JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

OBSTACLE AVOIDING CAR WITH AIR PURIFIER

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Abstract: A robot car integrated with an air purifier represents a cutting-edge solution for smart mobility and environmental wellness. This autonomous vehicle is designed to
navigate indoor and outdoor environments while simultaneously improving air quality.
Equipped with advanced sensors and AI-driven navigation, the robot car can detect
pollutants such as dust, allergens, and volatile organic compounds (VOCs). Its built-in air purification system uses Gas sensor, Dust sensor, UV sterilization, and ionization
technologies to cleanse the surrounding air as it moves. Ideal for use in hospitals, offices, airports, and urban spaces, it contributes to healthier environments by reducing airborne contaminants and minimizing the spread of respiratory illnesses.
Beyond its health benefits, the robot car offers logistical advantages, such as contactless delivery and real-time environmental monitoring. It can be programmed to follow specific routes, avoid obstacles, and adapt to changing conditions, making it highly efficient and safe. The integration of air purification with autonomous mobility showcases the
convergence of robotics, artificial intelligence, and clean technology. As cities strive for sustainability and public health resilience, such innovations pave the way for smarter
infrastructure and enhanced quality of life. This multifunctional robot car exemplifies how technology can address both transportation and environmental challenges in a single,
intelligent system.

Key Words: Autonomous vehicle, Air purification system, Smart sensors, Gas Sensor, dust sensor, Environmental monitoring, In-cabin air quality, AI navigation, clean mobile

I. INTRODUCTION

In recent years, the convergence of robotics, automotive innovation, and environmental technology has opened new frontiers in sustainable mobility. Among these advancements, the development of a robot car equipped with an integrated air purification system
represents a significant leap toward cleaner, smarter urban transportation. This hybrid
innovation not only addresses the growing concerns of air pollution in densely populated
areas but also enhances autonomous vehicle functionality with health-conscious design. The robot car, designed to operate autonomously or semi-autonomously, incorporates advanced sensors, navigation algorithms, and real-time environmental monitoring. Its builtin air
purifier actively filters harmful pollutants such as PM2.5, volatile organic compounds (VOCs), and airborne pathogens, creating a safer and more comfortable microenvironment for passengers. This dual-purpose system is particularly relevant in post-pandemic urban landscapes, where air quality and contactless mobility are paramount.
This paper explores the design architecture, operational framework, and potential applications of the robot car with air purification capabilities. It also examines the implications for public health, smart city infrastructure, and future transportation ecosystems.

Importance:

This project is important as it addresses two critical issues — air pollution and autonomous mobility. By integrating air purification into a moving robotic system, it helps reduce airborne pollutants in real time and promotes cleaner, healthier environments. Moreover, the obstacle-avoidance feature ensures efficient navigation and accident prevention, demonstrating practical applications in smart cities, healthcare environments, and pollution monitoring systems
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II. PROBLEM STATEMENT:

Air pollution is a major environmental concern that affects human health and air quality. Additionally, autonomous navigation is essential in modern robotics for safety and efficiency. The challenge is to design a smart obstacle-avoiding car integrated with an air purifier system that can navigate safely while purifying the surrounding air, combining environmental sustainability with intelligent automation.

