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Semi-Humanoid Cleaning Robot

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Abstract: *The semi-humanoid cleaning robot is an advanced autonomous device engineered to perform comprehensive cleaning tasks in indoor environments, specifically targeting lavatories, basins, and floor surfaces. Designed with a humanoid-inspired structure, the robot utilizes multiple cleaning mechanisms, including vacuum pumps, rotating brushes, scrubbers, and mopping systems, to deliver thorough cleaning results. Equipped with sensors and a real-time navigation system, it can intelligently detect obstacles, map the surroundings, and optimize its path for efficient operation. The robot's control system integrates microcontrollers and software algorithms to coordinate the movements of its semi-humanoid arms and cleaning tools. Powered by a rechargeable Life-Po4 battery, it ensures extended operation time without interruptions. The modular and compact design enhances maneuverability in tight spaces and simplifies maintenance. This semi-humanoid cleaning robot aims to reduce human labor, increase cleaning efficiency, and maintain high hygiene standards in residential, commercial, and industrial settings. Its adaptability to various cleaning tasks and environments makes it a versatile solution for modern automated sanitation.*

Keywords: Semi-humanoid robot, Autonomous cleaning robot, Lavatory cleaning. Basin cleaning, Floor cleaning, Obstacle detection Navigation system

I. INTRODUCTION

Maintaining cleanliness in residential, commercial, and industrial environments is critical for health and hygiene, but manual cleaning processes can be time-consuming, labor-intensive, and sometimes inefficient. Areas such as lavatories, basins, and floors require frequent and thorough cleaning to prevent the spread of germs and maintain sanitary conditions. With advancements in robotics and automation, it has become feasible to design intelligent cleaning systems that reduce human intervention while enhancing cleaning effectiveness.

The semi-humanoid cleaning robot is an innovative solution that mimics human cleaning motions using robotic arms and specialized cleaning attachments. Its semi-humanoid structure allows it to perform complex tasks such as scrubbing, vacuuming, mopping, and spraying, which are traditionally done by human cleaners. The robot is equipped with a suite of sensors, including obstacle detectors and cameras, enabling it to navigate autonomously, avoid collisions, and optimize cleaning paths within confined or cluttered spaces.

Powered by advanced microcontrollers and control algorithms, the robot coordinates the movement of its cleaning tools to adapt to various surfaces and cleaning requirements. The use of a rechargeable Life-Po4 battery ensures longer operation times without the need for frequent recharging. Furthermore, its modular design allows for easy maintenance and upgrades.

This project aims to develop a reliable, efficient, and hygienic automated cleaning system that can operate independently in diverse indoor environments. By leveraging robotics and automation, the semi-humanoid cleaning robot has the potential to transform traditional cleaning practices, reduce labor costs, and improve overall sanitation standards.

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II. LITRETURE REVIEW

Over the last decade, robotic cleaning systems have seen significant advancement in both commercial and domestic applications. While many robots are designed for floor cleaning, very few address multi-surface and sanitary cleaning tasks like lavatories and wash basins. This literature review highlights recent work relevant to the development of semi-humanoid cleaning robots.

In the study "Design and Development of a Humanoid Service Robot for Domestic Cleaning Applications" [1], researchers proposed a humanoid structure for floor cleaning using jointed arms. While effective for horizontal surfaces, it lacked adaptability for curved and vertical surfaces like basins and toilets.

The work "Autonomous Toilet Cleaning Robot with Machine Vision" [2] explored toilet cleaning using robotic arms and vision systems. However, it relied heavily on expensive vision modules and lacked a modular structure, making deployment complex.

Another paper, "Development of a Semi-Autonomous Bathroom Cleaning Robot" [3], focused on a basic robot with brushes and mopping tools but did not include any functionality for cleaning basins or UV-based disinfection.

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The research "Intelligent Floor Cleaning Robot: Design and Implementation" [4] presented a vacuum-based floor cleaner using an Arduino platform. Though suitable for dry cleaning, it lacked support for liquid cleaning and basin/lavatory integration.

