Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 15, Issue. 2 : 2024
ISSN :**1906-9685**

DESIGN AND IMPLEMENTATION OF AFFORDABLE AND MODULAR AUTONOMOUS CAR

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ABSTRACT - In today's rapidly evolving landscape of technological innovation, the development of autonomous vehicles has become a captivating area of exploration. Our project introduces an innovative solution: an Arduino-powered autonomous car, designed with the capability to navigate its environment independently, offering an immersive experience into the world of robotics and automation. At the core of this creation lies a harmonious integration of various components, each playing a pivotal role in ensuring the vehicle's autonomous operation. Motor controllers breathe life into the wheels, enabling smooth movement, while ultrasonic sensors act as vigilant guardians, continuously monitoring the surroundings and preventing collisions with obstacles. The mastermind behind this intricate system is the Arduino microcontroller, which orchestrates every function with precision, processing sensor inputs, controlling the motors, and ensuring the car navigates its path without human intervention. This working model goes beyond mere assembly; it provides aspiring engineers with invaluable hands-on experience, equipping them with practical knowledge in electronics, programming, and robotics. The project serves as an educational journey, where individuals learn to combine hardware and software seamlessly to create a functioning autonomous system. They gain skills in integrating sensors for real-time data collection, mapping routes, and employing algorithms to make decisions that guide the car's movement. Through this process, students and enthusiasts gain insights into the complexities of robotics and autonomous systems, preparing them for more advanced projects in the future. Furthermore, this autonomous car serves as a foundation for further innovation and experimentation. Looking forward, we envision incorporating more advanced sensors to enhance the vehicle's environmental awareness, enabling it to recognize more intricate obstacles and navigate in diverse conditions. Additionally, implementing sophisticated localization and mapping algorithms would allow the car to traverse complex environments with greater accuracy and efficiency. These innovations could include integrating GPS modules, LiDAR, or cameras for real-time object recognition and pathfinding. Furthermore, enabling wireless connectivity would provide the capability for remote oversight, allowing users to control or monitor the car's performance from a distance, enhancing the overall flexibility and potential of the project. The use of wireless communication could also pave the way for fleet management in autonomous vehicle systems, allowing multiple units to operate and communicate in harmony. Ultimately, this Arduino-based autonomous car is not just a technical project; it is a gateway to exploration, innovation, and the expansion of possibilities within the realm of autonomous

https://doi.org/10.36893/JNAO.2024.V15I12.044

robotics. It serves as a testament to ingenuity and the boundless potential of combining simple, yet powerful, technologies to create autonomous systems. This initiative is an invitation to engineers, hobbyists, and innovators to challenge the status quo, experiment with new ideas, and push the limits of what is possible in the evolving field of robotics. By offering a platform for learning and experimentation, we aim to inspire future advancements in the autonomous vehicle domain, contributing to the broader landscape of robotics, artificial intelligence, and automation.

