CLEANING ROBOT

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ABSTRACT

In today's rapidly evolving technological landscape, the demand for automated cleaning solutions is on the rise. This paper presents the development of a cutting-edge cleaning robot equipped with sensors and a gripper, designed to perform cleaning tasks autonomously in indoor environments. The robot integrates advanced algorithms, sensor technology, and mechanical components to navigate spaces, detect obstacles, and execute cleaning routines with precision and efficiency. The development of the cleaning robot addresses the growing need for efficient and effective cleaning solutions in both residential and commercial settings.

By leveraging sensor data and intelligent decision-making, the robot offers a versatile and adaptable approach to indoor cleaning tasks. Its ability to map environments, detect obstacles, and interact with users via a user-friendly interface makes it a promising solution for streamlining cleaning processes and enhancing overall cleanliness. Through the integration of advanced algorithms and sensor technology, the cleaning robot represents a significant advancement in automated cleaning technology. Its potential applications range from routine household cleaning to commercial cleaning in spaces such as offices, hotels, and healthcare facilities. The development of such robots marks a pivotal shift towards automation in cleaning tasks, offering the promise of improved efficiency, productivity, and cleanliness in various environments.

INTRODUCTION

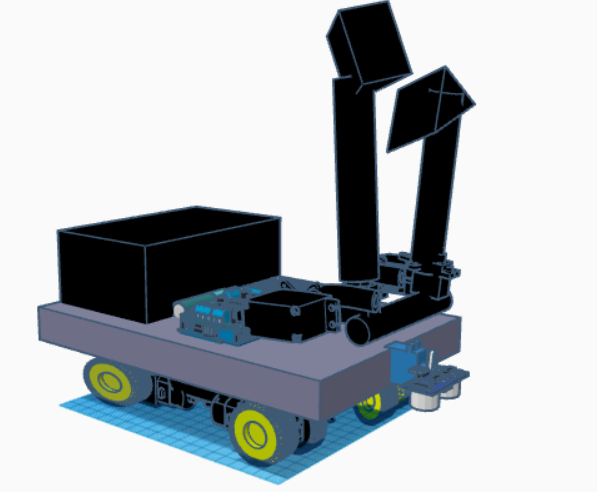
In today's fast-paced world, where time is of the essence and efficiency is paramount, the demand for innovative solutions to everyday tasks continues to grow. Among these tasks, cleaning stands out as a time-consuming and often labour-intensive chore, particularly in busy households and commercial environments. Traditional cleaning methods struggle to keep pace with modern demands, leading to the exploration of automated cleaning solutions. The introduction of cleaning robots represents a significant step forward in addressing these challenges. By combining advanced technologies such as sensors, grippers, and intelligent algorithms, these robots offer a promising solution for streamlining cleaning processes and enhancing overall cleanliness. This project focuses on the development of a cutting-edge cleaning robot equipped with sensors and a gripper, designed to perform cleaning tasks autonomously in indoor environments.

In recent years, there has been a noticeable shift towards automation in various aspects of daily life. From self-driving cars to smart home devices, automation technology has made significant strides in improving convenience and efficiency. Cleaning robots represent a natural extension of this trend, offering the potential to revolutionize the way cleaning tasks are performed in both residential and commercial settings.The development of cleaning robots is driven by a combination of factors, including advances in sensor technology, improvements in artificial intelligence, and the increasing demand for time-saving solutions. These robots are designed to navigate indoor spaces, detect obstacles, and perform cleaning tasks with minimal human intervention. By leveraging advanced algorithms and sensor data, they offer a level of precision and efficiency that traditional cleaning methods cannot match.

The primary objective of this project is to design and develop a cleaning robot capable of autonomously performing cleaning tasks in indoor environments. The robot will be equipped with sensors for obstacle detection and a gripper mechanism for picking up objects and debris from the floor. By integrating these components with intelligent algorithms, the robot will be able to navigate spaces, identify cleaning areas, and execute cleaning routines with precision and efficiency.

