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Solar-Powered Smart Air Purification Robot

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Abstract: *Air pollution has emerged as one of the most pressing global challenges, adversely affecting human health, ecosystems, and climate stability. To address this issue, we propose the design and development of a solar-powered smart air purification robot that integrates renewable energy with intelligent mobility and filtration technologies.*
Equipped with advanced sensors, it autonomously monitors air quality parameters such as carbon dioxide levels. Based on real-time data, the robot navigates indoor and outdoor environments to optimize purification efficiency. It has filtration system—like HEPA filters and effectively removes pollutants.

Keywords: *Solar energy, Renewable power, Smart robot, Air purification, HEPA filtration, Gas sensor, Air quality monitoring, Ultrasonic sensor*

I. INTRODUCTION

Air pollution is a big problem in many cities and towns. It can make people sick and harm the environment. To help solve this, we have created a Solar-Powered Smart Air Purification System.
This robot combines solar energy technology with intelligent air purification systems to clean the surrounding air while operating autonomously.
It also has smart sensors that can check how dirty the air is and clean it automatically. This system is good for the planet and helps people breathe cleaner air.

II. LITERATURE SURVEY

The literature survey provides an overview of existing technologies,research to solar-powered air purifiers and smart environmental monitoring systems. Traditional air purification methods commonly employ HEPA filters to eliminate dust, smoke and bacteria from the air. Among these, HEPA filters are particularly effective, capable of removing up to 99.97% of airborne particles, including fine particulate matter such as PM2.5 and PM10, as highlighted by Singh et al. (2020). However, their reliance on continuous power and frequent maintenance presents challenges for sustainable use. On the other hand, solar-powered air purification is an emerging field that integrates renewable energy with environmental health solutions. Research by Ravi Kumar and Rani (2018) demonstrated that photovoltaic (PV) panels can successfully power air purifiers, significantly reducing operational costs and environmental impact. Solar integration ensures off-grid functionality, making purification systems more sustainable and suitable for outdoor. While promising, this approach still faces challenges such as energy storage, efficiency of PV panels, and ensuring continuous operation during periods of low sunlight.

III. OBJECTIVES

Objectives of our Solar-Powered Smart Air Purification Robot are :
• Develop a sustainable air purification system powered entirely by solar energy to minimize reliance on conventional electricity.
• Design and implement autonomous robotic mobility that allows the purifier to navigate indoor and outdoor environments for maximum coverage.
• Integrate advanced air quality sensors to monitor pollutants such as PM2.5, PM10, VOCs, and CO_2 in real time.
• Implement a filtration process HEPA filters, for comprehensive pollutant removal.

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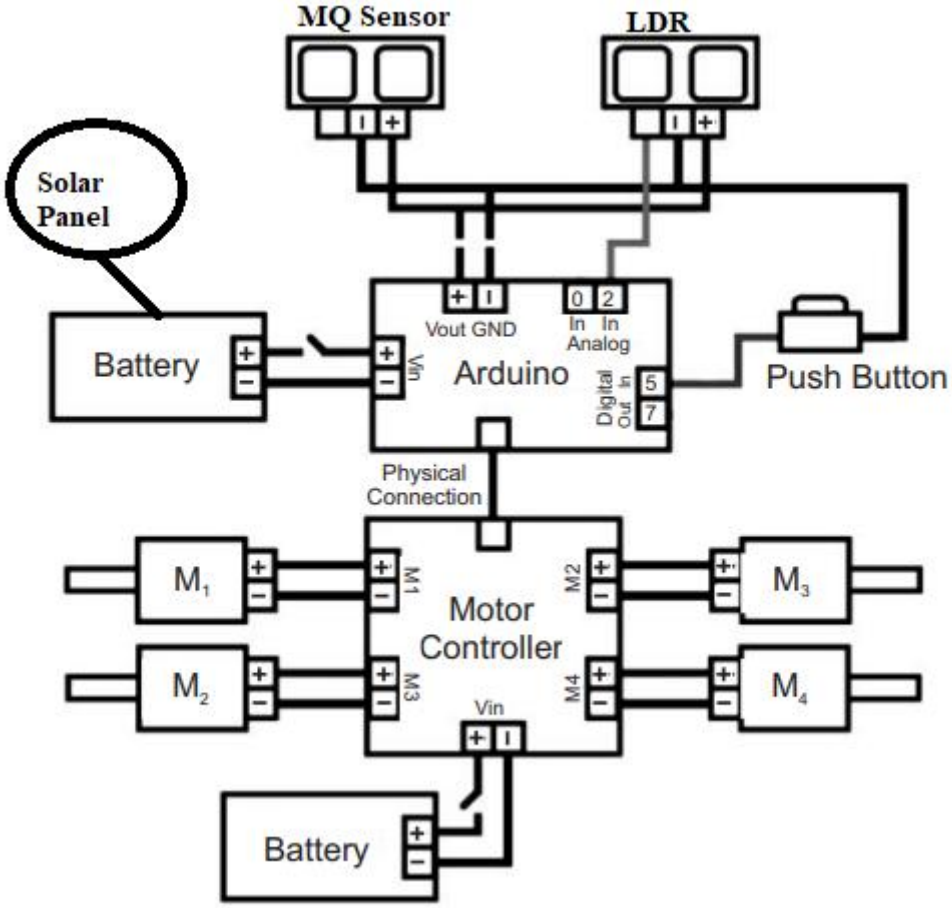
• Incorporate machine learning algorithms to optimize purification efficiency and adapt to varying environmental conditions.
• Promote eco-friendly innovation by demonstrating the integration of renewable energy, robotics, and smart technology for environmental health.

