Impact Factor (SJIF): 6.092 E-ISSN: 2583-1615

International Journal of Research in Academic World

Received: 13/April/2024 IJRAW: 2024; 3(5):51-57 Accepted: 18/May/2024

A Microcontroller-Based Automated Line following Car Equipped with IR Sensors

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Abstract

The line-following robot is a collection of components wherein the machine created is completely automatic, i.e., the machine automatically decides the path to be taken if one path is full. If a conflicting situation arises, then there is a priority set in directions, according to which the machine would run. Hinted by its name the imaginative working of a robotic car created by some basic components such as a battery pack, motor, and microcontroller is very simple, its objective is to follow a fixed path independently without any human intervention to reach a particular destination or to complete a task. The methodology used in the exploration is a project-based one wherein the line following robot schematics and workings will be researched, respectively. In addition, a schematic simulation will also be developed using the Proteus software simulation. The simulation will compute the basic understanding of how the schematic developed is working and responding to different parameters (in this research work the parameter of the line following the robot will be the path or line whose contrast will be picked up by the IR sensors) following that a proper conclusion along with extrapolations to the topic will be discussed.

Keywords: Line follower robot, Arduino micro-controller, Proteus simulation software, Keil, electrical components such as infrared sensors, motor, power pack, and wheels

1. Introduction

The research exploration into creating a schematic diagram for a line-following robot represents a significant advancement in robotics technology with widespread applications across various industries in the 21st century. This concept holds immense potential in domains ranging from surveillance to delivery, offering a cost-effective solution that can streamline operations and enhance efficiency. Central to this research is the utilization of an 8051 microcontroller, renowned for its robust Harvard architecture, as the core component of the line-following robot. Additionally, the integration of infrared (IR) sensors adds a crucial layer of functionality, enabling the robot to navigate along predefined paths with precision and accuracy.

The choice of the 8051 microcontroller stems from its well-established reputation for reliability and versatility in embedded systems. Its Harvard architecture, characterized by separate instruction and data memory spaces, lends itself perfectly to the demands of real-time control applications, such as guiding a line-following robot. This architecture ensures efficient execution of instructions, enabling the robot to respond promptly to environmental stimuli detected by the IR sensors. By harnessing the computational power of the 8051 microcontroller, the line-following robot can navigate complex paths autonomously, making it suitable for a wide range of practical applications.

Furthermore, the inclusion of IR sensors enhances the robot's ability to perceive and interact with its environment. These sensors function by emitting infrared light and measuring the intensity of reflected light to detect changes in surface contrast. In the context of a line-following robot, IR sensors serve as the primary means of tracking the path laid out before it. By analyzing the contrast between the path and its surroundings, the robot can make real-time adjustments to its trajectory, ensuring it stays on course. This reliance on IR sensors underscores the importance of accurate sensor calibration and robust signal processing algorithms to mitigate potential errors and deviations from the desired path.

The schematic diagram for the line-following robot represents a culmination of meticulous design considerations and engineering expertise. It encompasses the integration of the 8051 microcontrollers with IR sensors, along with supporting circuitry and components, to create a cohesive system capable of precise and reliable navigation. Key elements of the schematic diagram include the connections between the microcontroller and IR sensors, as well as the implementation

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of motor drivers and actuators for controlling the robot's movement. Additionally, provisions for power supply, signal conditioning, and data communication may also be incorporated to ensure optimal performance and functionality.

Therefore, the research exploration into developing a schematic diagram for a line-following robot powered by an 8051 microcontroller and equipped with IR sensors represents a significant stride towards advancing robotics technology. By leveraging the capabilities of these components, the line-following robot can navigate predefined paths autonomously, opening up new possibilities for applications across various industries. However, successful implementation hinges on meticulous design, rigorous testing, and continuous refinement to address challenges and optimize performance. Through interdisciplinary collaboration and innovation, the line-following robot holds promise as a versatile and indispensable tool in the modern era of automation and robotics.

