

Autonomous Floor Cleaning Robotic Vehicle

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Abstract

The day today activities of house cleaning require the house to be cleaned manually. Thus involves using the brooms of mops to cleaning and sweep the house. The conventional floor cleaning and machines is most widely used in airport platforms, railway platforms, hospitals, bus stands, malls and in many other commercial places. However with the advancements in technology and automation it is very much necessary to develop smart autonomous solutions for the domestic purposes also. This project deals with the concept of smart autonomous floor cleaning robot. The robot can be used autonomously to wipe and sweep floors in the house from time to time thus keeping the house clean and maintaining Hygiene. The developed machine is completely autonomous and doesn't require any manual intervention after it is started. The proposed system used vacuum as well as brushes to clean the floor as well as onboard water source to perform mopping operation.

Keywords: *Robot, Automation, Machine, Manufacturing, Hygiene*

INTRODUCTION

Effective cleaning and sanitizing helps and protect the health of the human beings directly and indirectly. Also, cleaning and sanitizing prevents the pest infestations by reducing residues that can attract and support bees, pests etc. It also improves the self life of the floor, walls etc due to regular cleaning and maintenance. In recent years, most of the people prefer to use trains or buses for commuting and hence these places are littered with biscuits covers, cold drink bottles etc. Hence, it is necessary to clean the bus stands and railways stations at regular interval. There is no one single cleaning method that is suitable cleaning technique and also the equipment should be user friendly. Cleaning work can be physically demanding and a

need has been identified to developed methods for systematic ergonomics evaluation robots are getting more popular for busy and aging populations due to lack of workers. However in India, unemployment is more and hence there is a need to develop less labour oriented cleaning machine. Hence, the present work is aimed to design, development and evaluation of a manually operated floor cleaning machine. In recent years, conventional floor cleaning machines are most widely used in airports , railway stations, malls, hospitals and in many commercial places, as cleaning is one of the important parameter for the sanitation and government regulations . For maintaining such places, cleaning the floor is the major task which is necessary.

In recent years, robotic cleaners have taken major attention in robotics research due to their effectiveness in assisting humans in floor cleaning applications at homes, hotels, restaurants, offices, hospitals, workshops, warehouses and universities etc. Basically, robotic cleaners are distinguished on their cleaning expertise like floor mopping, dry vacuum cleaning etc. Some products are based on simple obstacle avoidance using infrared sensors while some utilize laser mapping technique. Each cleaning and operating mechanism of robotic floor cleaners has its own advantages and disadvantages. For example, robots utilizing laser mapping are relatively faster, less time consuming and energy efficient but costly, while obstacle avoidance based robots are relatively time consuming and less energy efficient due to random cleaning but less costly. Countries like India are way back in manufacturing robotic cleaners. Importing them from abroad increases their costs. The main objective of this work is to provide a substantial solution to the problem of manufacturing robotic cleaner utilizing local resources while keeping it low costs.

This project deals with the concept of development of autonomous floor cleaning robotic vehicle. The developed machines can autonomously clean the entire floor. Further the machine implements dual mode of cleaning where in the floor is cleaned using brushes as well as vacuum technology. The machine is has an onboard power source so that it can also wipe the floor.

CONCEPT

The figure below shows the working concept of the project. As shown in the figure the developed machine consists of a vacuum based system as well as mechanism with brushed attached. When started, machine starts to move across the house floor. The brushes as well as vacuum based system work simultaneously. The brushes are operated using a mechanism which is designed in such a way that it tries to push the dust in the path of the machine towards the centre of the machine. The brushes are used in dual configuration where two brushes are present on either side of the machine and the dust on the floor is pushed by the brushed towards the centre of the machine. The centre of the machine is equipped with a vacuum suction system which automatically sucks the dust and collects it in the collection chamber. The entire machine operated autonomously, which means once started it can automatically clean the entire floor. The onboard water tank can also be used as an additional application to mop the floor thus making the machine versatile, autonomous and user-friendly. The system can be controlled in manual as well as automatic mode using the Bluetooth module connected to the project.

