

Swachh-Bharat Bot: A Sweeping Robot

Swapnil Jugal^{1*}, Kamal Sharma² and Vikrant V Agashe³

¹Proprietor, Hindustan Abhyantriki, Mumbai, India

^{2,3}Scientific Officer, Division of Remote Handling & Robotics, Bhabha Atomic Research Centre,
Mumbai, India

Phone Number: +91-9757028893

***Corresponding Authors' E-mails:** swapnil.jugal@gmail.com

Abstract

The Swachh Bharat Mission was launched by the Government of India on 2nd October, 2014 aiming towards a clean and trash-free India. Many cities and places in India and abroad are suffering with trash and litter lying on the roads, railway platforms, etc. Generally, manual sweepers and laborers are deployed for collecting trash at such places. In this paper, we present a sweeper robot that is capable of sweeping trash. There are various such sweeping robots and machines available in the market, but they focus mainly on dust and small-sized trash. The sweeper robot presented here is designed mainly for sweeping large-sized trash like one-liter bottles (empty as well as filled), metallic-cans, etc. The design and fabrication of such a sweeping mechanism is discussed in this paper.

Keywords: Swachh Bharat Mission, Swachh-Bharat Bot, Sweeping Machines, Sweeping Robots.

1. Introduction

There are several countries including India that are suffering from hygiene problems like trash lying at public places such as railway platforms, roads, etc. The laborers deployed by respective municipal corporations generally do the sweeping job. The laborers have their scheduled working hours and are not available 24x7. Also the people involved in sweeping tasks work under unhygienic conditions and have a high risk of suffering from various diseases. Therefore the sweeping task is a perfect job to be done by a machine or a robot. Hon'ble Prime Minister of India, Shri Narendra Modi, launched the Swachh Bharat Mission on 2nd October, 2014 and all the citizens of India took an oath to clean the trash at public places devoting at least two hours a week. The authors of this paper are also associated with the mission and went on railway platforms, roads and footpaths to sweep the trash lying there. It was observed that the trash lying there was containing large-sized items like plastic water bottles, metallic cans, pebbles, etc. There are various sweeping robots and machines available for automatic sweeping like [3], [4], [6], [7] but these machines are built to sweep dust and small-sized trash like leaves, small wrappers, etc. The ones which collect large-sized trash, like [2], [8], [9], [10] are too expensive and very big in size.



Figure 1: (a) Swachh-Bharat Bot (Side View)



(b) Swachh-Bharat Bot (Sweeping Mechanism)

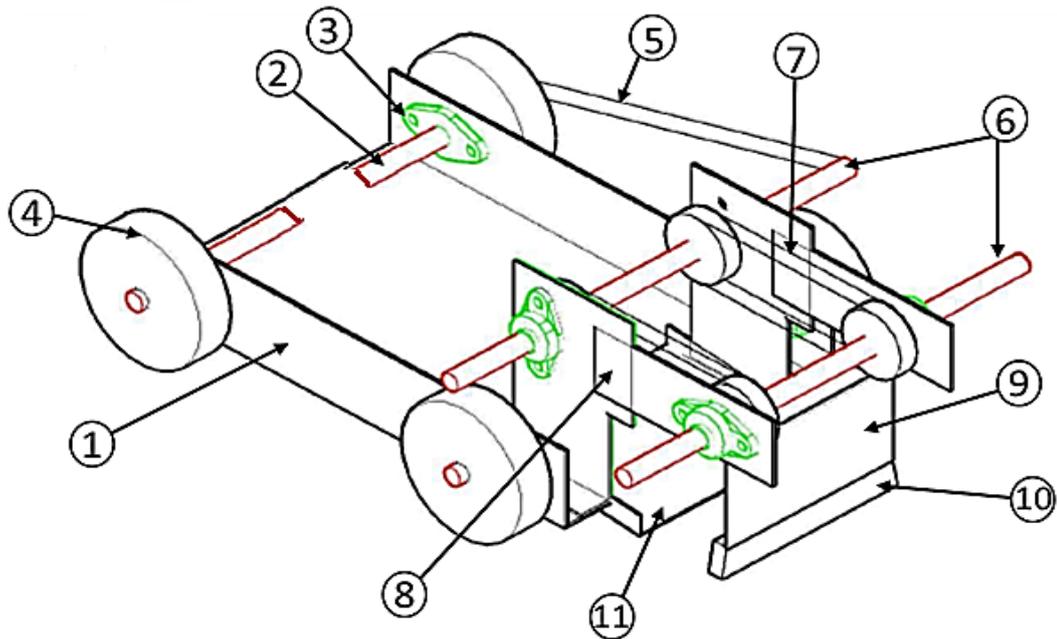
This paper presents a design that can collect large as well as small-sized trash over a flat, level surface and can help in promoting the Swachh Bharat Mission. We have named this design as Swachh-Bharat Bot. The design and fabrication of Swachh-Bharat Bot is discussed in the next section.

