Development of Autonomous Indoor Floor Cleaning Robot

Pranav Iyengar, **Ashish Umbarkar**

Abstract - Cleanliness plays an important role in everyday life. It is the most popular method of maintaining our surroundings free of contaminants and illnesses, as well as for social and academic well-being. Recently, a few cleaning-arrangements have become available to maintain your home dust-free. Machine-Controlled For the betterment of humanity, floor cleaners were given. In recent years, cleanliness has been a critical aspect in improving one's own health, so we are developing a robotic Automated floor cleaner that would safely clean the premises. Expert support robots, such as client care and indoor robots, account for a large portion of these robots. One of these robots' most basic requirements is the ability to explore in environments where a GPS system cannot be used. The robot should also be able to detect barriers and quickly reroute to reach the desired destination. While getting at the goal, the robot will also be cleaning the floor simultaneously and independently. The robot depends on Robot Operating System (ROS) structure. The SLAM (Simultaneous Localization and Mapping) would aid in creating a crash-free path for the robot from start to finish.

Keywords: Cleanliness, Automated floor cleaner, Safely, ROS, SLAM

I. INTRODUCTION

The importance of cleanliness in daily living cannot be overstated. It is the most widely used strategy for keeping our environment free of toxins and diseases, as well as for social and academic well-being. A few cleaning arrangements have recently been accessible to keep your home dust-free. Machine-Controlled Floor cleaners were distributed for the greater good of humanity. For homeowners who wish to keep their floors clean, a vacuum cleaner is one of the most helpful and vital tools. Each of the different cleaners has its own set of benefits and drawbacks. Dusting and sweeping are everyday household duties that must be completed in order to maintain a clean environment. Cleaning has been a key component of enhancing one's personal health in recent years, therefore we designed a robotic Automated floor cleaner to assist. In essence, as a robot, it decreases human mistake and improves cleaning productivity. Our robot would clean the floor efficiently and autonomously, avoiding obstacles on its path to its goal. This robot might be used in a number of places, such as offices, hospitals, residences, and public locations.

Manuscript received on 06 July 2022 | Revised Manuscript received on 13 July 2022 | Manuscript Accepted on 15 September 2022 | Manuscript published on 30 September 2022.
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Indoor cleaning robots are significant in this era of pandemics because they can assist sanitise the floor without requiring human intervention, which is especially important in hospitals with large crowds. Although robotic floor cleaners have been on the market for some time, they have only lately begun to increase their capabilities. As a consequence of technical improvements, manufacturers have indeed been able to tune and add more handy features, which has been a critical component in the development of entirely automated and highly effective cleaners. They are commonly used for floors in housing neighbourhoods and commercial malls. Programming software, batteries, a cleaning system, and other accessories and functions are often included in robotic floor cleaners to provide convenience and simplicity of use to the end user. One of the most basic tasks for autonomous robots is to move safely in any environment. In the last few years, autonomous robot routes have improved dramatically, particularly those involving SLAM (Simultaneous Localization and Mapping). Transcendent SLAM is distinguished by range-detecting SLAM, which uses the robot's encompassing scope as a component reference to constrain the robot while also constructing a guide of the robot's encompassing. This SLAM technique is extremely reliant on the accuracy of the reach finding sensors, as inaccurate readings will have a significant impact on the system's yield.

II. LITERATURE REVIEW

Usually, the floor is cleaned with a dry mop or wet mop, by hand as a possibility. At the highest level, they should be clean and tidy. This includes cleaning a variety of surfaces, especially concrete floors, heavily finished wood or marble floors. Between these floors, a rough, concrete floor surface, usually found in the center of the city, is covered with a large residue. The body of the robot is made up of many smaller parts. It has sensors, microcontrollers, actuators, and various components, just like any other robot. With the advent of technology, researchers are focusing more on robots to make human life easier. The design, development, and construction of the Smart Floor Cleaning Robot (CLEAR) protocol using IEEE Standard 1621 The learning robot has the ability to work in both independent and manual ways, as well as have additional features such as timing and a bagless dirt container with automatic ground disposal. This work has the potential to significantly improve a person's quality of life [1]. With the use of standard ROBOT automatic cleaning, this study discusses a ROBOT human-friendly home cleaning system.