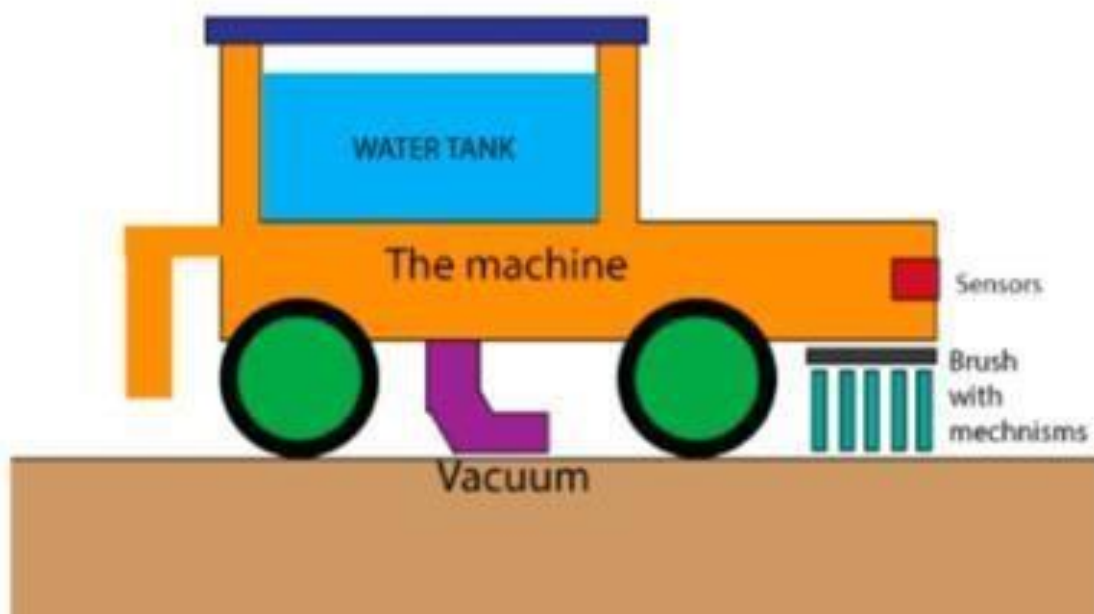


Figure no.:1

PROBLEM STATEMENT

With the increasing demand for automation and smart technologies, traditional manual floor cleaning methods are becoming inefficient and labor-intensive, especially in large spaces or

homes with diverse floor types. While there are various robotic floor cleaners on the market, many still face challenges with navigating complex environments, adapting to different floor types, and ensuring efficient, thorough cleaning across all areas without human intervention.

The problem is to design and develop an autonomous floor cleaning robotic vehicle that can efficiently navigate through various indoor environments, detect and clean dirt or debris on multiple floor types, and autonomously charge itself. The robot must be capable of cleaning without the need for human input, while overcoming challenges such as avoiding obstacles, ensuring full coverage, optimizing cleaning routes, and adapting to different floor surfaces, all while providing reliable, long-term performance.

PROCESS & WORKING

The working process of an Autonomous Floor Cleaning Robotic Vehicle involves multiple steps, from design and development to testing and refinement. Below is a step-by-step breakdown of how such a robotic vehicle works:

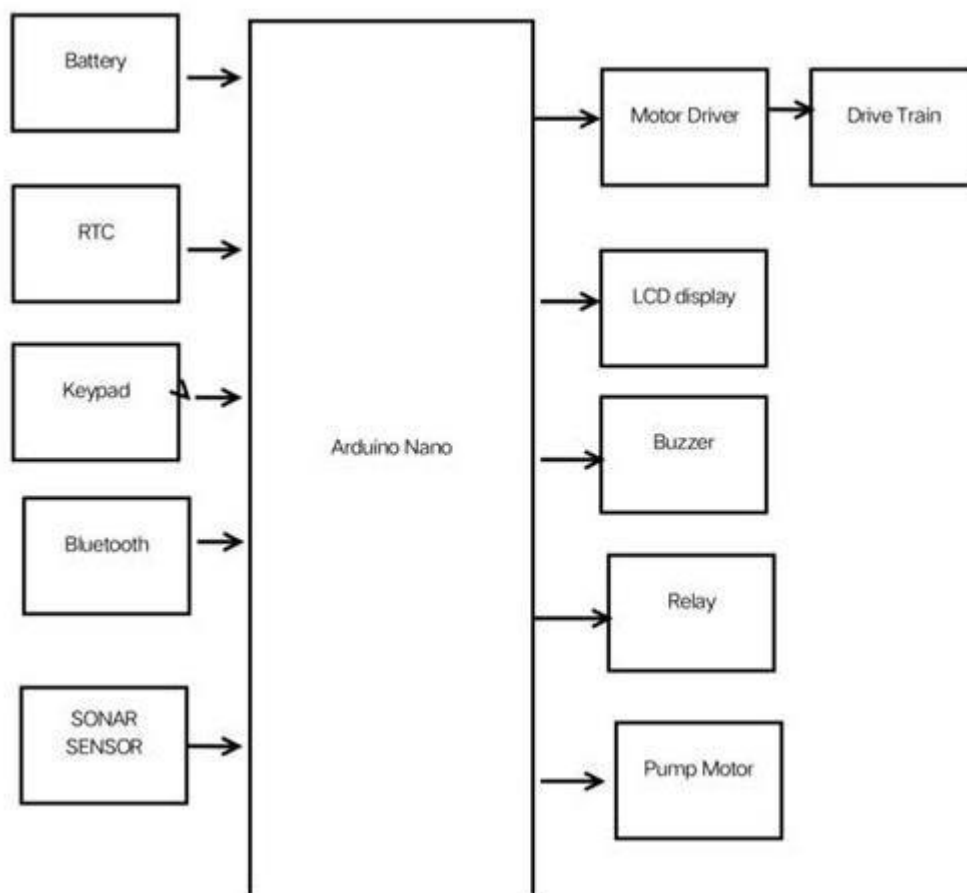


Figure no.: 2

1. Design and Architecture

- **Objective:** Create the robot's physical structure, including components like sensors, actuators, cleaning mechanisms, and the power system.

Steps

- **Mechanical Design:** The robot's body is designed to house all necessary components. This includes wheels for movement, a cleaning system (vacuum, mop, or brush), and a dustbin. The design also accounts for compactness and maneuverability.
- **Electrical Design:** This involves choosing the right power sources (typically lithium-ion batteries), actuators (for movement and brush rotation), and sensors (for navigation and obstacle avoidance).

2. Sensing and Navigation

- **Objective:** Enable the robot to detect obstacles, navigate the environment, and avoid collisions.

Steps

1. Sensor Selection

- **Ultrasonic Sensors:** Used for detecting objects and measuring distance to obstacles.
- **Infrared Sensors:** These help with object detection and determining proximity to walls or other objects.
- **LIDAR or Camera-based Vision:** Used to create detailed maps of the environment and ensure accurate navigation.
- **IMU (Inertial Measurement Unit):** Helps the robot track its position and orientation within a room.

2. Mapping and Localization

- **SLAM (Simultaneous Localization and Mapping):** The robot uses SLAM algorithms to create a real-time map of the environment while determining its position within that map. This allows the robot to navigate efficiently and avoid areas that have already been cleaned.
- **Path Planning:** Based on the map created, the robot calculates the most efficient route to clean all accessible areas while avoiding obstacles. The robot adjusts its path dynamically based on the environment.

3. Cleaning Mechanism

- **Objective:** Enable the robot to clean effectively across various floor surfaces using a combination of sweeping, vacuuming, and mopping.

Steps

- **Sweeping and Vacuuming:** The robot uses rotating brushes or side brushes to sweep dirt and debris into a central vacuum intake. Suction is used to collect this dirt into the dustbin.
- **Mopping:** If the robot is equipped with a mopping function, a wet mop is deployed to clean hard floors after vacuuming.
- **Surface Detection:** The robot uses its sensors or AI algorithms to identify different types of flooring (e.g., carpet, hardwood, and tile) and adjust its cleaning method accordingly. For example, it might lower the suction power for carpeted areas and increase it for tile or hardwood.

4. Power Management

- **Objective:** Ensure the robot has sufficient power to clean an entire room and can recharge it when necessary.

Steps

- **Battery:** The robot is typically powered by a rechargeable lithium-ion battery that provides enough energy for several cleaning cycles.
- **Charging:** The robot has a docking station where it can autonomously return to recharge when its battery is low. After recharging, it resumes its cleaning tasks from where it left off.
- **Power Consumption Optimization:** The robot adjusts its power usage by modifying the cleaning intensity, speed, or path planning to conserve energy when possible.

5. Autonomous Operation

- **Objective:** The robot must be able to operate without human supervision for cleaning tasks.