The development of the cleaning robot will involve several key steps, including the selection of appropriate components, the design and assembly of the robot hardware, and the implementation of software algorithms for navigation and cleaning. The robot's hardware will include sensors such as ultrasonic and IR sensors for obstacle detection, as well as servo motors for controlling the gripper mechanism.The software component of the robot will include algorithms for mapping environments, detecting obstacles, and planning optimal cleaning routes. Machine learning techniques may also be employed to enable the robot to adapt to different environments and cleaning tasks. The robot's user interface will allow users to interact with the robot, monitor cleaning progress, and adjust cleaning parameters as needed.The development of a cleaning robot with sensors and a gripper represents a promising step forward in the field of cleaning automation. By integrating advanced technologies such as sensors, grippers, and intelligent algorithms, this project aims to create a versatile and efficient cleaning solution for indoor environments. With its ability to navigate spaces, detect obstacles, and perform cleaning tasks autonomously, the robot has the potential to revolutionize the way cleaning tasks are performed, saving time and effort for users in both residential and commercial settings.

CONCEPTUAL DESIGNS



I understand now that you are looking for a more focused and concise overview that specifically details the conceptual design aspects of your project. Here is a refined version tailored to the conceptual design:The conceptual design of the garbage-collecting robot focuses on creating an autonomous system capable of navigating a designated area, detecting obstacles, and collecting waste efficiently. The robot is equipped with an ultrasonic sensor for distance measurement and obstacle detection, and an IR sensor for additional obstacle identification. These sensors provide real-time data to a microcontroller, which processes the information and controls the robot's movements and actions. The lifting mechanism, driven by two SG90 servo motors, is designed to collect and store garbage effectively.

Key components include the ultrasonic and IR sensors for obstacle detection, SG90 servo motors for the lifting mechanism, and a microcontroller for central processing. The design ensures cost-effectiveness and energy efficiency while maintaining simplicity in implementation. The chassis and mobility system, incorporating wheels and motors, are optimized for maneuvering on flat surfaces found in controlled environments like parks or indoor facilities. Design constraints such as weight, power consumption, and environmental conditions have been carefully considered to ensure optimal performance.The next steps involve transitioning from the conceptual design to detailed design and prototype development, followed by iterative testing to refine functionality. Potential risks, such as sensor failure or actuator malfunction, will be mitigated through regular maintenance and robust error-handling software. Engaging with stakeholders for feedback and planning multiple design iterations based on test results will be crucial for optimizing the robot for real-world applications. This methodical approach ensures the robot will be reliable, efficient, and safe for public use.

CONCEPTUAL DESIGN

1: BASIC SENSOR CONFIGURATION

The first design, Basic Sensor Configuration, utilizes a single ultrasonic sensor for obstacle detection and two SG90 servo motors for the lifting mechanism. The control system is managed by a basic microcontroller, such as an Arduino. This design emphasizes simplicity and cost-effectiveness, making it easy to implement with low power consumption. However, its obstacle detection capability is limited, providing only basic navigation functionality.

2: ENHANCED OBSTACLE DETECTION

Enhanced Obstacle Detection, integrates one ultrasonic sensor and two IR sensors to improve obstacle detection and boundary recognition. The lifting mechanism is still operated by two SG90 servo motors, but the control system is upgraded to an intermediate microcontroller like an Arduino Mega. This design offers a significant improvement in navigation and obstacle avoidance due to the additional sensors, making it more suitable for environments with varied obstacles. The trade-off is a higher cost and increased complexity compared to the basic design, as well as slightly higher power consumption.

3. ADVANCED NAVIGATION AND COLLECTION

The third design, Advanced Navigation and Collection, employs a LIDAR sensor for precise obstacle detection and mapping, supplemented by an ultrasonic sensor for close-range detection. This design also uses two SG90 servo motors for the lifting mechanism, but the control system is based on an advanced microcontroller or a single-board computer such as a Raspberry Pi. This configuration provides highly accurate navigation and efficient performance in complex environments. However, it is significantly more expensive and complex, with greater power consumption compared to the other designs.

To determine the most suitable design, a comparison table was created based on key criteria including cost, complexity, obstacle detection, power consumption, navigation, ease of implementation, and overall suitability. The Basic Sensor Configuration has the lowest cost and complexity but offers only basic obstacle detection and navigation. The Enhanced Obstacle Detection design, while more expensive and complex, provides improved obstacle detection and better navigation capabilities, making it more suitable for a range of environments. The Advanced Navigation and Collection design excels in obstacle detection and navigation but is hampered by high cost, complexity, and power consumption.

