



Design of an Arduino-Based Autonomous Robot for the Detection of Harmful Gas Leakage and Air Pollution

Saida Binta Alam, Richard Victor Biswas,
Zinniya Taffannum Pritee, Md. Nakib Shahria, Nasif Hannan and
Wahid Sadik

EasyChair preprints are intended for rapid
dissemination of research results and are
integrated with the rest of EasyChair.

May 18, 2023

Design of an Arduino-Based Autonomous Robot for the Detection of Harmful Gas Leakage and Air Pollution

Abstract— An Arduino-based automatic control robot is a system that can play an effective role in detecting harmful gas leakage and air pollution. The primary aim is to create a monitoring approach for air quality that is both effective and sustainable, while also being cost-efficient, particularly in residential areas, workplaces and public spaces. To develop this system, we need an Arduino Uno, dc gear motors, battery casing, 3.7volt batteries, jumper wires, switch, bread board, led, a L293D motor driver, a motor driver shield, jumper wires, and some advanced technologies such as MQ135 and MQ9 gas sensors, and ultrasonic sensors to enable the system to detect hazardous substances and avoid obstacles. MQ 135 can detect hazardous gases including Sulfur(S), Ammonia (NH₃), Benzene(C₆H₆). On the other hand, the MQ-9 can detect LPG, CO, CH₄ and so on. The project's outcome was a reliable and efficient system that can monitor air quality and promote safety and health in indoor environments. The project emphasizes how technological advancements may address societal challenges and contribute to sustainable development by creating a safer and healthier environment for individuals.

Index Terms— Arduino Based, Motor Control, Sustainable, Ultrasonic Sensors, Microcontroller, Motor Driver.

I. INTRODUCTION

Air pollution and gas leaks in indoor environments can have serious health implications for people, especially those who are exposed to it for prolonged periods. There is a need for an automated system that can identify these threats, warn individuals about them. The proposed system is built on a microcontroller that can operate automatically. The system under consideration intends to provide a reliable and effective method for monitoring air quality and warning people of any threatening condition for society, creating a secure and healthy living environment. The design, development, and results of the studies done to gauge the system's efficacy will all be covered in the research paper.

The objectives for an Arduino-based automatic robot to detect harmful gas leakage and air pollution to integrate advanced technologies such as MQ135 and MQ9 gas sensors, ultrasonic sensors, to enable the system to detect hazardous substances, avoid obstacles, and alert users of potential threats via mobile phones. To promote safety and health by providing an effective and sustainable method for measurement of air quality particularly in workplaces, residential areas, and public

This research paper includes a literature review to analyze previous studies, identify gaps, and present key findings. The methodology and modeling section explains the research approach and data collection methods. The results are analyzed and interpreted, followed by a discussion of limitations encountered during the study. The research direction and challenges section explore future avenues and potential obstacles. The paper concludes with a concise summary in the conclusion, highlighting key findings and their implications.

II. LITERATURE REVIEW

A real time and accurate GPS based environmental monitoring robotic system using IoT was designed by K. Nayanashitachowdary and M. Padmaja [1]. The system provides insight on using IoT in environmental data monitoring. The system includes GPS for accurate positioning, allowing precise data collection at specific coordinates.

A low-cost air quality monitoring system was designed by Anabi Hilary Kelechi, Mohammed H. Alsharif, Chidumebi Agbaetuo, Osichinaka Ubadike, Alex Aligbe, Peerapong Uthansakul, Raju Kannadasan, and Ayman A. Aly [2]. The system utilized Arduino and Thingspeak as components for its implementation. The authors discussed the importance of air quality monitoring and raising public awareness due to the negative effects that daily emissions of particulate and gaseous pollutants have on the environment and human health. Using Arduino and ThingSpeak, the authors implemented a sustainable air quality measuring system that uses carbon monoxide and air quality sensors to keep an eye on gas pollutants. The system uses HTTP protocols to send emails to spread notice of bad air quality and delivers real-time readings to a ThingSpeak internet channel for display. An alert goes off and emails are sent to the appropriate authorities when the level of pollutants exceeds a predetermined threshold. Juhi Chaudhary and Anurag Mishra [3] developed leakage detector and automated alarm system. The system's successful implementation demonstrates that low-cost technologies may be used to monitor air quality.

Abdullah J. Alabdullah, Badr I. Farhat, and Slim Chtourou [4] proposed Arduino-based monitoring system of air. In order to monitor and identify total volatile organic compounds (TVOC) in indoor as well as outdoor environments.

This research suggests a design for an Arduino-based system. The system attempts to inform inhabitants of the concentration levels and recommend steps to take because high concentrations of VOCs might cause health problems.