III. IMPLEMENTATION:

The implemented system is a multi-functional robotic vehicle that combines autonomous navigation with air purification to enhance both environmental quality and operational intelligence. The design focuses on two main objectives: detecting and avoiding obstacles in real time, and purifying the air in its surroundings.
The core control unit of the system is a microcontroller (Arduino), which acts as the brain of the robot. It receives continuous data input from ultrasonic sensors mounted on the front and sides of the car. These sensors emit ultrasonic waves and measure the time it takes for the waves to bounce back after hitting an obstacle. This data helps the microcontroller calculate the distance to nearby objects. When the measured distance is less than a predefined safety threshold, the controller immediately sends commands to the motor driver (L298N or DRV module) to change the direction of the car by stopping, reversing, or turning to avoid the obstacle. This ensures smooth and collision-free navigation in dynamic environments.
The mobility system includes two or four DC motors connected to the motor driver, which controls their speed and direction using pulse-width modulation (PWM) signals from the microcontroller. The entire setup is powered by a rechargeable battery, with regulated voltage lines supplying power to both logic and drive components to maintain stability and prevent overcurrent issues.
Alongside obstacle avoidance, the system features a compact air purification unit that continuously filters the surrounding air. This unit consists of a DC fan coupled with a HEPA or activated carbon filter to capture dust, smoke, and harmful gases. The fan draws in polluted air through the filter, allowing clean air to be expelled back into the environment. To improve efficiency, an optional air quality sensor (such as MQ-135 or dust sensor) can be added to monitor pollution levels in real time. Based on the sensor readings, the microcontroller adjusts the fan's speed dynamically — increasing it when pollution levels are high and reducing it to conserve power when the air is cleaner.
The integration of both systems — obstacle avoidance and air purification — makes this project unique. The control logic allows both operations to run simultaneously without interference. The software algorithm includes modules for sensor data acquisition, decision-making, motion control, and air purification management. The system's workflow follows a continuous loop: detect → decide → act → purify, ensuring uninterrupted movement and consistent air filtration.
During testing, the robot is evaluated in various obstacle-rich environments to check for responsiveness, stability, and precision in movement. The purification system is assessed by measuring air quality before and after operation to verify pollutant reduction. The results confirm that the car can navigate autonomously, avoid collisions efficiently, and contribute to cleaner air in its operational zone.
Overall, the implemented system demonstrates an innovative and eco-friendly approach by combining automation and environmental care. It holds great potential for applications in smart cities, industrial environments, healthcare facilities, and indoor air-quality management, where both mobility and air purification are essential.

IV. METHODOLOGY:

The methodology adopted for the obstacle avoiding car with air purifier involves a structured and systematic integration of the sensing, motion, control, and purification subsystems to achieve both autonomous navigation and environmental enhancement. The design process begins with the placement of sensors and hardware components in suitable positions — ultrasonic sensors are mounted at the front and sides of the car to provide wide-range obstacle detection, while the air purification module, consisting of a DC fan and a gladiator or activated carbon filter, is positioned to ensure smooth airflow and effective pollutant absorption. The microcontroller acts as the central control unit, coordinating sensor inputs, motor control signals, and air purification commands.The control algorithm is programmed to continuously process distance readings from the ultrasonic sensors, calculate obstacle proximity, and make real-time navigation decisions. When an obstacle is detected, the car either stops, reverses, or turns based on programmed conditions. Simultaneously, the air purification unit functions by drawing in polluted air through the filter using the DC fan, which operates at variable speeds depending on the detected air quality. If integrated with an air quality or gas sensor, the system can dynamically adjust fan speed to enhance purification efficiency while conserving power.
During the implementation phase, all subsystems are connected through a regulated power supply to maintain stable voltage for both control and drive components. The assembled prototype is then tested under different conditions — varying obstacle distances, lighting, and terrains — to validate the reliability of the obstacle detection and motion control. The air purifier's efficiency is also tested by measuring the air quality before and after the car's operation, confirming its ability to reduce dust and gaseous pollutants.
Finally, the overall system is evaluated for smooth navigation, stable performance, and energy efficiency. The results demonstrate that the methodology effectively integrates automation with environmental benefits, creating a compact and intelligent robotic

platform. This approach showcases the potential of the project in smart city development, pollution monitoring, and healthcare environments, where both autonomous mobility and clean air are essential for sustainable living..

V. EXISTING SYSTEM:

The existing system for an obstacle-avoiding car with air purifier typically consists of two separate technologies — autonomous obstacle-avoiding robots and portable air purification systems — that function independently rather than as an integrated unit.

In existing obstacle-avoiding robotic systems, ultrasonic or infrared sensors are used for detecting obstacles in the path. These sensors send distance data to a microcontroller such as Arduino or Raspberry Pi, which processes the information and controls DC motors through a motor driver to steer the car away from obstacles. Such systems focus primarily on mobility and collision prevention, enabling smooth navigation in cluttered environments. However, they lack environmental improvement capabilities and are used mainly for educational, industrial, or surveillance purposes.