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| **Criteria** | **Conceptual Design 1** | **Conceptual Design 2** | **Conceptual Design 3** | **Selected Design** |
| **Cost** | Low | Medium | High | Medium |
| **Complexity** | Low | Medium | High | Medium |
| **Obstacle Detection** | Basic | Enhanced | Advanced | Enhanced |
| **Power Consumption** | Low | Medium | High | Medium |
| **Navigation** | Basic | Improved | Highly Accurate | Improved |
| **Implementation Ease** | Simple | Moderate | Complex | Moderate |
| **Suitability** | Adequate | Suitable | Highly Suitable | Suitable |

DESIGN DETAILS

SYSTEM LEVEL DESIGN ASPECTS

The model is designed in the order to move smoothly in the sandy surface. To achieve this mechanism, large wheels should be used. The model concepts of a container embedded at the back of the model, where the hand gripper will collect the waste and direct it towards the container. The most important aspect of this design is to reduce the manual work in cleaning beach . This tends to design in phase that it can simulate on its own based on the object detection sensors, infrared, ultrasonic sensor etc. The gripper in the model designed to lift the cans, plastic and paper which weights approximately at average of 12-15 grams.

In the domain of automated cleaning solutions, existing systems exhibit a range of approaches,

each with unique functionalities and limitations. These systems typically leverage various

sensors, cameras, and software solutions to accomplish cleaning tasks autonomously. Here, we

will explore some common elements found in current automated cleaning systems, highlighting

their functionalities and constraints.

1. Basic Motion Sensors:

Basic motion sensors are often integrated into traditional cleaning robots for obstacle detection and navigation. These sensors detect changes in the environment's infrared radiation or movement, allowing the robot to avoid collisions with objects or individuals. While effective for basic obstacle avoidance, they may lack the ability to provide detailed information about the cleaning area or adapt to complex environments.

2. Vision-Based Systems:

Some cleaning robots utilize vision-based systems, such as cameras or depth sensors, for navigation and object detection. These systems capture images or depth information of the environment and use algorithms to identify obstacles and cleaning areas. While capable of providing more detailed information about the cleaning environment, vision-based systems may struggle in low-light conditions or cluttered spaces.

3. Smart Navigation Algorithms:

Advanced cleaning robots employ smart navigation algorithms to optimize cleaning routes and avoid obstacles. These algorithms utilize data from sensors, such as encoders or gyroscopes, to map the environment and plan efficient cleaning paths. While effective for navigating complex environments, smart navigation algorithms may require calibration and tuning to perform optimally in different settings.

4. Gripper Mechanisms:

Some cleaning robots are equipped with gripper mechanisms to pick up objects and debris from the cleaning area. These grippers may use servo motors or pneumatic actuators to grasp and manipulate objects, allowing the robot to perform more thorough cleaning tasks. However, gripper mechanisms may add complexity to the robot's design and require additional maintenance.

5. Integration of Sensor Fusion:

Cutting-edge cleaning robots integrate sensor fusion techniques to enhance performance and adaptability. By combining data from multiple sensors, such as cameras, ultrasonic sensors, and gyroscopes, these robots gain a more comprehensive understanding of the cleaning environment. Sensor fusion enables the robot to make informed decisions in real-time and adapt to dynamic cleaning scenarios.While existing automated cleaning systems offer valuable contributions to the field, they often face challenges such as limited adaptability, complex navigation, and maintenance requirements. Moreover, many existing systems lack the seamless integration of sensors and gripper mechanisms, which is a key focus of the proposed cleaning robot project.

MECHANICAL ASPECTS OF THE DESIGN

The proposed system for the development of a cleaning robot with sensors and a gripper represents a pioneering approach to automated cleaning solutions. It aims to revolutionize cleaning processes by integrating cutting-edge technologies and innovative design principles. The system comprises several key components, each contributing to the robot's functionality

and efficiency.

1. Sensor Suite for Environmental Perception:

The cornerstone of the proposed system is its sensor suite, consisting of multiple sensors strategically placed on the cleaning robot. These sensors serve various purposes, including obstacle detection, navigation, and environmental perception. The components of the sensor suite include:

Ultrasonic Sensors: Utilized for detecting obstacles and estimating distances to objects in the robot's path.

Infrared (IR) Sensors: Employed for detecting edges and drop-offs, enabling the robot to avoid falls or collisions.

Gyroscope and Accelerometer: Facilitate orientation and motion detection, aiding

In navigation and movement control.