2. Requirements

i). Motor Driver IC
ii). Geared Motors x 2
iii). IR Sensor Module x 2
iv). Connecting Wires
v). Power pack
vi). Virtual designer for Arduino
vii). Zuno line follower design.
viii). Zumo robot for Arduino
ix). Arduino 836 microcontroller

3. Literature Survey

The survey conducted on public perception of automatic vehicles offers a nuanced exploration of the attitudes, concerns, and expectations surrounding this revolutionary technology. With a sample size reflective of regions where automatic vehicles are already prevalent among the general populace, the findings provide invaluable insights into the complex interplay of factors shaping societal acceptance and readiness for the autonomous future of transportation.

At the forefront of the survey's findings is the revelation that a significant majority, approximately 62 percent, of respondents harbor positive sentiments toward automatic vehicles. This indicates a palpable enthusiasm and openness towards embracing this transformative mode of transportation. However, it is equally striking that nearly 38 percent of participants expressed reservations or negative reviews. This divergence in opinion underscores the varied perspectives and expectations that permeate discussions around the adoption of automatic vehicles.

One of the paramount concerns highlighted by the survey revolves around the safety of automatic vehicles. While 42 percent of respondents expressed confidence in the technology's ability to minimize accident risks, a considerable 58 percent remained skeptical or cautious. This underscores the imperative for continuous advancements in safety features and rigorous testing protocols to instill confidence among skeptics and mitigate concerns regarding the reliability of autonomous systems on the road.

Another critical aspect illuminated by the survey pertains to the effectiveness of emergency response systems in automatic vehicles. While a significant majority, accounting for 70 percent of respondents, expressed trust in these systems to promptly address emergencies, a notable 30 percent harbored reservations about their adequacy in critical situations. This underscores the importance of enhancing emergency response capabilities within autonomous vehicles to ensure swift and effective interventions in unforeseen circumstances, thereby bolstering overall safety on the roads.

Privacy emerges as a salient concern among survey participants, with 70 percent expressing apprehensions about potential privacy breaches stemming from the constant need for location tracking in automatic driving. This underscores the pressing need for robust data protection mechanisms and transparent policies governing the collection, storage, and usage of sensitive personal information within autonomous vehicle systems.

Furthermore, there exist notable reservations regarding the suitability of automatic technology for commercial vehicles, such as buses and trucks. Approximately 80 percent of respondents expressed concerns about the limitations of sensor systems in accurately detecting pedestrians and two-wheeler drivers, raising valid apprehensions about the safety implications of deploying autonomous technology in high-capacity vehicles that share the road with vulnerable road users.

Therefore, the survey findings offer a rich tapestry of insights into the multifaceted landscape of public opinion surrounding automatic vehicles. While there exists a palpable enthusiasm for the transformative potential of this technology, significant concerns persist regarding safety, privacy, and functionality. Addressing these concerns through continuous innovation, robust regulatory frameworks, and proactive engagement with stakeholders will be paramount in fostering widespread acceptance and successful integration of automatic vehicles into the fabric of modern transportation systems.

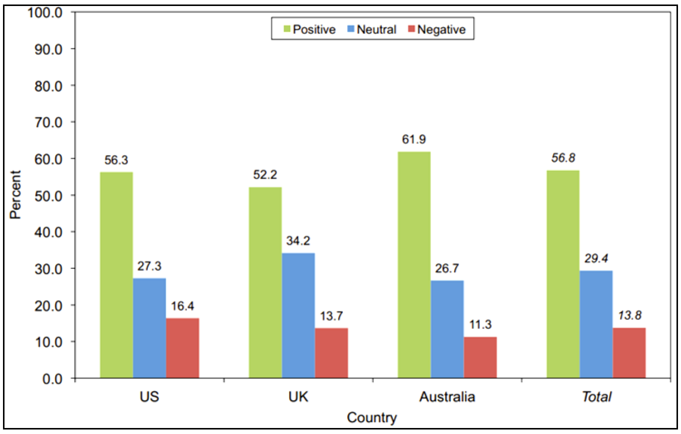


Fig 1: The general opinion of people of different countries regarding autonomous and self-driving vehicles.