Researchers B. Perumal, J. Deny, K. Alekhya, V. Maneesha, and M. Vaishnavi [5] implemented an air pollution monitoring system utilizing the Arduino IDE. The authors suggested a method for monitoring air pollution with an Arduino microcontroller. The device monitors air quality real time and receives information from a foreign server for Microsoft Excel analysis. The method accurately monitors air quality in Million Metrics (PPM), and the findings support this. Due to the rise in industrial activity and its effects on biodiversity and quality of life, the system is meant to address the need for air quality monitoring.

IOT based air pollution monitoring system using Arduino a research experiment performed by Poonam Pal, Ritik Gupta, Sanjana Tiwari, Ashutosh Sharma [6] The project incorporates an LCD display and a webpage to display the pollution level in parts per million (PPM). The objective is to enable remote monitoring of air pollution levels from any computer or mobile device, ensuring easy access to crucial information.

Mykhailo Lobur, Dmytro Korpyljov, Nazariy Jaworski, Marek Iwaniec, Uliana Marikutsa [7] proposed ambient air pollution sensing system provide real-time low-cost flexible measurement. In their research publication, the authors developed a system capable of measuring the five crucial air parameters in urban areas that significantly impact human health. These parameters include carbon monoxide (CO), fine particulate matter (PM 2.5), carbon dioxide (CO2), temperature, and humidity. The system then transfers this collected data to advanced applications at a higher level for analysis and forecasting purposes.

III. METHODOLOGY & MODELING

Our Arduino-based automatic robot is a system that can play an effective role in detecting harmful gas leakage and air pollution. The system was connected to a servo motor and ultrasonic sensor, which enabled it to move autonomously. Here is the list of components we have used in our project. The following is the list of components-

1. HC-SR04 Ultrasonic Sensor
2. L293D Motor Driver Shield
3. Gas Sensor MQ-135
4. Gas Sensor MQ-9
5. Arduino UNO R3
6. Servo Motor SG91R
7. DC GEAR MOTOR
8. Robot Car Chassis 4WD
9. Battery Holder (4 Pieces AA)

The detection of harmful gases in the environment was carried out using the Gas Sensor MQ-135 and Gas Sensor MQ-9. However, for our study, we employed the MQ-139 gas sensor, which can detect a range of detrimental gases including ammonia (NH3), sulfur (S), carbon dioxide (CO2), and various other harmful gases and smoke.

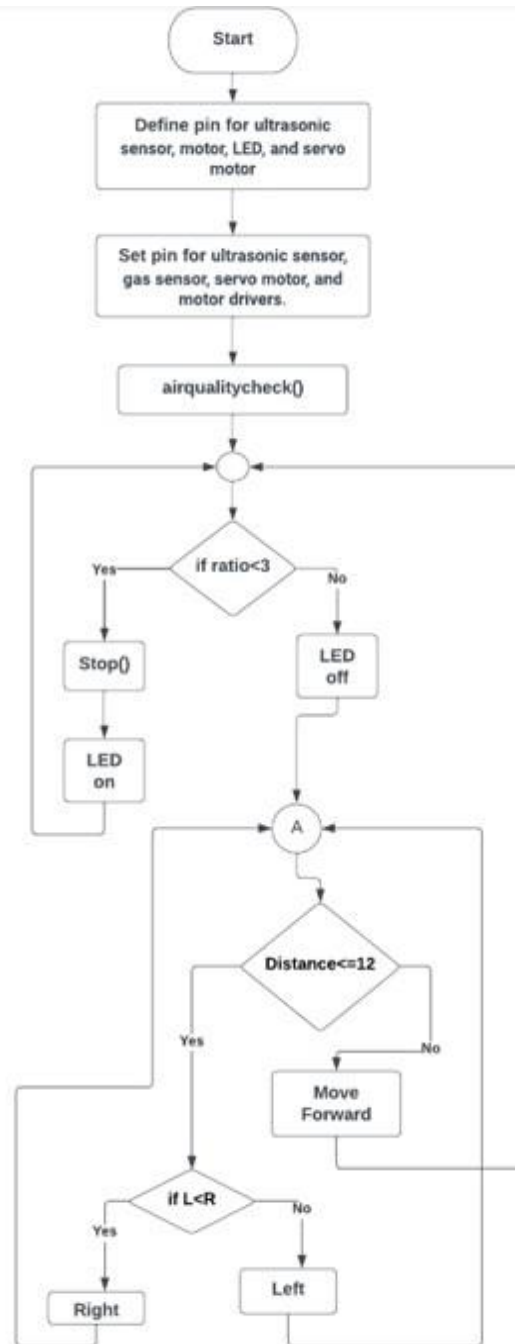


Fig. 1: Working flow-chart of Automatic Robot

We first assembled the chassis using components, wires and necessary components and then we mounted the motors on the chassis. Connect the motor driver module to the microcontroller and the motors, ensuring that the connections are correct.