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To ensure that the system cleaning effect is enhanced, a manual prototype of a rotating brush device is constructed. We can find in all of this research article that the shortcomings of research are that robots can work automatically and automatically. As a result, we are now designing a robot that can operate without any human effort [2]. Robot Operating System (ROS) is a free and open source software that is probably best known for its advanced mechanical system. ROS is used to support messaging communication, devices, bulk boards, and machine communication, among other things. In robotic applications, it provides a variety of libraries, bundles, and a few connecting tools. ROS is an optical transmitter that allows communication between values, and is commonly referred to as middleware. ROS provides a number of offices that assist analysts in developing robotic applications. ROS is used as a primary basis in this study as it spreads messages like points between multiple hubs and has a well-defined boundary. Class functionality, modularity, and simultaneous asset management are all aspects of ROS. ROS enhances the overall performance of the framework by ensuring that cables do not attempt to read and write on shared assets, but instead transmit and purchase messages. In addition, ROS supports us in creating the physical universe, creating a robot model, performing calculations, and imagining the physical world instead of creating a complete framework for material. As a result, the draft can be revised as needed, giving it a better result when it is finally done mechanically [3]. SLAM Independent robots should be able to safely explore the environment without colliding with humans or colliding with objects. Simultaneous localization and mapping (SLAM) allows the robot to access this function by knowing what the environment looks like (the map) and where it resides in relation to the environment (to create space). SLAM can be used using a variety of 1D, 2D and 3D sensors such as acoustic sensor, laser range sensor, stereo view sensor and RGB-D sensor. ROS can be used to make various SLAM algorithms such as Gmapping, Hector SLAM, KartoSLAM, Core SLAM, Lago SLAM.

In comparison to the rest, KartoSLAM, Hector SLAM and Gmapping are the best of the bunch. These methods have similar performance in terms of map accuracy, however they are conceptually distinct. That is, Hector SLAM relies on EKF, Gmapping on RBPF occupancy grid mapping and KartoSLAM on graph based mapping. For a robot with limited computing capabilities, gmapping can be effective. Like the ROS slam gmapping node, the mapping package in ROS supports laser-based SLAM (Simultaneous Localization and Mapping).

SLAM (Simultaneous Localization and Mapping) is the most used execution for area awareness and climate recording in a driving of any autonomous vehicle. For confinement and temperature planning, most robots with SLAM combinations depend primarily on a laser locator. In any case, since the SLAM is poorly sculpted, the laser beam locator must be extremely accurate. The high-precision laser rangefinder is prohibitive and limits its use in a wide range of robots [4]. This study examines the differences between manual and automated robots, as well as how the two could be integrated to create a single robot. It features a scheduling option and can self-empty. CLEAR competes with a slew of companies that sell the same products at exorbitant prices. This study paves the way for effective sweeping and scrubbing of floors. Water is sprayed onto the floor using an automatic water sprayer. This robot can also be controlled manually with the use of a remote control. Reduces labor costs, saves time and ensures thorough cleaning. The robot works autonomously in automated mode. Operations such as sweeping, cleaning and changing the path in the event of an obstacle are performed automatically. However, new ideas are continually being considered to improve the developed system and add additional functionality. In addition, the speed of the robot can be adjusted and it can move randomly in any direction [5]. This paper presents a complete new technique for solving the problem of locating and navigating robots indoors when GPS is not available. The proposed method eliminates the need to install and maintain additional navigation systems. Instead, it should rely on an established video monitoring system that operates 24 hours a day, seven days a week. The document outlines the criteria for a service robot that will enable the method to be implemented. The ability to remotely maintain the location and navigation system is a significant advantage of this technology. This would also cut the cost of future maintenance of the robotic system in half [6]. Abhishek Pandey, Anirudh Kaushik, Amit Kumar Jha,Girish Kapse [7] The paper is a technical survey which discusses about the working about the robot using different micro-controller and how it can be used efficiently. Through sweeping, vacuuming and cleaning mechanisms, in this study we have introduced a floor cleaning robot for domestic contexts. In the experimental setup, the robot was able to clean the floor with a cleaning efficiency of 85% and 92% in autonomous and manual modes, respectively. The robot can clean the floor closest to the wall up to 16cm on average. It can clean the floor at a speed of _180 cm2 / sec avoiding collisions with moving objects. In terms of three cleaning mechanisms: sweeping, vacuuming, and scrubbing, and its ability to scrub household floors with heavy layers of chalk dust at a comparable cleaning speed, the given robot is promising over others cited in the literature. The future study will focus on improving outcomes, robot design and testing in common home settings, all of which have the potential to improve humanity's quality of life. The robot was created using indigenous technology and, if it passes consumer tests, it will become a commercially viable product. [8][9-17]