2. Swachh-Bharat Bot: Design & Fabrication

The authors of this paper went to various railway platforms and places that deploy automatic sweeping machines. It was found that the available sweeping machines were assisted by a human operator who pushes the machine and the machine sweeps the platform just like a grass-cutting machine. These sweeping machines are based on the designs given in [3], [4], [6] in which the sweeping action is performed by a rotating brush. Also the sweeping robot [7] can autonomously sweep inside a room. But such machines or robots can sweep only dust and small-sized trash like leaves, small wrappers, etc. The machines that can sweep large-sized trash are based on the design as given in [2], [8], [9], [10]. But these machines are very costly and huge in size. An operator generally rides on these machines to drive and sweep an area. Therefore we came up with a design that is smaller in size, cheaper in price, collects large as well as small-sized trash and is easy to be made autonomous. The design details are discussed below.

The Swachha-Bharat Bot (see Figure 1) is a floor sweeping robot with an ability to sweep the objects that lie in its line of action. It's a z-shaped robot when viewed from side. It consists of a four wheeled cart (1 in Figure 2) and a sweeping mechanism. The cart has the provision for a removable bin, for collection of objects that are swept in. Objects (trash) are transferred from floor to the bin through collecting pan (11 in Figure 2). Collecting pan is always in contact with the floor. Sweeping mechanism is mounted on the front side of the robot. Two motors along with the battery are mounted on the rear side of the robot. Sweeping mechanism consists of brushes (10 in Figure 2), mounted on the brush-mounting plate (9 in Figure 2), which revolve around an oblong path. The sweeping mechanism shaft (6 in Figure 2) is interconnected with the left wheel driving shaft (2 in Figure 2) through the chain drive (5 in Figure 2). The left motor actuates the left wheel driving shaft which further actuates the sweeping mechanism leading to sweeping action of the brushes mounted on it. The motion of left rear wheel gets transmitted to the sweeping mechanism shaft through a chain drive.

The setup should be able to sweep the objects with size comparable to a one-liter mineral water bottle. With this assumption in mind, the collecting pan's width was decided. Accordingly then width of the chassis of the cart was finalized. The length of the cart is chalked out keeping in mind the provision for bin and the actuator mounting. The wheels to be mounted are decided on the standard wheels available in the market. A survey was done to check out the availability of brushes to be used and some of them were finalized. After deciding the brushes its mounting bracket was finalized. Accordingly the height of the sweeping mechanism and mounting bracket was fixed. The length of the sweeping mechanism was finalized with the span for which the brushes will be perpendicular to



1	Chassis
2	Left Wheel Driving Shaft
3	Bearing
4	Wheel
5	Chain Drive that transmits motion from rear end wheel to Sweeping Mechanism Shaft

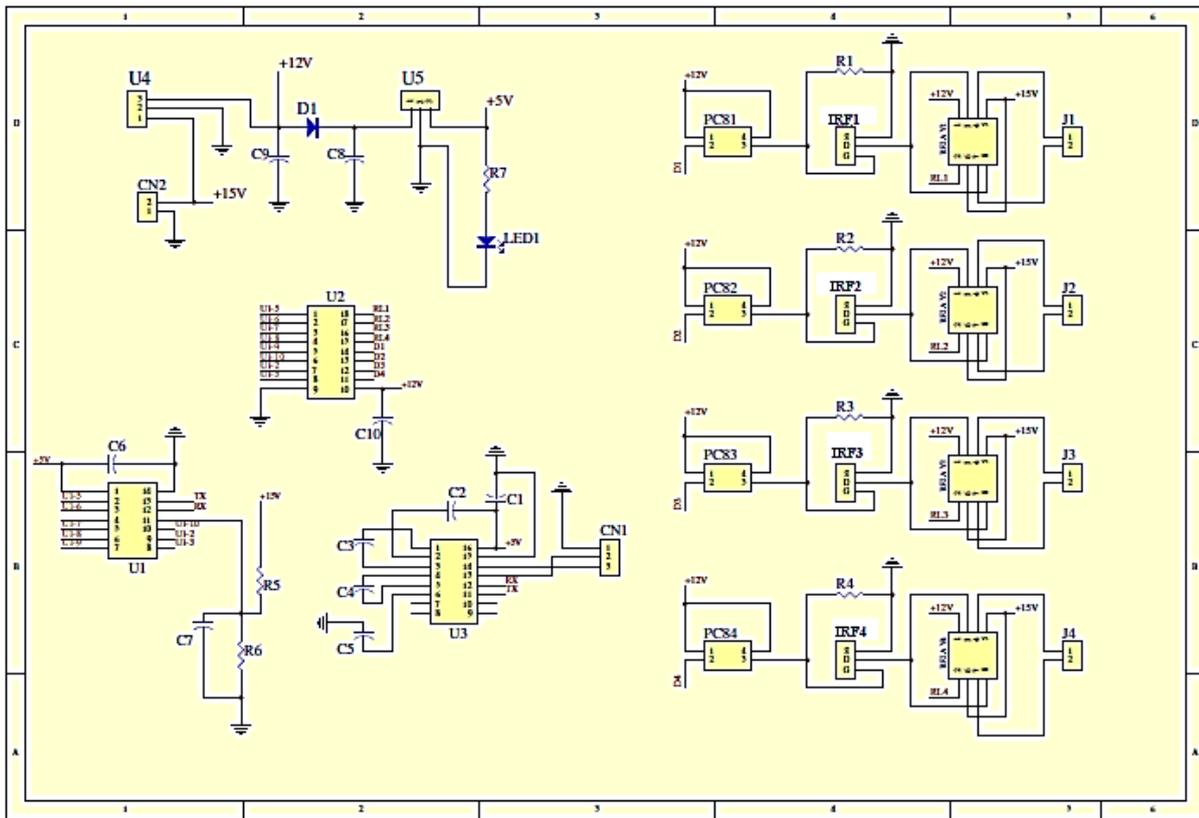
6	Sweeping Mechanism Shafts
7	Chain Drive between Sweeping Mechanism Shafts
8	Sweeping Mechanism Mounting Bracket
9	Brush-Mounting Plate
10	Brush
11	Collecting Pan