I. INTRODUCTION The automotive industry has undergone a significant transformation in recent years, shifting its focus from high-performance vehicles to those that prioritize safety, comfort, and efficiency. This shift has been driven by the increasing demand for intelligent technologies that maximize these attributes. One of the most promising innovations in this field is the development of autonomous cars, which are designed to operate independently without human intervention. An autonomous car is a computer-controlled vehicle capable of navigating its surroundings, making real-time decisions, and executing tasks such as driving, braking, and turning without any direct human control. The growing need for such technology is propelled by several key factors: the need for safer driving conditions, the rise in global population and consequently, the number of vehicles on the road, the demand for more efficient time management, and better resource utilization. As the world's population continues to increase, the number of cars on the road also grows, placing significant strain on transportation infrastructure, including roads, parking spaces, and fuel stations, especially for electric and hybrid vehicles. In response to these challenges, governments worldwide have implemented various safety measures, including the introduction of advanced technologies such as closed-circuit television (CCTV) cameras and road sensors to monitor traffic and enhance road safety. However, despite these efforts, road accidents continue to claim lives. In the United States alone, over 52,000 fatalities were reported in 2020 due to road accidents, and this number rose to more than 55,000 in 2021, highlighting the persistent issue of human error. Despite technological advancements, these incidents demonstrate that human mistakes remain a significant cause of accidents. In light of this, the exploration of alternative solutions, such as autonomous vehicles, has become crucial in the effort to reduce road fatalities and improve transportation systems. Researchers have devoted considerable effort to studying and developing autonomous car technologies, with various approaches presented in the literature. For instance, studies such as those in [3], [11] focus on real-time obstacle and object detection for autonomous cars using Arduino, while others, such as [5], [6], [7], [9], and [10], present minimalist self-driving car models that primarily focus on three key functionalities: navigating based on road direction, detecting stop signs and halting for a designated period, and recognizing traffic signs to make appropriate decisions. In [4], [8], [13], autonomous cars are built using Arduino Uno microcontrollers and ultrasound technology to aid in navigation, while other studies, such as [12], describe working miniature prototypes of self-driving cars using Raspberry Pi and Arduino. The use of Raspberry Pi and Arduino, along with open-source software, has gained attention for its low-cost and customizable approach. A notable feature of our project is its cost-effectiveness. Many existing systems in the literature rely on expensive, specialized hardware, but our approach uses Arduino, an open-source platform that fosters community-driven development and innovation. This allows for easier customization and enhancement, making the system more accessible for educational purposes. Unlike other projects that focus solely on specific aspects of autonomous driving, such as obstacle detection or line following, our project integrates multiple functionalities into a cohesive system. This includes the use of ultrasonic sensors for obstacle detection, infrared sensors for line detection, and TSOP sensors for traffic light detection, all working together to enable the car to navigate autonomously. This integrated approach offers a more complete and practical educational experience, demonstrating the power of combining multiple technologies to create a fully functional autonomous vehicle. By making this system more accessible and cost-effective, we aim to foster further exploration and innovation in the field of autonomous vehicles, ultimately contributing to the broader vision of safer and more efficient transportation systems.

II. LITERATURE SURVEY

A. . A. Dairi, F. Harrou, M. Senouci, and Y. Sun, "Unsupervised obstacle detection in driving environments using deep-learningbased stereovi-sion," Robotics and Autonomous Systems, vol. 100, pp. 287 – 301.

In the paper titled "Unsupervised Obstacle Detection in Driving Environments Using Deep-Learning-Based Stereovision" by A. Dairi, F. Harrou, M. Senouci, and Y. Sun, the authors present an innovative approach for detecting obstacles in driving environments using a deep-learning-based stereovision system. The method focuses on developing an unsupervised learning technique to enhance obstacle detection, a crucial task for autonomous driving. Traditional methods of obstacle detection often rely on manually labeled datasets, which require significant human intervention and are time-consuming to create. In contrast, the proposed deep-learning-based stereovision system eliminates the need for supervised learning by utilizing stereo camera images to infer depth information about the environment. The deep learning model is trained to recognize and segment obstacles based solely on the visual input from the stereo cameras, making it more adaptable and scalable in dynamic driving scenarios. The system's ability to learn features from raw image data without the need for pre-labeled training sets makes it highly efficient, especially for real-time applications in autonomous driving. The paper's key contribution lies in its exploration of unsupervised learning for obstacle detection, a step forward from the reliance on manually annotated data. By using a deep convolutional neural network (CNN) architecture, the system processes stereoscopic images to detect obstacles with high accuracy. This method benefits from the combination of stereovision's depth perception capability and deep learning's power to extract complex features from images. The authors demonstrate the effectiveness of their approach through extensive experiments conducted in various driving environments, highlighting its robustness and real-time performance. The proposed system outperforms traditional techniques in terms of accuracy and efficiency, particularly in scenarios where labeled data is scarce or unavailable. Additionally, the approach contributes to the broader goal of improving the safety and reliability of autonomous vehicles, as detecting obstacles in real-time is critical for collision avoidance. By reducing the dependence on manual data labeling and enhancing the system's adaptability, the paper offers a promising direction for the future of autonomous driving technologies.

B. J. D. Rupp and A. G. King, "Autonomous driving - a practical roadmap," in SAE Technical Paper, SAE International, 10 2010.