III. STRUCTURE OF THE ROBOT

3.1 Problem Statement

In recent times we have learnt the lesson that only dusting the surrounding is not enough for the cleanliness, and the biggest teacher is the COVID pandemic. With COVID era we all began to use sanitizer frequently and disinfect out homes and offices regularly. And another main aspect is the social distancing or the fear of getting infected easily. In market we find robots with vacuum cleaners but do not find solutions for both the problems together, because of which we still depend on labour work to come and disinfect our homes and offices, which increases the risk of infection in chance of the spreading it too.

So, to counter these issues we are developing a robot which would disinfect the surround autonomously and effectively.

3.2 Design of the Robot

Design of the robot was done keeping in mind the several problems it should solve. Starting with the cleanliness then carrying the disinfectant and moving smoothly and running efficiently. Design of the robot was done using Autocad. The robot is divided into 3 parts. The bottom part where the robot wheels is connected with DC motors and motors to the robot with aluminium pipes. The Y bracket connecting the wheel motor to the base of the robot was designed to reduce the material and efficiently support the robot. The acrylic plate is mounted on the robot to carry the disinfectant and the other modules like raspberry pi, Arduino and sensors like LIDAR. Rear part of the robot carries 2 motors to which sponge is attached for the sweeping purpose.

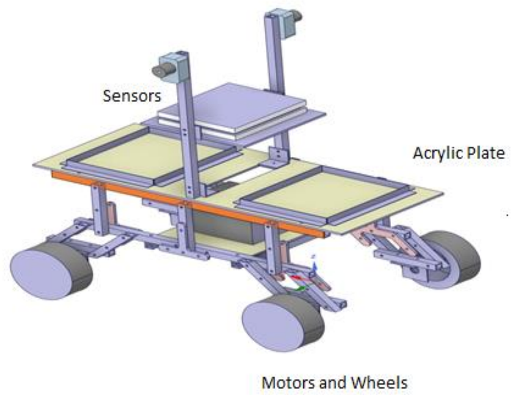

Fig. 1 CAD Model of the Robot

3.3 Analysis

Analysis of the robot was done using ANSYS software to confirm the toughness and rigidity of the robot. The main part was the acrylic plate as it carried the major load like the disinfectant and the sensors and modules. The stress analysis of the acrylic plate was done. Stress Analysis is engineering discipline based on solid mechanics. It is basically used to check if the component can withhold the stresses and strains applies on it. In today's world it is done using computer. Finite element method (FEM) is widely used to solve these problems. FEM discretises a domain into many elements. Each element contains many nodes. After this the stresses are applied and results are obtained. Below are the constants given used to Analyse the component.