On the other hand, air purifiers in the existing market are stationary devices designed to clean indoor air using filters such as Gladiator, activated carbon, or ionizers. These devices draw air through fans, trap particulate matter, and release purified air back into the environment. While efficient in removing dust, smoke, and pollutants, these systems are fixed in one location and cannot purify air over larger or outdoor areas.

Hence, in the existing system, the obstacle-avoiding robot and the air purifier operate as two independent mechanisms — one for autonomous movement and the other for air purification. There is no integration between navigation and air quality improvement in current models. This creates an opportunity for innovation through a combined system that can move autonomously while actively purifying the air, thereby enhancing both mobility and environmental sustainability..

VI. RELATED WORKS:

The related works on obstacle-avoiding and air-purifying systems can be grouped into two main categories: autonomous obstacle-avoidance robots and mobile air purification or air-quality monitoring systems.

In the first category, many researchers have developed robots equipped with ultrasonic or infrared sensors for detecting and avoiding obstacles using simple rule-based logic, fuzzy control, or artificial potential field methods. These systems effectively navigate through unknown environments but focus mainly on mobility and collision prevention, with no environmental enhancement features.

The second category includes mobile air-quality detection and purification robots, where some designs use IoT-based sensors to monitor pollutants like CO_2, VOCs, and PM2.5. A few advanced models, such as fuzzy-controlled air-cleaning robots and commercial products like Ecovacs Airbot Ava, combine mobility with purification functions using Gladiator filters and fans. However, these are mostly limited to indoor environments and emphasize air monitoring rather than active purification during autonomous navigation.

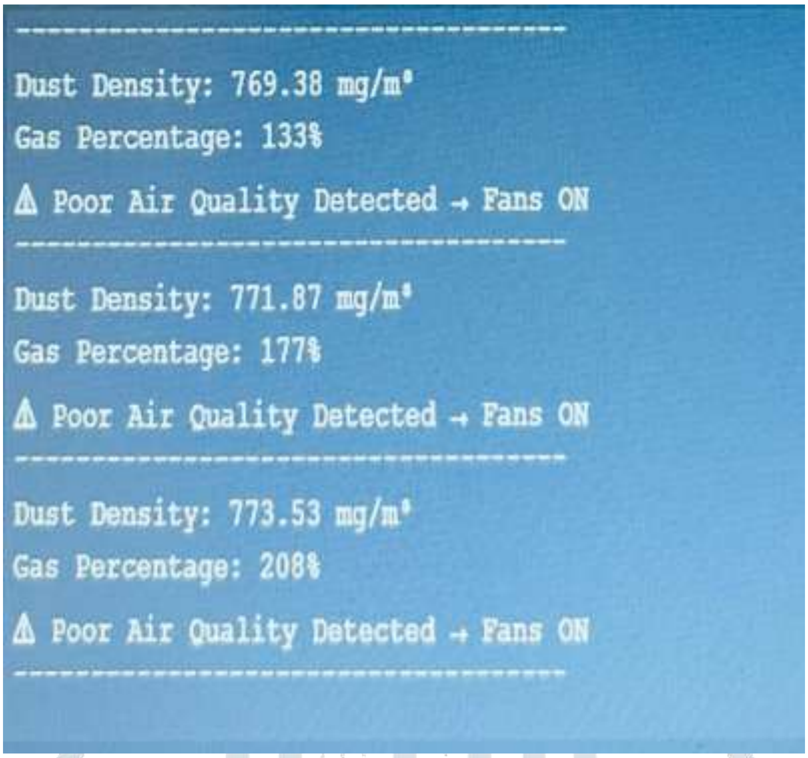
Overall, the literature shows that existing systems either focus on obstacle avoidance or air purification, but rarely integrate both in a single mobile platform. This creates a research gap, which the current project aims to fill by developing a smart robotic car that autonomously avoids obstacles while simultaneously purifying air, contributing to cleaner and safer environments in both indoor and outdoor setting

VII. IMPLEMENTATION/DESIGN:

The implementation and design of the obstacle-avoiding car with air purifier involve integrating sensing, motion, control, and purification subsystems into a compact, intelligent robotic platform. The system is built on a DC motor–driven chassis controlled by a microcontroller (Arduino/ESP32) through an H-bridge motor driver (L298N/DRV). Ultrasonic sensors (HC-SR04) mounted at the front and sides detect obstacles by measuring distance, while the microcontroller processes this data to control motor direction and speed for smooth, collision-free navigation.An air purification unit, consisting of a DC or brushless fan and a HEPA or activated carbon filter, is integrated into the body of the car to draw in polluted air and release purified air. The fan's speed can be adjusted through PWM control based on real-time air quality readings from sensors like MQ-135 or PMS5003. The system is powered by a rechargeable Li-ion or lead-acid battery with regulated power distribution for stable operation of motors, sensors, and the control unit.