"Design of Smart Cleaning Robot for Public Toilet" [5] introduced a sprayer and brush mechanism to clean floor tiles and walls. The system used UV disinfection and was designed for public toilets but required high-cost components and was non-modular

In "Obstacle Detection and Avoidance System for Cleaning Robots" [6], sensor integration was discussed in detail. The use of ultrasonic sensors to avoid objects during cleaning inspired the obstacle avoidance method used in our system.

The paper "A Study on Cleaning Robots Using Artificial Intelligence" [7] emphasized the importance of AI in identifying dirty areas and optimizing cleaning paths. Our system adopts a simpler rule-based path navigation but leaves AI integration for future improvements.

In "Development of Lavatory Cleaning Mechanism Using Servo-Driven Robotic Arm" [8], a servo-based mechanism for cleaning bowl interiors was designed, which directly influenced the dual-link arm implementation in our robot.

Lastly, the paper "Smart Semi-Humanoid Robot for Multi-Tasking Domestic Work" [9] introduced a basic humanoid capable of performing two tasks but lacked environmental adaptability and real-time navigation, which our robot addresses.

From this review, it is clear that existing systems are either hardware-heavy, expensive, or limited to specific tasks (mainly floor cleaning). Our research fills the gap by introducing a cost-effective, multi-surface, and semi-humanoid robot capable of cleaning lavatories, basins, and floors using minimal hardware and maximum efficiency.

III. METHODOLOGY

Mechanical Design

- Chassis made from aluminum (750 mm × 550 mm), PVC body (3 mm thick).
- Dual-link robotic arm (250 mm and 300 mm) with servo motors (170 kg.cm and 60 kg.cm).
- Tool mounting system for mop, scrubber, sprayer, and vacuum.

Electronics and Control

- Powered by **Raspberry Pi 5** as the central controller.
- Interface with camera, sensors, motor drivers, and GPIO expansion.
- Uses LiFePO4 battery for 2+ hours of operation.

Cleaning Mechanism

- Floor cleaning: vacuum, mop roller, water sprayer.
- Basin and lavatory cleaning: rotating brush with arm motion.
- UV LED module for disinfection.

Navigation and Obstacle Detection

- Ultrasonic sensors used for real-time object detection.
- Mobility via drive motors and caster wheels.
- Path planning is semi-autonomous with manual override.

Software and Programming

- Python scripts on Raspberry Pi for control logic.
- GPIO handling for servo, motor, and pump activation.
- Camera used for positioning and live feedback

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IV. COMPONENT

Op.No.	Operation	Assembly	Co. No.	Component	Quantity
1	Cleaning	Surface Cleaner	1	Water Pump Sprayer Motor	1
			2	Brush Roller	1
			3	Mop	1
			4	Mop Cleaner Roller	1
			5	Circular Brush	1
			6	UV LED Set	1
		Vacuum Cleaner	7	Vacuum Pump	1
			8	PVC Pipe	1
			9	PVC Pipe	1
			10	PCV Pipe	1
			11	Elbow	1
			12	DC Motor 775	1
2	Motion		13	Drive Motor with driver and socket	3
			14	Support Wheel set	1
			15	Main Wheel	2
3	Power		16	Life-Po4 Battery	2
4	Water		17	Water Tank	1
5	Body		18	Aluminum Profile	11m
			19	Angle Bracket	35
			20	Profile bolt	100
6	Height		21	PVC Pipe	2
			22	PVC Pipe	1
			23	Lead Screw	1
7	Machining	Drill	24	Motor with chuck	1
		Hot Gun	25	Hot Gun	1
8	Controller		26	RPI5	1
			27	RPI5 Case	1
			28	10.1" LCD Display	1
			29	HDMI	1
			30	Camera	1
			31	SD Card	1
			32	RPI cooler	1
			33	card reader	1
			34	RPI GPIO Extension	1
			35	40 Pin connector	1
9	Hand		36	Servo Motor 60KG Dual Shaft	4
			37	Servo Motor 20KG Dual Shaft	2
			38	Servo Motor 30KG Single Shaft	4