Steps

- **Automatic Cleaning Mode:** Once activated, the robot starts cleaning autonomously, detecting dirt, navigating, and cleaning all areas within its defined environment (e.g., room, floor).
- **Obstacle Avoidance:** The robot uses its sensors to avoid obstacles, such as furniture or walls, and re-routes itself when encountering something in its path.

- **Area Coverage:** Using its sensors and algorithms, the robot determines which areas have already been cleaned and which still need attention, ensuring comprehensive coverage.

6. User Interaction and Control

- **Objective:** Provide an intuitive and convenient interface for users to control and schedule cleaning tasks.

Steps

Mobile App Integration: Most modern robots allow users to control the robot remotely via a mobile app. The app might provide features such as:

- Scheduling cleaning tasks at specific times.
- Tracking cleaning progress in real-time.
- Starting, stopping, or pausing cleaning sessions.

Voice Control: Integration with voice assistants (e.g., Amazon Alexa, Google Assistant) allows users to control the robot using voice commands.

Manual Override: If needed, the user can take manual control of the robot to clean specific areas using remote controls or the app.

7. Maintenance and Diagnostics

- **Objective:** Ensure that the robot is easy to maintain and troubleshoot when needed.

Steps

- **Dustbin Emptying:** The robot's dustbin can be easily emptied by the user when full, and the mop or brush may need to be cleaned periodically.
- **Filter Replacement:** The robot's filters (for vacuuming) may need replacement or cleaning at regular intervals to maintain efficiency.
- **Error Detection:** The robot is equipped with diagnostic tools that help it detect and report issues such as stuck wheels, full dustbins, or other mechanical failures.

8. Safety Features

- **Objective:** Ensure the robot operates safely within its environment and doesn't cause harm or damage.

Steps

- **Obstacle Collision Detection:** The robot uses its sensors to detect obstacles in real-time and adjust its movement to avoid bumping into furniture, walls, or other objects.
- **Drop Sensors:** These sensors prevent the robot from falling down stairs or ledges by detecting sudden drops in elevation.
- **Emergency Stop:** The robot may have a button or feature that allows users to stop the robot if needed.

Flow of Operation (Simplified)

- **Initialization:** The robot is powered on, and its sensors calibrate. It begins scanning the environment and starts creating a map of the area.
- **Cleaning:** The robot starts navigating the space using the mapped environment, activating its cleaning mechanisms (vacuuming, mopping, sweeping) as it moves.
- **Obstacle Detection:** While cleaning, the robot detects obstacles and reroutes to continue cleaning efficiently without bumping into or damaging anything.
- **Battery Management:** If the battery is low, the robot autonomously returns to its charging station. Once charged, it resumes cleaning from where it left off.
- **Completion:** Once the cleaning is finished or the scheduled cleaning time ends, the robot returns to its base and stops.

LITERATURE SURVEY

A deep literature review was carried out to study the currently existing systems and to arrive at the problem definition. A number of research papers were also studied to find the currently existing problems and the proposed solutions over them. The literature review on the similar topic is as follows. Some of the commercially available cleaning systems along with their price is given below which was studied as part of literature review.

Some Related Projects

- Cleaning Robot
- Automatic Floor Cleaning

FUTURE SCOPE

This project deals with the development of automatic floor cleaning machine. The machine can automatically move on the floor at the set time and clean the floor autonomously. The developed project has the system to set time to trigger which gets stored in the robotic vehicle and at the time the robotic vehicle starts autonomously cleaning the home. The system can automatically clean the floor using cleaning mechanism and the vacuum suction system and collect it in the dust collection chamber which can be emptied when full. Thus we can conclude that this project involves development of advanced autonomous floor cleaning robotic vehicle.

The project has wide scope for further modification. The project can be further implemented with LIDAR sensors for fast response time while navigation and computer vision for dynamic trajectory planning while cleaning the floor.

CONCLUSION

The working process of the Autonomous Floor Cleaning Robotic Vehicle integrates a combination of hardware and software systems to ensure efficient, intelligent, and autonomous floor cleaning. The robot uses advanced sensors for navigation, floor recognition, and dirt detection, combined with powerful cleaning mechanisms and autonomous features, ensuring a seamless cleaning experience. Through AI and real-time decision-making, the robot adapts to different environments and continuously improves its cleaning performance.

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