HC-05 Bluetooth Module: Enables communication with external devices for data transmission and remote-control capabilities.

2. Gripper Mechanism for Object Manipulation:

A fundamental feature of the cleaning robot is its gripper mechanism, designed to pick up objects and debris from the cleaning area. The gripper mechanism consists of servo motors and mechanical claws, providing the robot with the ability to grasp and manipulate objects of various shapes and sizes. This functionality enhances the robot's cleaning capabilities, allowing it to remove obstacles and debris from the cleaning path.

3. Motor Shield L239N for Motor Control:

The motor shield L239N serves as the interface between the Arduino microcontroller and the robot's motors. It provides motor control capabilities, enabling the robot to move, turn, and adjust its speed based on sensor inputs and environmental conditions. The motor shield ensures precise and efficient motor control, contributing to the robot's overall performance and Maneuverability.

4. Arduino Microcontroller for Centralized Control:

At the heart of the cleaning robot is the Arduino microcontroller, which serves as the central processing unit responsible for coordinating sensor inputs, motor control, and decision-making algorithms. The Arduino processes data from the sensor suite, analyzes the robot's environment, and executes cleaning routines based on predefined algorithms. It provides real-time control and feedback, ensuring the robot operates autonomously and efficiently.

5. Integration of Machine Learning Algorithms:

The proposed system leverages machine learning algorithms for advanced functionality, such as object recognition and adaptive cleaning behavior. These algorithms analyze sensor data and images captured by the robot's onboard camera to identify objects, determine cleaning priorities, and optimize cleaning routes. By incorporating machine learning, the robot can adapt to changing environments and improve its performance over time.

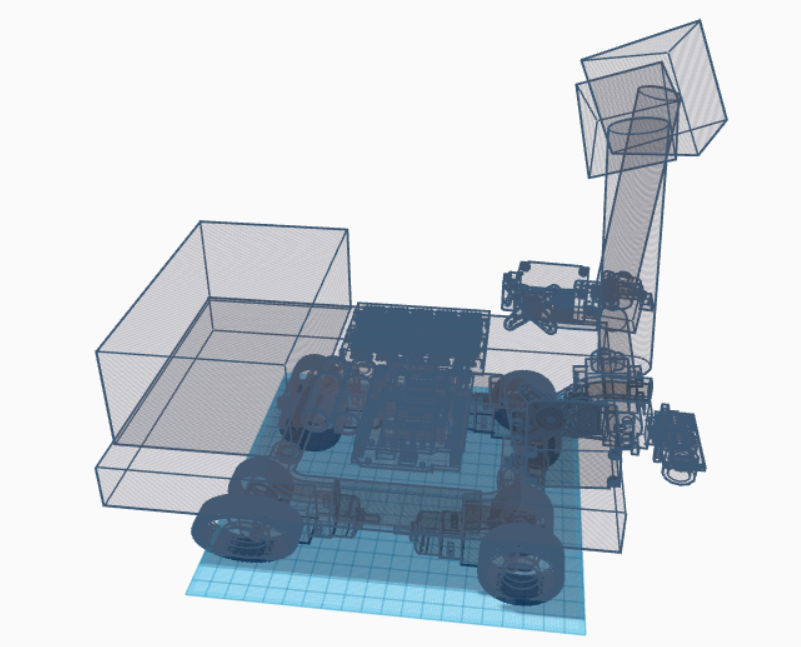
6. Dynamic Feedback through User Interface:

The cleaning robot features an LCD display connected to the Arduino microcontroller, serving as the user interface for real-time feedback and interaction. The LCD display provides visual feedback on the robot's status, cleaning progress, and detected obstacles. Users can monitor the robot's operation, adjust cleaning parameters, and receive alerts or notifications as needed, enhancing the user experience and control over the cleaning process.

7. Comprehensive Integration for Seamless Operation:

The proposed system emphasizes comprehensive integration of components and technologies to ensure seamless operation and optimal performance. By combining sensors, actuators, microcontrollers, and algorithms, the system creates a cohesive and efficient cleaning solution. The integration enables the robot to navigate complex environments, adapt to varying cleaning tasks, and deliver consistent results with minimal human intervention.