In the paper "Autonomous Driving - A Practical Roadmap" by J. D. Rupp and A. G. King, the authors provide a comprehensive analysis of the key technological advancements and practical challenges in the development of autonomous vehicles. Published in 2010 as part of the SAE Technical Papers, the paper outlines the roadmap for achieving fully autonomous driving capabilities, discussing various stages of progress required for vehicles to operate independently in complex environments. The authors emphasize that autonomous driving technology is not just about building cars with the ability to drive themselves but requires an integrated approach, incorporating advancements in sensors, computing power, and machine learning. They detail the importance of sensor technologies such as radar, LiDAR, and cameras in providing real-time data for autonomous systems to perceive and interpret their surroundings accurately. Moreover, they address the need for advanced algorithms to process this sensory data, enabling the vehicle to make decisions, adapt to changing conditions, and ensure safety. Rupp and King also explore the critical roadblocks that need to be overcome for the widespread adoption of autonomous vehicles. These include legal, regulatory, and ethical considerations, such as ensuring that the vehicles comply with traffic laws, making decisions in emergency scenarios, and addressing concerns about liability in the case of accidents. They highlight the role of public acceptance and trust in autonomous technology, noting that consumer skepticism about safety and reliability must be addressed before autonomous vehicles can be widely adopted. The paper suggests that gradual implementation, starting with semi-autonomous systems and progressing toward fully autonomous vehicles, will help overcome these challenges. Additionally, the authors discuss the role of collaboration between various stakeholders, including automotive manufacturers, technology companies, regulators, and researchers, to push the boundaries of autonomous driving technologies. By examining the technological, regulatory, and societal aspects of autonomous driving, this paper provides a detailed and forward-thinking perspective on the future of transportation.

C. P. Sharma, H. Liu, H. Wang, and S. Zhang, "Securing wireless communications of connected vehicles with artificial intelligence," in 2017 IEEE International Symposium on Technologies for Homeland Security (HST), pp. 1–7, April 2017.

In the paper "Securing Wireless Communications of Connected Vehicles with Artificial Intelligence" by P. Sharma, H. Liu, H. Wang, and S. Zhang, the authors explore the security challenges associated with wireless communications in connected vehicles and propose the use of artificial intelligence (AI) to address these concerns. With the increasing adoption of connected and autonomous vehicles, the reliance on wireless communication systems for exchanging data between vehicles (V2V) and between vehicles and infrastructure (V2I) has become a critical part of ensuring safe and efficient driving. However, this interconnectedness also introduces significant security risks, including vulnerabilities to cyber-attacks, data breaches, and communication interception. The paper emphasizes the importance of securing these communication channels to protect sensitive information, maintain system integrity, and prevent malicious activities that could compromise the safety of autonomous vehicles. To address these security challenges, the authors propose using AI techniques, particularly machine learning algorithms, to detect and mitigate potential threats in real-time. AI can be used to monitor the communication networks of connected vehicles, identifying anomalous behavior and

https://doi.org/10.36893/JNAO.2024.V15I12.044

intrusions by analyzing patterns in the communication data. By employing techniques such as anomaly detection, pattern recognition, and classification, AI-based systems can dynamically respond to evolving threats without requiring manual intervention. The paper also discusses the potential for integrating AI with traditional security measures, such as encryption and authentication protocols, to create a robust and adaptive security framework. Additionally, the authors highlight the importance of scalability, as the security system must be capable of handling the increasing volume of data and the growing number of connected vehicles. They conclude that AI-driven security solutions have the potential to significantly enhance the resilience of wireless communication systems in connected and autonomous vehicles, ensuring the safety and privacy of users while facilitating the broader adoption of these technologies.

IMPLEMENTATION

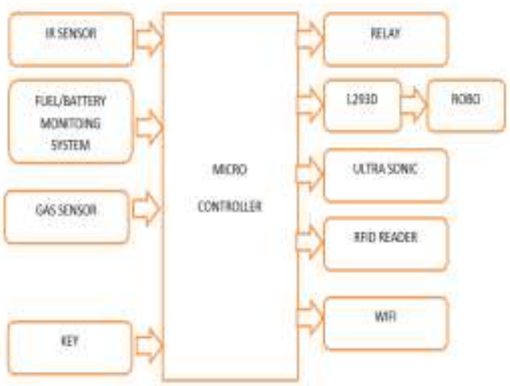

Fig: Block Diagram

POWER SUPPLY

A **regulated power supply** transforms unregulated AC (Alternating Current) into a stable DC (Direct Current). It guarantees consistent output despite variations in input. A regulated DC power supply is also known as a linear power supply, it is an embedded circuit and consists of various blocks

- **Regulated Power Supply Definition**: A regulated power supply ensures a consistent DC output by converting fluctuating AC input.
- **Component Overview**: The primary components of a regulated power supply include a transformer, rectifier, filter, and regulator, each crucial for maintaining steady DC output.
- **Rectification Explained**: The process involves diodes converting AC to DC, typically using full wave rectification to enhance efficiency.
- **Filter Function**: Filters, such as capacitor and LC types, smooth the DC output to reduce ripple and provide a stable voltage.
- **Regulation Mechanism**: Regulators adjust and stabilize output voltage to protect against input changes or load variations, essential for reliable power supply

