of bend. At higher speeds, it would be difficult for the robotic platform to conform to its laid path if the bend angle is considerably high, but can do so relatively well when the bend angle is less. At lesser speeds, PSLB can handle greater degree of bends efficiently. A study on the same was performed and is listed out in the result section.

D. Santization

The exposure of the germicidal Far UVC.207-222 nm light to its immediate surroundings helps to disinfect the environment. However, if the PSLB maneuvers at high speed then the exposure of the Far UVC.207-222 nm light should be at its maximum so as to have a good disinfection whereas when the speed is on the lower side, it exposure maybe be kept low for each unit area of its surroundings would have a greater exposure with respect to time. In some cases, there could be people around indoors where the robot would work. Then to avoid exposure of direct Far UVC.207-222 nm light to individuals, the light cap could be used to control the intensity of Far UVC.207-222 nm light exposure to its immediate surroundings. Fig. 7 and Fig. 8 demonstrates the two extremes of how the light cap controls the exposure of the germicidal Far UVC.207-222 nm light to its surroundings.

Fig. 7 100% exposure of Far UVC.207-222 nm light to its surroundings as controlled by the UV C light cap

Fig. 7 0% exposure of Far UVC.207-222 nm light to its surroundings as controlled by the UV C light cap

V. Results

A. Result Validation

We performed a comparative study of how accurately the PSLB can maneuver on the laden track for varying speeds and calculated it for fifty trials. The results, as was obtained, is presented in Table I.

TABLE I. Comparative Study of how accurately PSLB can follow the bends in its path at varied speeds

Sr. No.	Angle of Bend in path (in degrees)	Speed of Bot (in m/s)	Path Follow Percentage Accuracy (for 50 trials)
1	10	2	100
		5	100
		10	98
2	20	2	100
		5	100
		10	96
3	30	2	100
		5	98
		10	98
4	40	2	100
		5	98
		10	94
5	50	2	98
		5	98
		10	92
6	60	2	98
		5	96
		10	90
7	70	2	96
		5	94
		10	86
8	80	2	90
		5	86
		10	86
9	90	2	88
		5	84
		10	82
10	100	2	80
		5	76
		10	60

The results were then plotted in a graph for a visual understanding. From Fig. 8, we can decipher that at lower speeds the robot has a very high accuracy in following the path, however, as the speed increased, the robot steered off its course a couple of times during the trials, considering the bend of the path to be constant. Again, when the speed is considered to be constant, at higher bend angles, path follow accuracy is lower compared to lesser path bend angles. Thus to maintain above 90% path follow accuracy, Table II shows the maximum operating speed for the maximum bend angles in its path.

TABLE II. Operating Speed of PSLB for atleast 90% path follow accuracy for studied bend angles

Sr. No.	Operating Speed (in m/s)	Safe Bend Angles (in degrees)
1	2	<=80
2	5	<=70
3	10	<=60

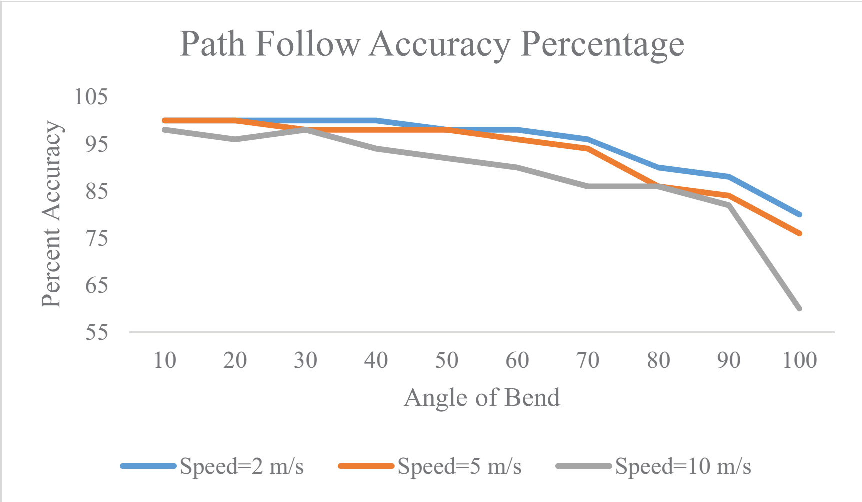

Fig. 8 Path Follow Accuracy Percentage with respect to bend angles in path at varying speeds for PSLB

VI. Discussion and Conclusion

- The user just needs to lay the path in the environment, following the safe bend angle measures for the chosen operating speed of the bot, where it is desired to be sanitized.
- The power requirements are moderately good as PSLB can operate for five hours at a stretch, when operated at a speed of 2 m/s. It would possibly require just a few minutes of operation during every sanitization round.
- The user must always be careful to avoid direct contact of the germicidal Far UVC.207-222 nm light coming from bot for long exposure to the same can be harmful. Thus while being in close contact of PSLB and the bot is operational, its recommended to use the ultraviolet light cap to cover it up by the maximal percentage. Keeping this hazard in mind, we have also designed two different switches for PSLB. One to power up the bot as a whole and make it operational, except for the Far UVC.207-222 nm light, and the other to power up the ultraviolet light. This would ensure that one could still be in close contact with PSLB safely if the Far UVC.207-222 nm light isn't switched on.
- The positioning of the sensors in the bot plays a crucial role for an efficient maneuver of PSLB on the laden path.

VII. Future Scope of Work

- We in our design have used only two IR sensors. However, to ensure a more efficient black line detection, we could well use a sensor array interfaced to the micro-controller.
- Tele-operation of the robot instead of IR sensors through joystick could prove to be useful for external surroundings.
- By using another low-cost, low-powered, high precision Ultra-Wide Band (UWB) technology, we can make our robot autonomous in both outdoor and indoor environments.
- Robotic Operating System (ROS) may be used to make a modular design of software framework.
- Obstacle avoidance could also be possible through the implementation of LIDAR and laser range finder sensors to get the accurate distance from an object while roaming around in space.
- IMU sensor, consisting of accelerometer and gyroscope, may be implemented to check the stability of the bot in the rough terrain.
- This can also be extended to be used in places where automated processes are to be carried out, like in manufacturing industries.

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