Table 1: Specification of the Material

Material	Acrylic
Density	1.39 x 103 kg/m3
Young' Modulus	2500 MPa
Poisson's Ratio	0.37
Bulk Modulus	3205.1 MPa
Shear Modulus	9212.41 MPa
Tensile Yield Strength	64.8 MPa
Tensile Ultimate Strength	62 MPa
Compressive Yield Strength	110 MPa

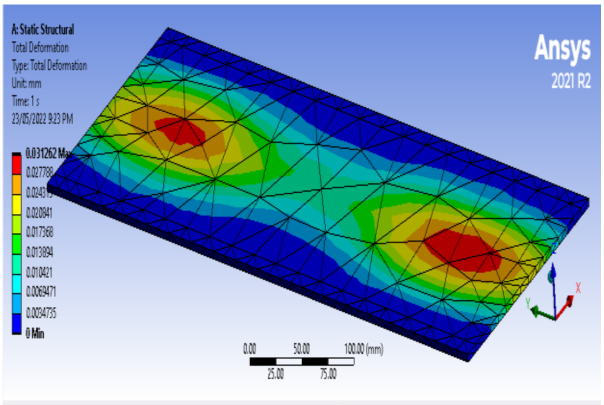

Fig. 2 Total deformation of the plate

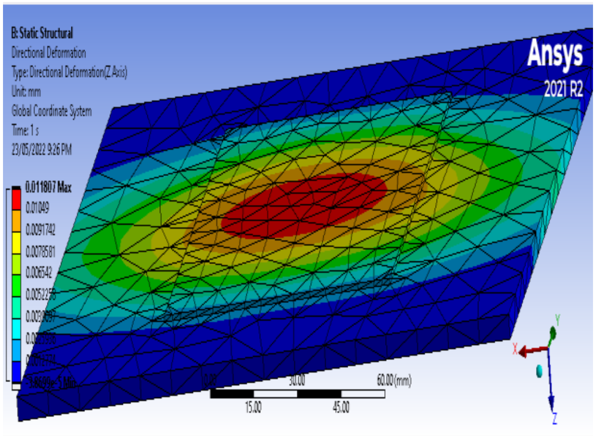

Fig. 3 Directional Deformation of the plate

3.3 Mechanical Structure of the Robot:

Raw material which was used to manufacture the robot was aluminum as it is easy to perform operations on it and it is cheap and light. Various operations used to manufacture the robot was Laser Cutting, grinding, Drilling etc. The pipes are connected with the help of nuts and bolts.

Table 2 Motor Specification

Parameter	Geared Motor (Wheels)	Motor (Sweeping)
RPM	60	60
Stall Torque	30 kg-cm	1 kg-cm
No Load current	300 mA	40 mA
Load Current	900 mA	180 mA
Weight	164 gm	30 gm

Fig. 4 Mechanical Structure of the Robot

Retrieval Number: 100.1/ijrte.C71990911322
DOI: 10.35940/ijrte.C7199.0911322
Journal Website: www.ijrte.org

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3.4 Circuit of the Robot

Raspberry pi is used as the main computer to control the robot. The robot would be using Robot Operating System (ROS) and Simultaneous Localisation and Mapping (SLAM) about which the description is given in the Literature Review. The Raspberry is connected with Inertial Measurement Unit (IMU) sensor and LIDAR sensor both of which give input to the Raspberry pi. IMU will see to the angular position and acceleration of the robot where as the LIDAR will detect for the obstacles in front of the robot. The specification of the materials is given in table below.

Table 3 Material Specification

SR NO	Component	Specification
1	Raspberry Pi	4 Model B
2	Arduino	Mega 2560
3	LIDAR	360 degree – 8M
4	Motor Driver	L298N
5	Universal PCB	
6	9-Axis Attitude Gyro Accelerometer Magnetometer Sensor Module	MPU9250
7	Relay Module	12V
8	Battery	11.1V; 5400 mah

The power source is connected to the Raspberry pi and the motor drivers independently, A Universal PCB is attached to the raspberry pi to which a buck converter is connected and IMU too. The LIDAR is connected via USB and mounted above to give input to the ROS. Arduino ATMega 2560 is connected to the Raspberry pi. ATMega works as a microcontroller which controls the motors of robot. The speed, rotational direction and the permutation of the motors to drive the robot to move forward, backward, right and left. There are 3 separate motor drivers linked to the ATMega and a Relay module which control the pump. The motor gets power from the battery itself as stated above and the directional controls from the Arduino.