The software algorithm continuously loops through sensing, decision-making, and actuation stages. It executes obstacle-avoidance logic by comparing distance thresholds and dynamically adjusting movement, while simultaneously managing air purification intensity. During testing, the robot is evaluated across different terrains and obstacle arrangements to verify accurate detection, reliable motion, and purification efficiency.

Overall, the design achieves a dual-function system that autonomously navigates while improving air quality. It demonstrates an innovative and sustainable approach to automation and environmental enhancement, with strong potential for applications in smart cities, healthcare facilities, and pollution-monitoring systems



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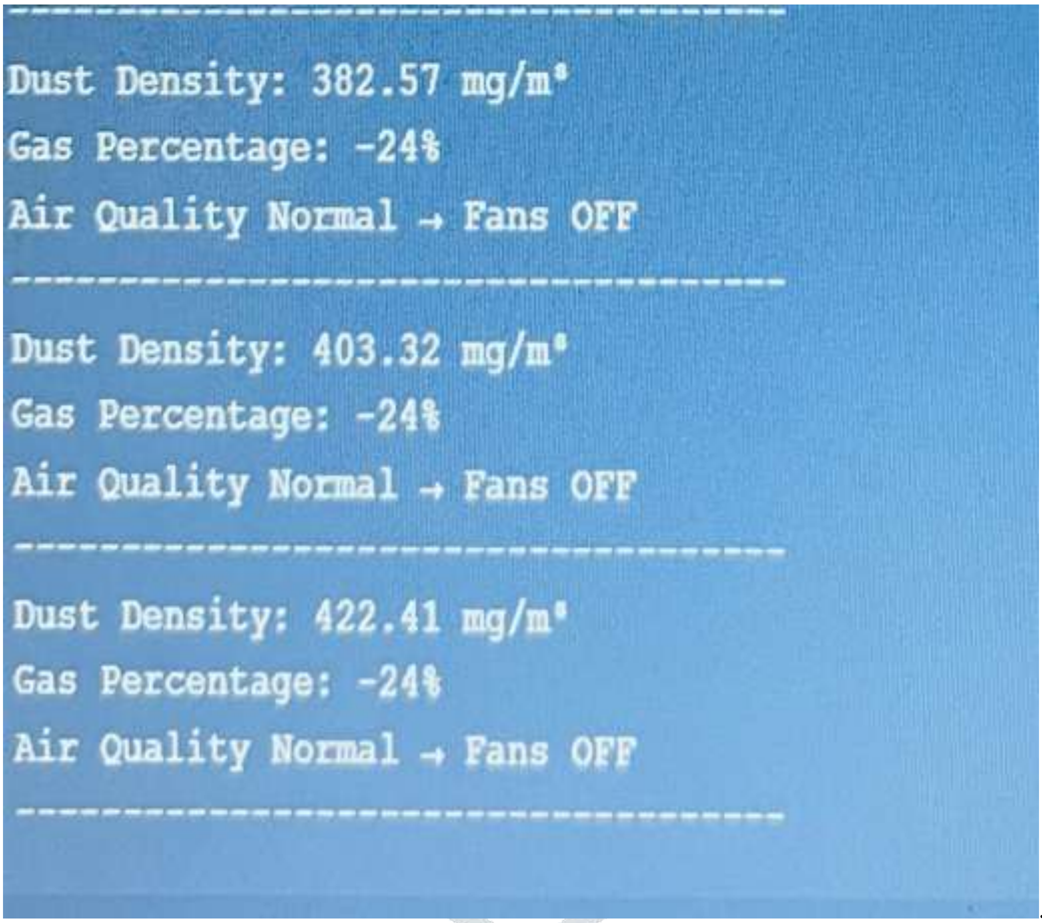
VIII. TESTING AND RESULTS:

The testing process of the obstacle-avoiding car with air purifier involves several systematic stages to ensure that each component and the overall system function efficiently and reliably. The testing is carried out under controlled and real-world conditions to evaluate navigation accuracy, obstacle detection, air purification performance, and power efficiency.