SENSORS

Sensors are used for sensing things and devices etc. A device that provides a usable output in response to a specified measurement. The sensor attains a physical parameter and converts it into a signal suitable for processing (e.g. electrical, mechanical, optical) the characteristics of any device or material to detect the presence of a particular physical quantity. The output of the sensor is a signal which is converted to a human-readable form like changes in characteristics, changes in resistance, capacitance, impedance, etc.

IR SENSOR WORKING AND APPLICATIONS

In the electromagnetic spectrum, the infrared portion divided into three regions: near infrared region, mid infrared region and far infrared region.

In this blog we are talking about the IR sensor working principle and its applications.

What is an IR Sensor?

IR sensor is an electronic device, that emits the light in order to sense some object of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation. These types of radiations are invisible to our eyes, but infrared sensor can detect these radiations.

Fig: Ir Sensor

MQ2 GAS SENSOR WORKING AND ITS APPLICATIONS

Sensors are the electronic devices used for interaction with the outer environment. There are various types of sensors available that can detect light, noise, smoke, proximity etc… With the advent in technology, these are available as both analog and digital forms. Besides forming a communication with the outer environment, sensors are also a crucial part of safety systems. Fire sensors are used to detect the fire and take appropriate precautions on time. For smooth functioning of control systems and sensitive electronics, humidity sensors are used for maintaining humidity in the unit. One of such sensor used in safety systems to detect harmful gases is MQ2 Gas sensor.

What is an MQ2 Gas Sensor?

MQ2 gas sensor is an electronic sensor used for sensing the concentration of gases in the air such as LPG, propane, methane, hydrogen, alcohol, smoke and carbon monoxide.

MQ2 gas sensor is also known as chemiresistor. It contains a sensing material whose resistance changes when it comes in contact with the gas. This change in the value of resistance is used for the detection of gas.

MQ2 Gas Sensor

MQ2 is a metal oxide semiconductor type gas sensor. Concentrations of gas in the gas is measured using a voltage divider network present in the sensor. This sensor works on 5V DC voltage. It can detect gases in the concentration of range 200 to 10000ppm.

RFID READER

Active RFID and Passive RFID technologies, while often considered and evaluated together, are fundamentally distinct technologies with substantially different capabilities. In most cases, neither technology provides a complete solution for supply chain asset management applications. Rather, the most effective and complete supply chain solutions leverage the advantages of each technology and combine their use in complementary ways. This need for both technologies must be considered by RFID standards initiatives to effectively meet the requirements of the user community.

RFID Reader Module, are also called as interrogators. They convert radio waves

https://doi.org/10.36893/JNAO.2024.V15I12.044

Returned from the RFID tag into a form that can be passed on to Controllers, which can
Make use of it. RFID tags and readers have to be tuned to the same frequency in order to
Communicate. RFID systems use many different frequencies, but the most common and
Widely used & supported by our Reader is 125 KHz.