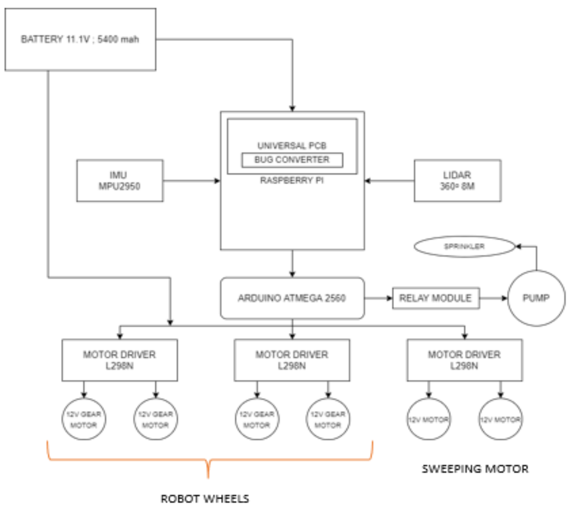

Fig. 5 Block Diagram

3.5 Cleaning Mechanism

The cleaning is very simple and efficient, the working component is the motors to which sponge is attached. The motors rotates continuously which perform the sweeping of the floor. The disinfectant is also sprayed on to the floor which disinfectants it. The command for the spray and the sweeping is given by the microcontroller (Arduino ATMega). As soon as the obstacle is detected and the robot stops, the cleaning is also stopped avoiding the cleaning of the same place again. The flow of command can be seen in figure below.

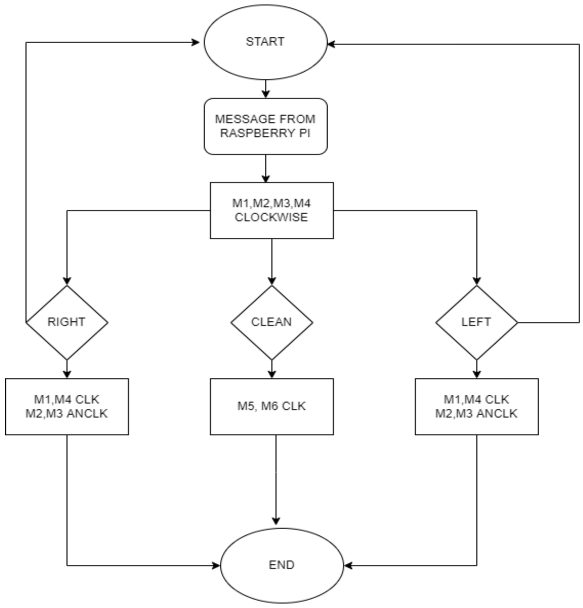

Fig 6. Flowchart

* M1, M2, M3, M4 are motors
CLK- Clockwise
ANCLK- Anticlockwise

IV. RESULTS

The efficiency of the robot is calculated as the area covered by the robot to the given destination to the area cleaned by it.

$$\text{Efficiency } \% = \frac{\textit{Area sweeped by the ROBOT}}{\textit{Area covered my the ROBOT}} \text{ X } 100$$

The efficiency came out to be 90%. For calculating the efficiency of the robot, the robot was made to clean an empty room of 10’x11’. While cleaning the robot we saw the robot was able to clean 100’. It could not cover the corner of the room because of the rectangular structure. But the problem could be overcome having an alternative cleaning mechanism whereas instead of attachment of the motors and rotatable sweepers we can have a long foam roller extended to the trackwidth of the robot.

V. CONCLUSION

The robot is clearly designed on the basis of the modern technology. The robot has the features required for the cleaner. The robot was designed in AUTO-CAD software and the parts are analysed. The robot has its own significance in the given time as it can clean or disinfect the surrounding on its own without any human intervention. IT saves the labour cost and the risk of infection to the personnel working at the given place. Nonetheless there are still new ideas to improve the given system which paves the way for future graduates to work upon.

Retrieval Number: 100.1/ijrte.C71990911322
DOI: 10.35940/ijrte.C7199.0911322
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Retrieval Number: 100.1/ijrte.C71990911322
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