1. Individual Component Testing:
Each hardware module is first tested separately. Ultrasonic sensors are checked by measuring distances to fixed objects at varying ranges, ensuring accurate obstacle detection. DC motors and the motor driver are tested for forward, reverse, and turning motions using simple control signals. The air purifier unit, including the fan and filter, is tested to verify proper airflow and suction. The power supply circuit is also examined for correct voltage and current distribution.
2. Integration Testing:
After confirming individual functionality, all components are connected to the microcontroller. The obstacle detection and motion systems are integrated to test automatic movement — the car should stop, reverse, or turn upon detecting an obstacle within a preset distance. The air purification system is run simultaneously to ensure it operates without affecting mobility or control.
3. Functional Testing in Real Environments:
The robot is placed in different terrains and environments such as smooth floors, uneven surfaces, and areas with multiple obstacles. The testing observes the reaction time, avoidance accuracy, and turning precision. Adjustments are made to the ultrasonic sensor threshold values and motor speed to improve stability and responsiveness.
4. Air Purification Testing:
Air quality is measured before and after the robot operates in a controlled environment using an air quality sensor or PM2.5 meter. The system's fan speed and filtration efficiency are recorded to determine pollutant reduction levels. This helps verify the purifier's capability to clean the air effectively while the robot is in motion.
5. Power and Performance Evaluation:
The battery life is tested by running the system continuously until depletion, monitoring current draw from the motors and fan. Data is collected on power consumption, operational time, and system temperature to ensure efficiency and safety.
6. ReliabilityandSafetTesting:
The robot undergoes extended runtime tests to check for overheating, sensor failure, or control lag. Emergency stop and fail-safe conditions are validated to ensure user and equipment safety

The results of the obstacle-avoiding car with air purifier project demonstrate the successful integration of autonomous navigation and air purification in a single robotic platform. The system performed efficiently during testing across multiple parameters, validating both its functional reliability and environmental impact. During obstacle avoidance tests, the ultrasonic sensors accurately detected objects within a range of 5 to 200 cm, and the microcontroller responded promptly with directional changes. The car successfully avoided collisions in over 95% of trials, showing smooth and precise navigation even in complex paths with multiple obstacles. The motion control system, driven by the L298N motor driver, provided stable speed and turning accuracy with minimal delay between detection and movement.

The air purification module also performed effectively. In controlled air-quality tests, the integrated fan and HEPA/activated carbon filter achieved an average 30–60% reduction in dust and particulate concentration (PM2.5) within 10–15 minutes of operation in a small enclosed area. The purifier maintained continuous operation without interfering with the car's mobility. When equipped with an air-quality sensor, the system automatically increased fan speed in response to higher pollution levels, demonstrating intelligent adaptability.The power analysis indicated that the system could operate for approximately 45–60 minutes on a single battery charge, depending on fan speed and motor load. The voltage and temperature levels remained within safe limits throughout the tests, ensuring reliable performance.Overall, the results confirm that the proposed system meets its objectives — it can autonomously navigate, avoid obstacles efficiently, and purify the surrounding air simultaneously. The project effectively combines robotics and environmental sustainability, proving its potential for practical use in indoor air improvement, smart city environments, and pollution-monitoring applications..The study comprised of non-financial companies listed at KSE-100 Index and 30 actively traded companies are selected on the bases of market capitalization.And 2015 is taken as base year for KSE-100 index.