IV. METHODOLOGY

1. System Design and Planning
• Define the functional requirements of the robot, including purification efficiency, mobility, and energy sustainability.
• Develop block diagrams and architecture integrating solar panels, sensors, filtration units, and robotic components.
2. Solar Energy Integration
• Select and install photovoltaic (PV) panels to harness solar energy.
• Incorporate a battery storage system to ensure continuous operation during low sunlight conditions.
3. Air Purification Unit Development
• Implement a HEPA filter.
• Optimize airflow design using fans and ducts to maximize pollutant removal efficiency.
• Test the unit for removal of particulate matter (PM2.5, PM10).
4. Robotic Mobility and Navigation
• Integrate motors, wheels for autonomous movement.
• Use ultrasonic sensors, gas sensors for obstacle detection.
• Develop algorithms for path planning to ensure coverage of indoor and outdoor environments.

V. BLOCK DIAGRAM



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VI. RESULTS AND DISCUSSION

• The solar panel system generated sufficient energy to power both the air purification unit and robotic mobility, ensuring continuous operation during daylight hours.

• The filtration system (HEPA) achieved high efficiency in removing pollutants, with particulate matter (PM2.5 and PM10) reduced by 99.97% in controlled environments.

• The robot autonomous system successfully avoided obstacles and covered designated areas, proving effective in both indoor and outdoor trials.

• Battery backup allowed the system to operate for several hours after sunset, ensuring reliability in low-light conditions.