Figure 2: Swachh-Bharat Bot (CAD Model)

the floor while sweeping. The collecting bin is designed for easy removal and disposal of garbage from the robot. The total load (weight of the robot + load for sweeping action) was assumed to be 80 kgs.

The parameters were finalized and the CAD model was generated which is shown in Figure 2. The mechanical structure was built according to this CAD model and minor modifications were incorporated to suit the flaws of manufacturing.

Two 12 V permanent magnet DC motors (0.1 hp and 25 rpm each) were mounted at the driving shaft (2 in Figure 2). To run this setup, a 12 V, 18Ah Battery was used. A Quad motor controller (see Figure 3) was developed to control the two motors for rear wheels (provision for two extra motors was given for future use). The two motors can be controlled for an overall forward, backward, turn right and turn left motion of the complete system, the turning being done by differential skid-steering.



U1	MAX 232
U2	ULN2803 Darlington transistor array
U3	PIC 16F1823 Microcontroller

U4	IC 7812
U5	IC 7805
PC81 - PC84	PC817 Opto coupler
IRF1 - IRF4	IRF540 FET for Motor driving

Figure 3: Schematic for Quad Motor Controller for Swachh-Bharat Bot

The main features of the controller are listed as under:

1. Provision for controlling 4 DC brushed motors with maximum rating up to 24V and 6A.
2. Variable Input supply 12V - 30V.
3. On board voltage regulators for Microcontroller and FETs.
4. Serial port interface for receiving commands from a computer, simple command structure, direction can be specified as "-" or "+" speed.
5. "Double Pole Double Throw" relays used for changing direction of rotation.
6. IRF540 FET is turned ON/OFF by PWM of 200Hz for applying variable voltage to motor. With this arrangement the motor can run at variable speeds in either direction.