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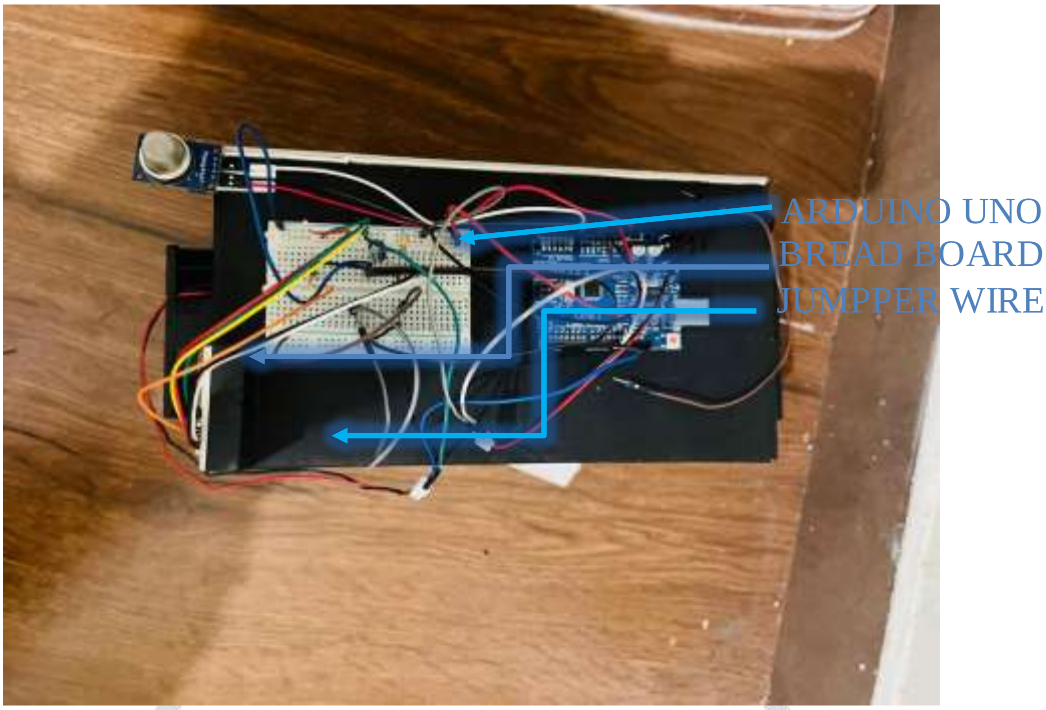
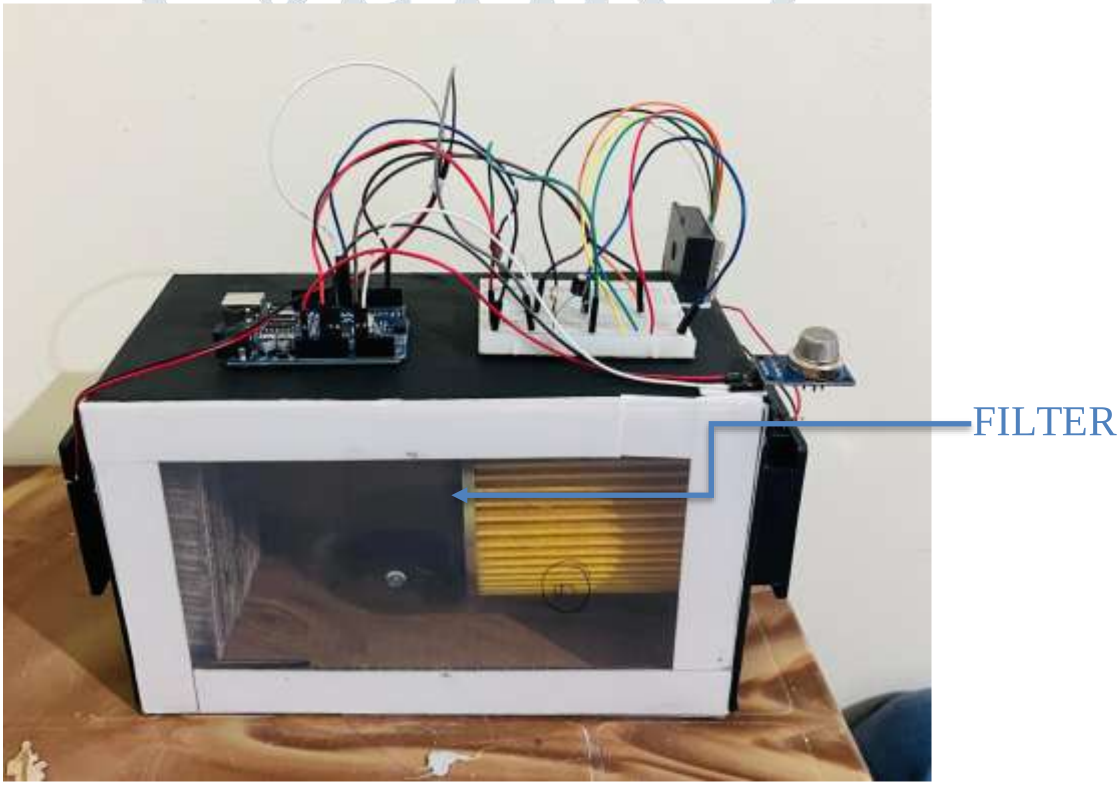