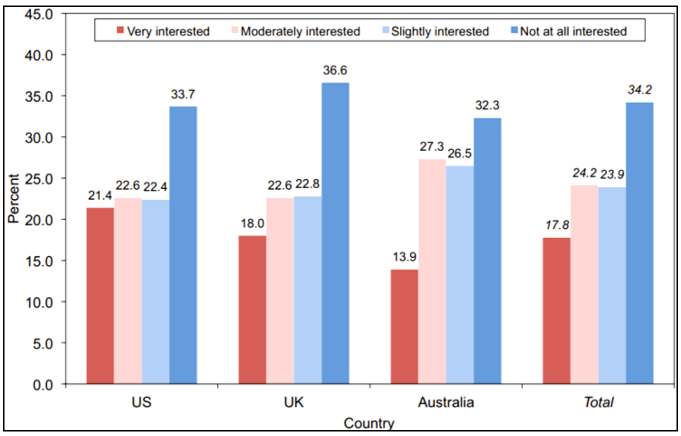


Fig 2: Overall interest in owning and willingness to pay for self-driving technology.

4. Research Gap Identified in Research Survey

Delving into the intricacies of integrating infrared (IR) sensors into vehicles for accident prevention in India unveils a multifaceted landscape where various factors intersect, necessitating meticulous research and analysis.

Fundamentally, the decision to incorporate IR sensors into vehicles stems from their unique capability to detect heat signatures emitted by objects, thus offering an additional layer of awareness to drivers. In India's bustling streets, characterized by a myriad of road users including pedestrians, cyclists, motorcyclists, and diverse vehicles, this technology holds immense potential to preemptively identify potential hazards that may not be immediately visible to drivers. The proactive nature of IR sensors aligns with the country's road safety needs, where swift reactions can mean the difference between a near miss and a catastrophic collision.

Yet, the successful implementation of IR sensor technology in Indian vehicles demands a granular understanding of its technical nuances and practical implications. Research must delve into optimizing sensor placement, configuration, and calibration to ensure optimal performance across diverse driving scenarios prevalent in India's urban, suburban, and rural landscapes. Moreover, given the variability in environmental conditions such as temperature, humidity, and ambient light, studies are needed to assess the robustness of IR sensors under different climatic conditions, including monsoons, fog, and smog.

Furthermore, addressing the human factors aspect of IR sensor integration is paramount. Research should explore driver perceptions, attitudes, and behavioral responses to IR sensor-based accident prevention systems, encompassing factors such as trust in technology, acceptance of alerts, and potential adaptation effects over time. Understanding how drivers interact with IR sensor technology in real-world driving situations, including their reliance on sensor alerts and the propensity for complacency, is crucial for designing effective human-machine interfaces and training programs that optimize user engagement and mitigate unintended consequences.

Additionally, the economic feasibility and scalability of IR sensor deployment in India merit comprehensive investigation. Cost-benefit analyses should assess the potential economic benefits stemming from accident prevention, including reductions in healthcare costs, property damage, and productivity losses. Simultaneously, studies are needed to evaluate the affordability and accessibility of IR sensor technology to different segments of the population, considering factors such as vehicle ownership patterns, income levels, and regional disparities.

Moreover, exploring the regulatory and policy dimensions of IR sensor integration is imperative. Research should examine the regulatory frameworks governing vehicle safety standards, data privacy, and liability implications associated with IR sensor deployment. Collaborative efforts involving policymakers, regulatory bodies, industry stakeholders, and research institutions can help establish clear guidelines and standards that promote the safe and responsible implementation of IR sensor technology in Indian vehicles.

In essence, unraveling the complexities of integrating IR sensors into vehicles for accident prevention in India demands a holistic approach that encompasses technical innovation, human-centered design, economic analysis, and regulatory alignment. By navigating these intricacies with rigor and foresight, stakeholders can unlock the transformative potential of IR sensor technology to enhance road safety and save lives on Indian roads.