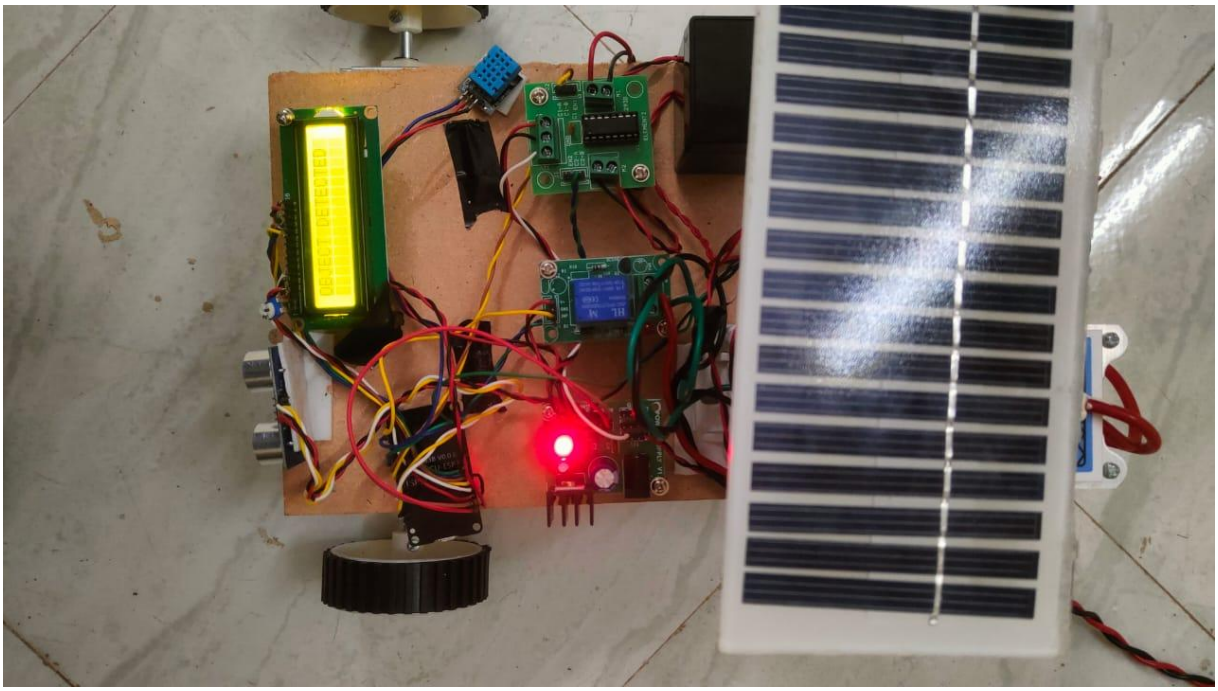

Fig 6.1 Hardware Connection

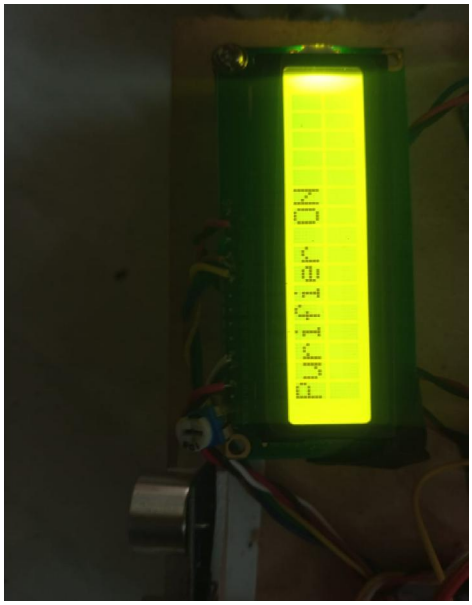

Fig 6.2 Purifier ON

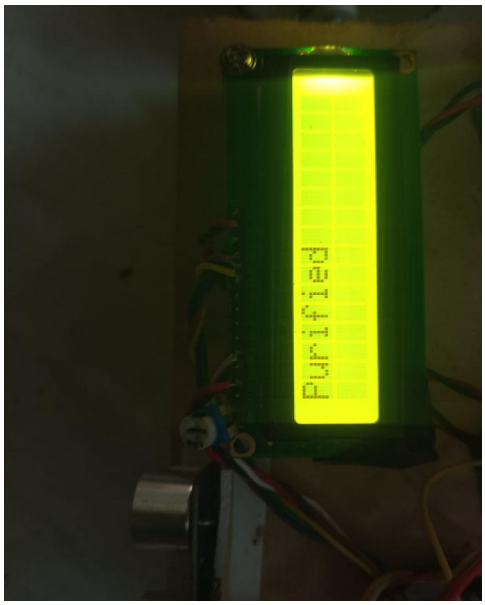

Fig 6.3 Purified

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VII. CONCLUSION

- The Solar-Powered Smart Air Purification Robot is an innovative and eco-friendly system designed to reduce air pollution and improve air quality. It works by using solar energy to power its sensors, motors, and air purifiers — making it a self-sustaining and green solution.
- With the help of smart sensors and IoT technology, the robot can automatically detect polluted air, move to the affected area, and clean it efficiently. It can be used in homes, schools, offices, hospitals, and outdoor areas to create a healthier environment.

FUTURE SCOPE

- More Advanced Sensors : Use better sensors to detect more types of gases and pollutants for accurate air quality measurement.
- Enhanced Air Quality Detection : Future models can use advanced sensors (like CO_2, PM2.5) for more accurate air quality monitoring.
- Scalability for Public Use : Larger versions of the robot can be deployed in parks, schools, and industrial areas to improve environmental air quality.

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