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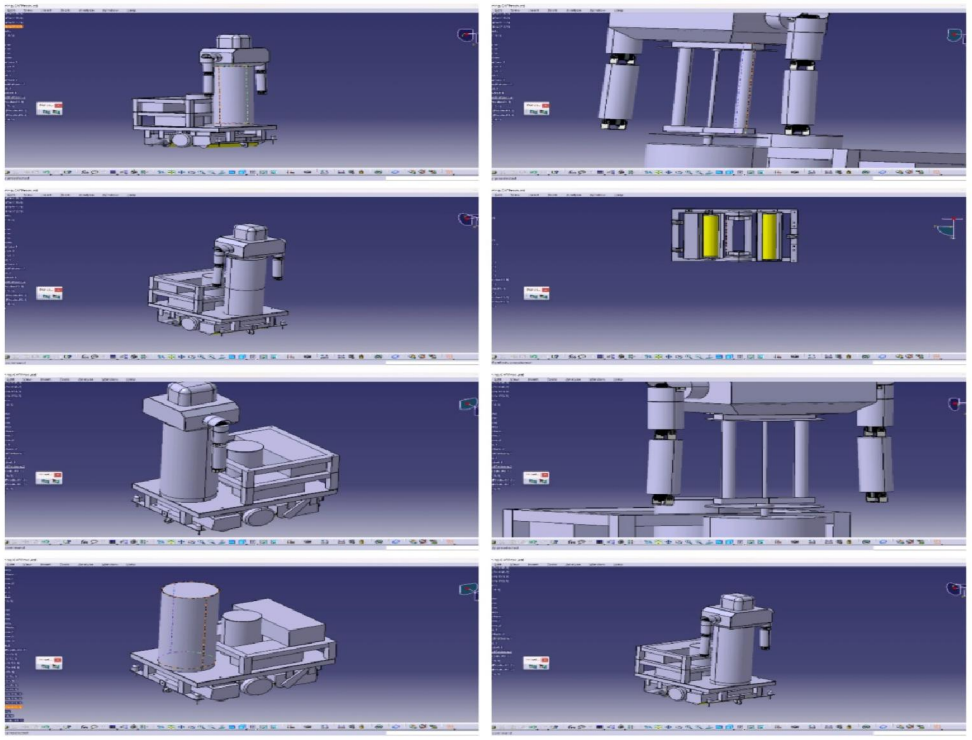
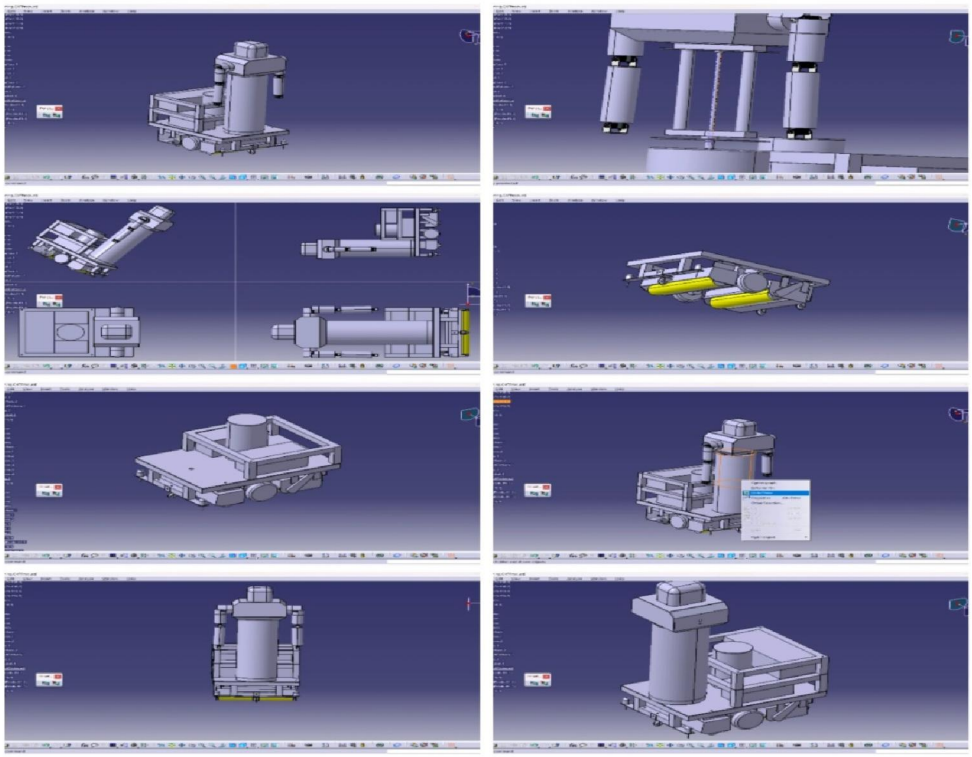
CAD DESIGN OF SYSTEM