We attached the servo motor and ultrasonic sensor to detect hazardous substances, avoid obstacles, and to detect distance then, following motor movements and the signals.

IV. RESULTS ANALYSIS

In this project, a computer simulation was performed to test the performance of the Arduino based automatic robot that can detect air pollution and harmful gases in the air. The simulation helped to model the robot's movement and sensor readings in the environment. By varying the parameters such as robot's speed and the sensitivity of its sensors, the evaluation of how well the robot can detect the air pollution and harmful gases in the environment was possible.

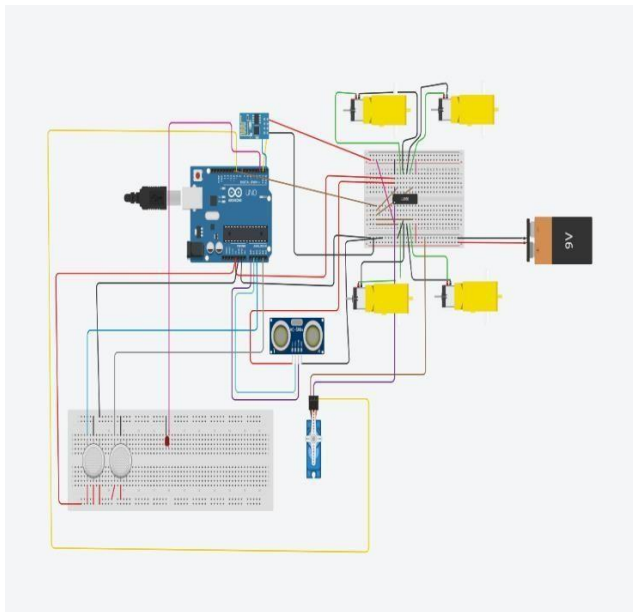


Fig. 2: Simulations Diagram

The simulation rotor speed analysis of the robot against time demonstrates that the rotor speed is increasing as time progresses. The graph of the figure helped to analyze the behavior of the system. For example, the robot's sensors had a limited range, which meant that it could only detect pollutants within a certain distance.

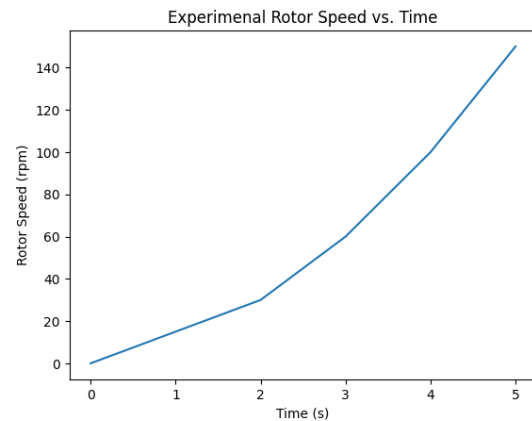


Fig. 3: Rotor speed vs Time (Simulation Analysis)

The robot detects air quality and harmful gases with the help of MQ135 and MQ9 sensor. It can measure Rs/R0 ratio.

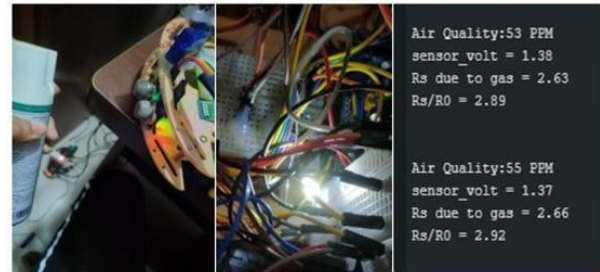


Fig. 4: Air Quality vs Rs/R0 ratio

Also, after long term use the sensors may give slightly different value. Additionally, the robot's movement was restricted by its wheels, which may not be able to navigate certain terrains.

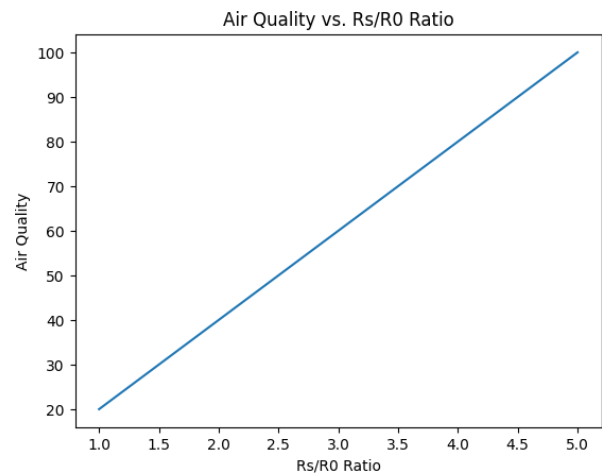


Fig. 5: Detection of Air Pollution and Harmful Gases Based on Rs/R0 ratio.