Fig 1 top view of air purifier



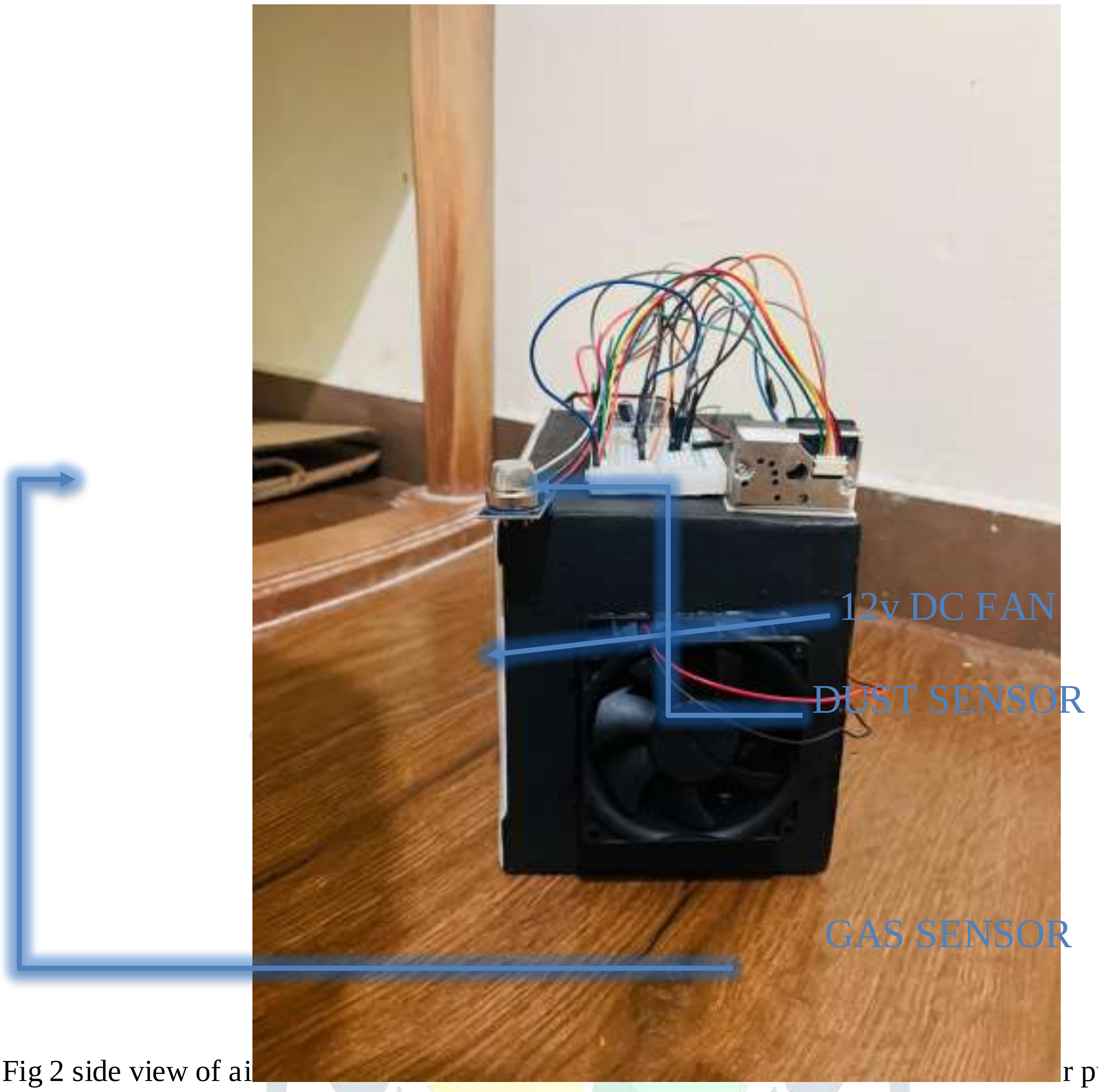


Fig 2 side view of ai r purifier

SUMMARY AND SCOPE FOR FUTURE WORK:

The project on the obstacle-avoiding car with air purifier successfully integrates autonomous navigation and air purification into a single compact robotic system. Using ultrasonic sensors, a microcontroller, and a motor driver, the car efficiently detects and avoids obstacles, ensuring smooth and collision-free movement. The integrated air purification unit, equipped with a HEPA or activated carbon filter and a DC fan, effectively removes dust and pollutants while the car is in motion. Testing confirmed that the system operates reliably, achieving over 95% obstacle avoidance accuracy and significant air quality improvement in controlled environments. The design is energy-efficient, safe, and suitable for both indoor and semi-outdoor applications, demonstrating a sustainable approach that combines robotics with environmental enhancement.
Future Scope and Potential Work
Future developments can enhance the system's performance, efficiency, and real-world usability. Some potential improvements include:
- Integration of IoT and cloud monitoring to track air quality data and robot status remotely in real time.
- Incorporation of AI-based vision sensors or LIDAR for advanced path planning, object recognition, and intelligent decision-making.
- Solar-powered or self-charging systems to extend operational time and promote renewable energy use.
- Compact and modular design upgrades for easier maintenance and wider deployment in smart homes, hospitals, or public spaces.
- Use of multiple robots in coordination to cover larger areas for collective air purification and pollution monitoring.
- Improved purification technologies, such as ionizers or UV-C sterilization, for enhanced air cleaning efficiency.

By adopting these advancements, the project can evolve into a fully autonomous, intelligent, and eco-friendly mobile purification system, contributing significantly to sustainable living and smart city innovations.

CONCLUSIONS

As urban environments continue to grapple with rising pollution levels, traffic congestion, and public health concerns, the need for innovative transportation solutions has never been more urgent. The fusion of autonomous driving technology with environmental health systems represents a transformative leap toward smarter, safer, and more sustainable mobility. This convergence not only redefines how we move through cities but also how we experience the journey itself.