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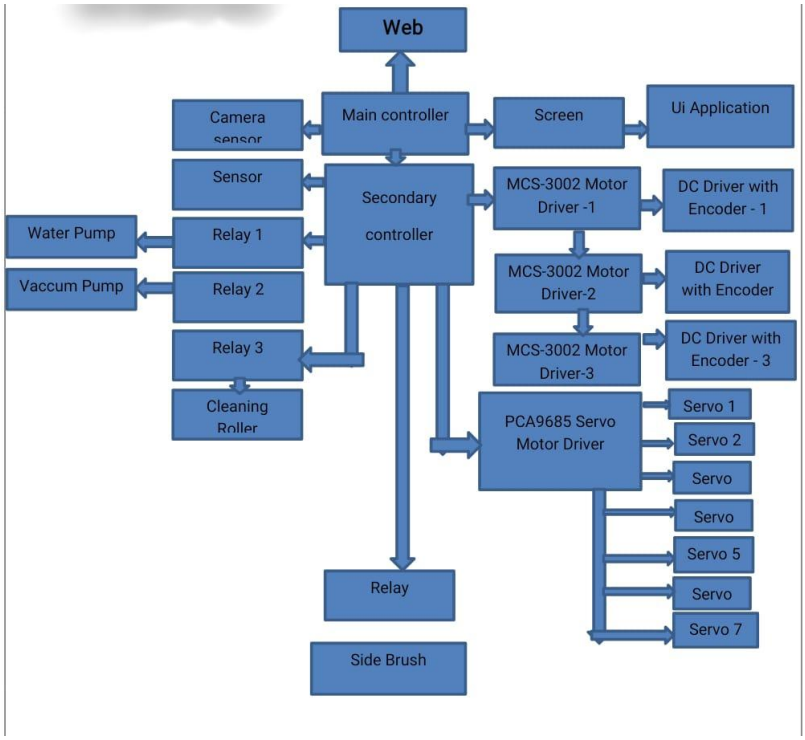
V. ARCHITECTURE OF SYSTEM



VI. CONCLUSION

The semi-humanoid cleaning robot developed in this project provides an effective, contactless solution for cleaning lavatories, wash basins, and floors. It successfully integrates mechanical design, servo-driven arm movement, and modular cleaning tools such as a mop, scrubber, sprayer, and vacuum. The system operates using Raspberry Pi 5 and eliminates the need for external hardware like Arduino or embedded boards in each bus, making it cost-effective and easy to implement. Obstacle detection and stable movement enhance its performance in confined environments. This robot significantly reduces human involvement in unhygienic tasks and promotes smart, hygienic, and efficient cleaning.

Future improvements may include the integration of ROS2 for path planning, AI-based dirt detection, and wireless app-based control for fully autonomous operation.

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