5. Proposed Methodology

The following steps will be used to understand and implement a simulation:

Step one is to design the mechanical components of the robot which may include motors, chassis, IR sensors, etc.

The most important part is to complete the design of the schematic similar to Figure 3. A schematic design will be implemented in the Proteus simulation software that should be able to simulate the line following the car.

Following, during the simulation it is very important to define a few parameters in the software. First is the path that the line following the car would take and second, the code file that will contain all the necessary commands required to be uploaded to the microcontroller.

We first wrote code in the standard assembly-level program with the help of research and various sources. Following that, we ran the assembly-level program on Keil simulating software wherein it was confirmed that there were zero errors while building the project. Moving on, we converted our file into a hexadecimal file which was then uploaded to Proteus simulation software.

Adding on to that, the car path will now be decided along with the speed constraints that must be applied in the simulation.

Figure 3 below, represents the schematic of the project. The schematic portrays two IR sensors connected to the microcontroller along with a motor and a battery pack. However, the schematic diagram constructed using Arduino Nano microcontroller will be used. This is also the bound of this project that explores the applications of microcontrollers.

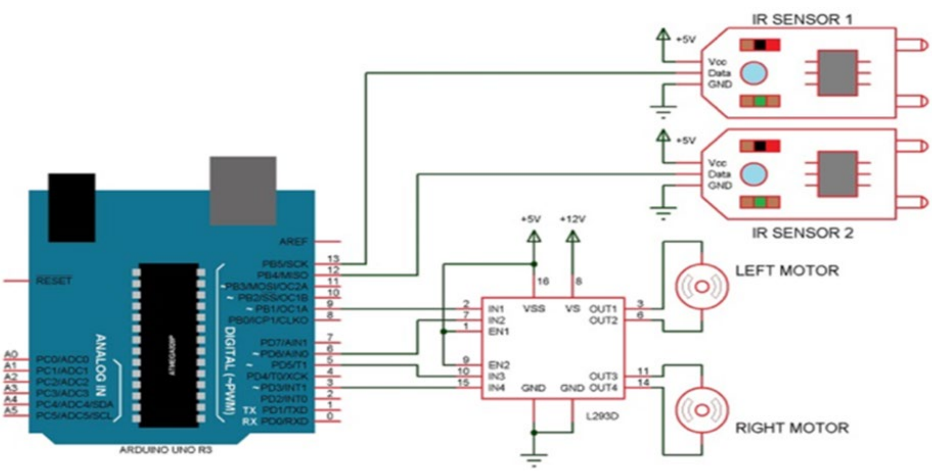
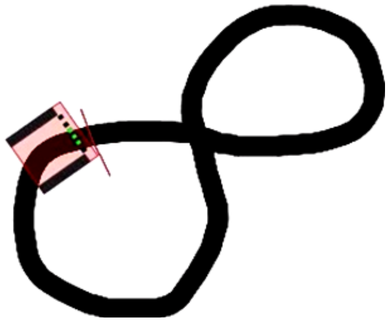


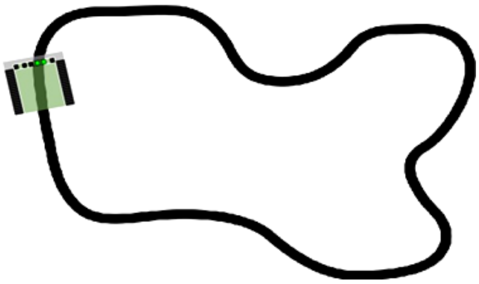
Fig 3: (Model circuit diagram)

The simple car path can be seen in Figure 4 below:

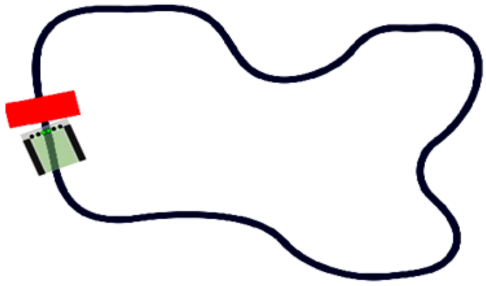
a: (Model simulated diagram)



b: (Model simulated diagram



c: (Model simulated diagram)



d: (Model simulated diagram)