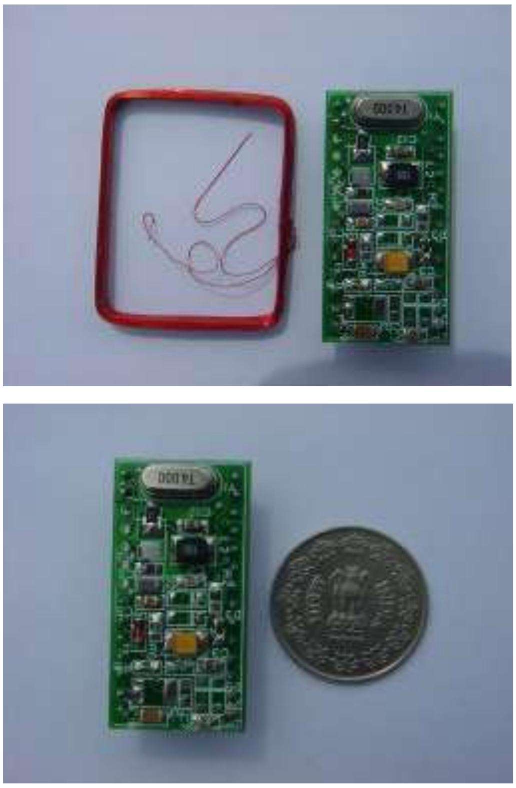

Fig: Rfid Reader

DESCRIPTION

The paper titled "Design and Implementation of Arduino-based Low-Cost Autonomous Car" presents an innovative approach to building a cost-effective autonomous vehicle using an Arduino microcontroller platform. The primary goal of this project is to develop an autonomous car that can navigate and perform basic driving functions, such as obstacle avoidance and line-following, all while maintaining a low cost. The authors aim to provide an affordable solution for education and experimentation in the field of robotics and autonomous systems. The car is equipped with several essential components, including motors for propulsion, ultrasonic sensors for detecting obstacles, infrared sensors for following lines on the road, and a microcontroller—Arduino—serving as the central control unit. The Arduino microcontroller is programmed to process input from the sensors, make decisions based on this data, and send commands to the motors to control the car's movements. The design incorporates a range of simple but effective sensors to ensure the car's autonomy. For example, the ultrasonic sensors are responsible for detecting objects in the car's path, enabling it to avoid collisions. Additionally, the infrared sensors help the car follow a pre-defined track or line, ensuring smooth and accurate navigation along the route. The Arduino's flexibility allows easy customization and integration of different sensors, making it an ideal choice for a low-cost, educational autonomous vehicle.The implementation of this autonomous car model also demonstrates the practical application of fundamental principles in robotics and control systems. The authors focus on simplicity and cost-effectiveness without compromising the essential features needed for autonomous navigation. The project is designed to be a hands-on learning tool, allowing students and hobbyists to better understand concepts like sensor integration, motor control, and decision-making algorithms. The low-cost nature of the project makes it accessible to a wide range of people, including those with limited resources or experience. Additionally, the open-source nature of the Arduino platform encourages further development and innovation, as users can experiment with various modifications to improve the car's performance. While the project is primarily designed for educational purposes, it also has the potential for real-world applications, particularly in research and development of autonomous systems at

https://doi.org/10.36893/JNAO.2024.V15I12.044

a smaller scale. The car's ability to autonomously navigate obstacles and follow predefined paths is a fundamental step toward the development of fully autonomous vehicles. The authors highlight the significance of using such an affordable, open-source platform to introduce more people to the concepts of robotics and autonomous driving technology, laying the groundwork for further innovations in the field. This project, with its emphasis on low-cost implementation and accessibility, represents a significant step toward democratizing autonomous vehicle technology and provides an excellent foundation for future advancements in autonomous robotics

CONCLUSION In conclusion, the development of self-driving or automated cars has gained immense popularity due to their potential to address a wide range of issues, including driver fatigue, navigating through heavy traffic, and ensuring greater safety on the road. With the advent of autonomous vehicle technology, many of the challenges traditionally associated with human-driven cars, such as accidents caused by distractions or errors in judgment, could be minimized or even eliminated. While major companies like Tesla have made significant strides in the development of automated vehicles, they still face several challenges, such as technical issues with autopilot features, high costs, and reliability concerns. This paper presents a practical, low-cost self-driving car model that can detect and avoid obstacles using ultrasonic sensors, follow lanes with infrared sensors, and respond to traffic signals with a TSOP sensor to make decisions about stopping or going. The design of this car aims to tackle the real-world issues of automated vehicle navigation in a simplified and cost-effective manner, demonstrating that the technology can be made accessible even at smaller scales. The hardware components discussed, such as ultrasonic sensors, DC motors, and infrared sensors, are readily available and inexpensive, making the system easier to assemble, maintain, and program, which is an important factor for further research and development in the field. Moreover, the software used to control the system is designed to work efficiently with the hardware, making it a functional prototype for the exploration of autonomous car technology. The paper emphasizes that, although the model presented here is a basic representation, it holds significant potential for future advancements in autonomous vehicles. By incorporating artificial intelligence and further refining the underlying technologies, the vision of a fully automated, safe, and reliable car that can operate without human intervention is becoming increasingly achievable. As the field of autonomous vehicles evolves, this model serves as a stepping stone toward creating affordable and practical self-driving cars that can eventually revolutionize the automotive industry and transform the way people approach transportation. In the future, with continuous advancements in sensors, computing power, and AI algorithms, fully autonomous vehicles that operate seamlessly in complex, real-world environments will become a reality, ensuring safer, more efficient, and user-friendly driving experiences for everyone.

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