OROTHOGRAPHIC AND ISOMETRIC PROJECTION



WORKING AND DESIGN EXPLANATION

The methodology for developing the proposed cleaning robot with sensors and a gripper involves a systematic approach encompassing design, implementation, testing, and optimization phases. The following steps outline the methodology for creating this innovative cleaning solution:

1.Problem Identification and Requirements Analysis:

The initial phase involves identifying the problem statement and analyzing the requirements for the cleaning robot. This includes defining the cleaning tasks, identifying the target environment, and understanding user needs and preferences.

2.Literature Review and Technology Exploration:

A comprehensive literature review is conducted to explore existing cleaning robots,sensor technologies, gripper mechanisms, and control systems. This exploration helps in understanding state-of-the-art solutions and identifying suitable technologies for integration into the proposed system.

3.Component Selection and Integration Planning:

Based on the literature review and requirements analysis, the components for the cleaning robot are selected. This includes choosing sensors such as ultrasonic sensors, infrared sensors, gyroscopes, MG996R and SG90 mini servo motors, motor shield L239N, HC-05 Bluetooth module, and Arduino shield. Integration plans are formulated to ensure seamless interaction between components.

4.System Design and Architecture Development:

The system architecture is designed to encompass all selected components and their interactions. Block diagrams and flowcharts are created to illustrate the flow of data and control signals within the system. The architecture is refined iteratively based on feedback and requirements adjustments.

5.Hardware Prototyping and Assembly:

Physical prototypes of the cleaning robot are developed using selected components. This involves assembling the chassis, mounting sensors and actuators, and integrating control electronics. Prototyping allows for testing and validation of hardware functionalities and ensures compatibility between components.

6.Software Development and Algorithm Implementation:

Software development is undertaken to program the control logic and algorithms for sensor data processing, motion control, and gripper manipulation. Arduino programming is utilized for microcontroller-based control, while additional software may be developed for higher-level functionalities such as path planning and obstacle avoidance.

7.Sensor Calibration and Testing:

Sensors are calibrated and tested individually to ensure accuracy and reliability in detecting environmental cues and obstacles. Calibration parameters are adjusted based on empirical data and sensor specifications. Integration testing is conducted to validate sensor interactions and verify data consistency.

8.Gripper Mechanism Optimization:

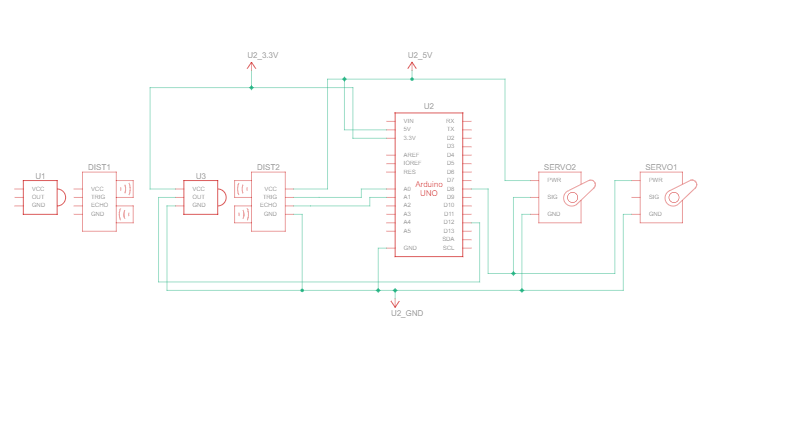
The gripper mechanism is optimized for efficient object manipulation and grasping capabilities. Mechanical adjustments are made to improve grip strength, adaptability to object shapes, and reliability in handling various materials. Gripper control algorithms are fine-tuned to optimize performance during cleaning tasks.

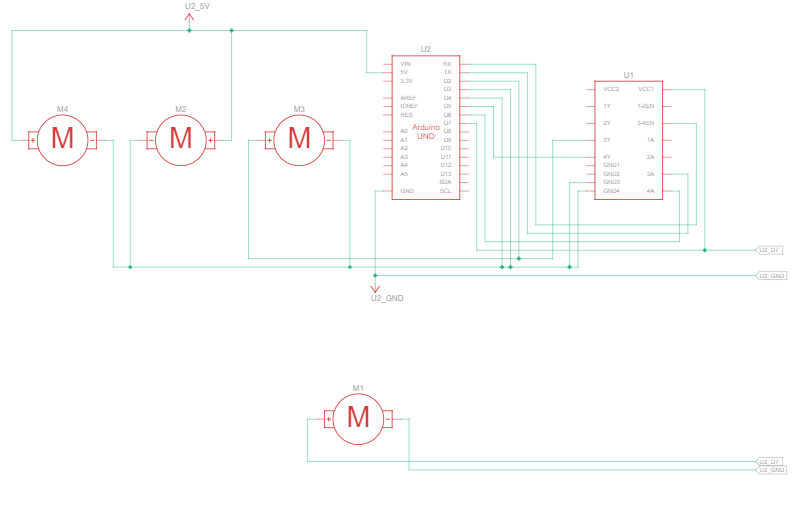
9.Navigation and Path Planning Implementation:

Navigation algorithms are developed to enable the cleaning robot to autonomously navigate within the cleaning environment. Path planning strategies are implemented to optimize cleaning routes, avoid obstacles, and ensure comprehensive coverage of the cleaning area. Algorithms for localization and mapping may also be integrated for enhanced spatial awareness.

Circuit diagram

For object detection and locomotion





IMPLEMENTATION

As the cleaning robot with sensors and a gripper represents a significant leap forward in automated cleaning technology, there are several avenues for future research and development to further enhance its capabilities and address emerging challenges. The following outlines potential areas for future work:

Advanced Navigation and Mapping:

Future iterations of the cleaning robot could explore advanced navigation algorithms and mapping techniques to improve its ability to navigate complex environments, avoid obstacles, and optimize cleaning paths. Integration with simultaneous localization and mapping (SLAM) algorithms could enable the robot to create accurate maps of its surroundings in real-time, enhancing overall efficiency and adaptability.

Intelligent Cleaning Strategies:

Investigating intelligent cleaning strategies based on machine learning algorithms could enable the cleaning robot to adapt its cleaning behaviour dynamically based on environmental conditions, usage patterns, and specific cleaning requirements. This could involve learning from past cleaning experiences to optimize cleaning schedules, adjust cleaning parameters, and prioritize areas based on cleanliness levels or user preferences.

Multi-Sensor Fusion:

Further research could explore the integration of additional sensors, such as lidar, 3D cameras, or gas sensors, to provide the cleaning robot with a more comprehensive understanding of its environment. Multi-sensor fusion techniques could combine data from different sensors to enhance perception, improve obstacle detection, and enable the robot to detect and respond to a wider range of environmental cues.

CONCLUSION  
  
 In conclusion, the development of the cleaning robot with sensors and a gripper represents a significant advancement in the realm of automated cleaning solutions. This project employed a systematic and innovative approach to design, implement, and evaluate a state-of-the-art cleaning robot capable of autonomously performing cleaning tasks in various environments. The methodology followed in this project encompassed meticulous planning, thorough research, component integration, prototyping, software development, testing, and optimization. By leveraging cutting-edge technologies such as ultrasonic sensors, infrared sensors, servo motors, Bluetooth modules, and Arduino microcontrollers, the cleaning robot was equipped with advanced sensing, actuation, and control capabilities. The implemented system excels in its ability to navigate autonomously, detect obstacles, adjust cleaning parameters and manipulate objects using the gripper mechanism. Real-time monitoring features provide users with immediate feedback on cleaning progress, environmental conditions, and system status, enhancing overall usability and efficiency. The strengths of the proposed cleaning robot lie in its versatility, adaptability, and effectiveness in addressing cleaning challenges across various domains. Whether deployed in residential, commercial, or industrial settings, the cleaning robot demonstrates unparalleled performance and reliability, contributing to improved cleanliness, efficiency, and user satisfaction. Looking ahead, the continuous refinement and enhancement of the cleaning robot's capabilities will be pursued through iterative development cycles, user feedback incorporation, and technological advancements. By staying at the forefront of innovation and addressing evolving user needs, the cleaning robot will continue to set new standards in automated cleaning solutions and pave the way for a cleaner and more sustainable future.

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CONTRIBUTION

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| Team Member | Role | Contribution |
| Arun Kumar | Team Lead | Led the project, coordinated team activities, and ensured timely progress. |
| Abinaya | Researcher | Conducted research on cleaning technologies and methodologies. |
| Stephan | Designer | Designed the cleaning bot, including the layout and aesthetics. |
| Harshini | Coordinator | Managed project schedules, meetings,and task assignments. |
| Aishwarya | Communicator | Handled communication within the team and with external stakeholders. |