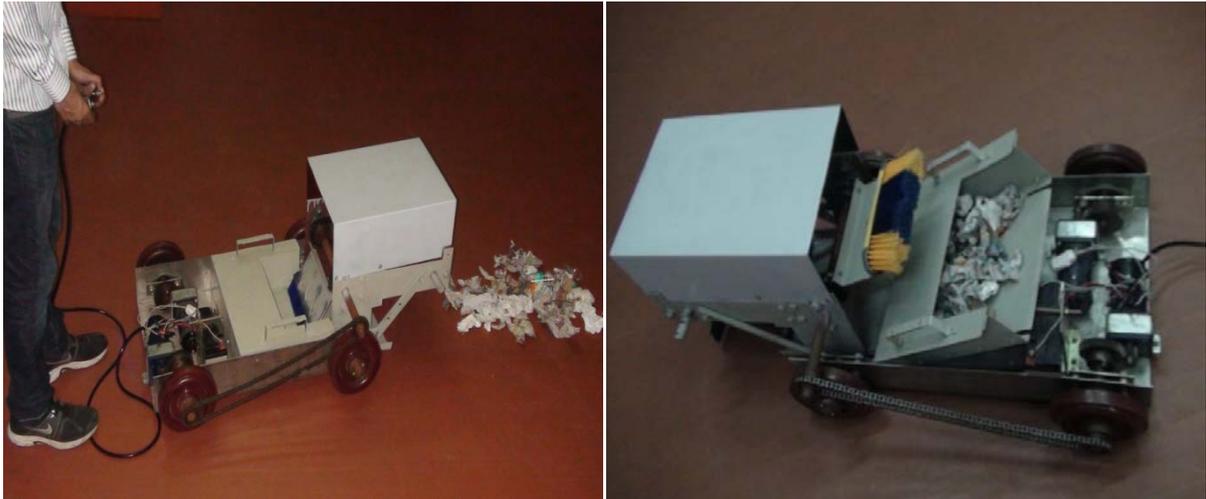


Figure 4: (a) Swachh-Bharat Bot collecting Trash

(b) Swachh-Bharat Bot with collected Trash

7. Smooth transition to new speed. The controller will take care of acceleration when changing speed or direction with auto-zero speed direction change
8. Microcontroller PIC 16F1823 @ 32MHz running the program for maintaining communication with a PC. Time bound strict communication protocol for communication failure detection and safe stopping of robot.
9. Battery Voltage monitoring and reporting to computer.

Using the controller module, the Swachh-Bharat Bot can be tele-operated from a computer.

The basic difference between the existing sweeping mechanisms and the Swachh-Bharat Bot is that the sweeping mechanism in existing machines is generally a rotating brush that is quite good for sweeping dirt and small-sized trash. The sweeping machines for large-sized trash deploy big rotating brushes and vacuum based sweepers. The Swachh-Bharat Bot, whereas, uses a chain-sprocket based platform over which the mounted brushes revolve rather than rotating.

The brushes revolve around an oblong path while pushing trash inside the collecting pan. This allows for an increased duration of contact between the sweeping brushes and ground. Also it provides easy sweeping of comparatively larger objects. The trash slides down to the bin that can further be removed and the collected trash can be disposed off. This operation is similar to how a human performs sweeping while collecting the trash into a dust-pan.

In this fashion, the Swachh-Bharat Bot is capable of sweeping dust, small-sized trash (like pouches, wrappers, leaves, etc.) as well as large-sized (like empty or filled water bottles (up to 1 litre), metallic cans, pebbles, etc.). The sweeping action of the Swachh-Bharat Bot is shown in Figure 4.

3. Conclusion & Future Work

The Swachh-Bharat Bot is developed to promote the Swachh-Bharat mission. It is designed to mimic the human action of sweeping. The important features are listed below:

1. The Swachh-Bharat Bot is capable of sweeping small-sized trash as well as large-sized trash.
2. The Sweeping brushes are removable and can be changed easily.
3. The size is quite small as compared to the other sweeping machines with similar sweeping capability.

4. The price is quite less (less than INR 50,000) as compared to the other sweeping machines with similar capabilities.

5. It can be operated manually also by pushing it over the sweeping area.

The future plans are to make it autonomous so that it can detect the trash on its own and collect it without human-guidance. Various sensors can be mounted as in [1], [5] to make it autonomous.

4. Acknowledgment

We would thank Dr. P.K. Pal and Dr. D.N. Badodkar for their invaluable guidance. We would like to thank Mr. Jagadish Kota, Mr. Peter Jacob and Mr. Mileswhar Dharne for providing help with the electrical setup of Swachh-Bharat Bot.

References

- [1] Abhidipta Mallik, Kota Solomon Raju, Pramod Kumar Tanwar. Design of an elementary level surface sweeping and wiping robot for domestic use. Proceedings of International Conference on Devices, Circuits and Communications, 2014.
- [2] Andreas Voelkle. Street Sweeping Machine. Patent No.: US 482663 A. Sep 13, 1892.
- [3] Dieter Patzold, Alfons Schreiber, Peter Tiwi. Floor-Sweeping machine. Patent No.: US 4484371 A, Nov 27, 1984.
- [4] Dieter Patzold, Alfons Schreiber, Peter Tiwi. Floor-sweeping machine. Patent No.: US 4502173 A, Mar 5, 1985.
- [5] Guan-Hong Kuo, Chih-Yung Cheng, Chen-Jeh Wu. Design and Implementation of a Remote Monitoring Cleaning Robot. Proceedings of International Automatic Control Conference (CACCS), 2014
- [6] Hermann Haaga. Sweeping machine. Patent No.: US 5896611 A, Apr 27, 1999.
- [7] Joseph L. Jones, Newton E. Mack, David M. Nugent, Paul E. Sandin. Autonomous Floor-Cleaning Robot. Patent No.: US 7571511 B2, Aug 11, 2009.
- [8] Mott Carl W. Street sweeping machine. Patent No.: US 2614279 A, Oct 21, 1952.
- [9] Thomas Weight. Street Sweeper. Patent No.: US 371722 A, Oct 18, 1887.
- [10] Wendel Adolph H, Worwa Richard G. Powered sweeping machine. Patent No.: US 3604051 A, Sep 14, 1971