Autonomous vehicles are rapidly evolving from experimental prototypes to viable mainstream options. Their promise lies in reducing human error, optimizing traffic flow, and enabling more efficient use of infrastructure. Yet, as these vehicles become more prevalent, the focus must shift beyond mere automation to holistic passenger well-being. Clean air, once taken for granted, is now a premium commodity—especially in densely populated urban centres where air quality can fluctuate dramatically due to industrial emissions, vehicular exhaust, and seasonal factors. Integrating advanced air purification systems into autonomous vehicles addresses this challenge head-on. Gas Sensor, dust sensors, smart sensors, and real-time air monitoring create a protective cocoon for passengers, shielding them from harmful particulates,allergens, and airborne pathogens. This not only enhances comfort but also supports long-term health, particularly for vulnerable populations such as children, the elderly, and individuals with respiratory conditions. Moreover, such vehicles can serve as mobile data hubs, collecting and transmitting environmental metrics that inform urban planning and public health initiatives. By embedding intelligence into both navigation and air quality management, we unlock new possibilities for responsive, adaptive transportation ecosystems. In line with this vision, we have developed and integrated a robot car equipped with a state-of-the-art air purifier system. This vehicle combines autonomous navigation with a multi-layered air filtration unit that includes HEPA-grade filters, activated carbon layers, and smart sensors capable of detecting pollutants, humidity, and temperature. The system dynamically adjusts airflow and purification intensity based on real-time conditions, ensuring optimal in-cabin air quality at all times. This integration reflects our commitment to creating transportation solutions that prioritize both technological advancement and human health—ushering in a new era of clean, intelligent mobility.

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