Overall, the project successfully showcased the potential and feasibility of utilizing an Arduino-based robot for the purpose of air pollution monitoring and detecting harmful gases. However, it is important to acknowledge that there are areas for further improvement and enhancement in terms of the robot's capabilities and limitations.

One aspect that could be further explored is the refinement of the robot sensing mechanisms. While the project employed specific gas sensors such as the MQ-135, future iterations could consider incorporating additional sensors or advanced technologies to expand the range of detectable gases and improve the accuracy of measurements.

V. LIMITATIONS OF RESEARCH

Although the Arduino-based robot was able to detect and measure air pollution and harmful gases in environments, the acknowledgement is that there were some limitations to the project. For example, the robot's sensors had a limited range, which meant that it could only detect pollutants within a certain distance. Also, after long term use the sensors may give slightly different value. Additionally, the robot's movement was restricted by its wheels, which may not be able to navigate certain terrains. Overall, while the project demonstrated the feasibility of using an Arduino-based robot for air pollution monitoring and harmful gas detection, there is still room for improvement in terms of the robot's capabilities and limitations.

VI. CHALLENGES & RESEARCH DIRECTION

The future improvements for the Arduino Based Autonomous Robot to Detect Air pollution and Harmful Gases can make more efficient and useful for the society. The updates that can be added to the project in future are:

Improving Robot's Sensing Capabilities: The project can be improved by enhancing the robot's sensing capabilities to detect wider range of pollutants.

Enhancing Robot's Mobility: The robot's mobility can be improved so that it can navigate a wider range of environment.

Adding Alert Feature: By adding GPS module the robot can send alert to the mobile phones via message or calling along with the location.

Adding Wi-Fi or Bluetooth Module: By adding Wi-Fi or Bluetooth module the robot can be controlled manually.

Expanding the Project scope: By adding sensors that can detect other factors, more comprehensive monitoring of air quality beyond just pollutant levels can be done.

Implementing Machine Learning: Implementing machine learning to analyze the data collected by the robot will help to identify patterns and trends in air pollution that would be difficult with human analysis.

VII. CONCLUSIONS

In conclusion, this project was effective in developing and implementing a robotic system based on the Arduino Uno microcontroller that could identify dangerous gases, reduce air pollution, and stop accidents inside of buildings while protecting the public's health. The research improved the robot's capabilities by using cutting-edge technologies for obstacle avoidance, including gas sensors and ultrasonic sensors. The team received actual knowledge in developing and programming embedded systems for real-world applications through this project. The robot is an advantageous upgrade to the current technologies for air pollution monitoring, harmful gas detection and management since it has the ability to improve society by preventing accidents and assuring safety. Overall, this research.

REFERENCES

- [1] K. Nayanatichowdary and M. Padmaja, "A Real and Accurate GPS based Environmental Monitoring Robotic System using IoT," in *2021 Fifth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC)*, Palladam, India, 2021, pp. 242-247, doi: 10.1109/I-SMAC52330.2021.9640769
- [2] A. H. Kelechi, M. H. Alsharif, C. Agbaetuo, O. Ubadike, A. Aligbe, P. Uthansakul, R. Kannadasan, and A. A. Aly, "Design of a Low-Cost Air Quality Monitoring System Using Arduino and ThingSpeak," *IEEE Access*, vol. 7, pp. 145051-145061, 2019.
- [3] J. Chaudhary and A. Mishra, "Detection of Gas Leakage and Automatic Alert System using Arduino," *SSRN Electronic Journal*, vol. 20
- [4] A. J. Alabdullah, B. I. Farhat, and S. Chtourou, "Air Quality Arduino Based Monitoring System," in *2nd International Conference on Computer Applications & Information Security (ICCAIS)*, 2019.
- [5] B. Perumal, J. Deny, K. Alekhya, V. Maneesha, and M. Vaishnavi, "Air Pollution Monitoring System by using Arduino IDE," in *Second International Conference on Electronics and Sustainable Communication Systems (ICESC)*, 2021.
- [6] P. Pal, R. Gupta, S. Tiwari, and A. Sharma, "IoT-based air pollution monitoring system using Arduino," in *Proceedings of the IEEE International Conference on Internet of Things (IoT)*, International Research Journal of Engineering and Technology (IRJET), 10 Oct, vol. 4, 2017.
- [7] M. Lobur, D. Korpiljov, N. Jaworski, M. Iwaniec, and U. Marikutsa, "Arduino Based Ambient Air Pollution Sensing System," in *2020 IEEE XVIth International Conference on Perspective Technologies and Methods in MEMS Design (MEMSTECH)*, IEEE, 2020, pp. 1-4.