Fig 4(a, b, c & d): The simple car path

The demonstration video link of the above simulation is https://youtu.be/Kt4xO8BmPwE

The figure represents a path that was designed to test the line following the car. An infinite symbolled loop was chosen to test the path, it was also made sure that the path had to be closed for the car to travel in a loop. After the loop the speed of the car was configured, the standard speed was between the bound of 200mm/s to 500mm/s, if exceeded the simulation would have had trouble declaring the starting point of the car's journey. This speed band was declared by a method of trial, error, and observation.

Figure 5 below shows the complete schematic that was followed using the Arduino design schematic along with added libraries from the Zuno schematic design.

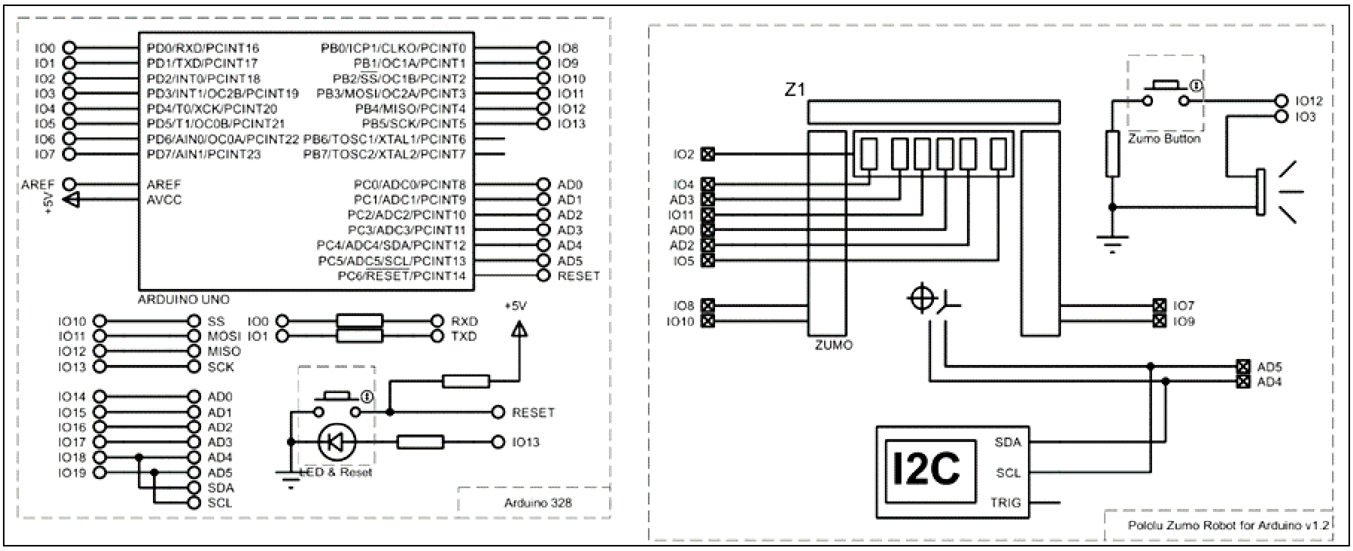


Fig 5: (Proposed circuit diagram)

6. Our Contribution

The integration of infrared (IR) sensors into automobiles for early accident detection and prevention represents a transformative leap forward in automotive safety technology, ushering in a new era of proactive collision avoidance capabilities. This innovative approach combines cutting-edge sensor technology, advanced data processing algorithms, and responsive vehicle systems to create a comprehensive safety net for drivers and pedestrians alike.

At the core of this system are the IR sensors themselves, strategically positioned around the vehicle to provide 360-degree coverage of the surrounding environment. These sensors operate by detecting the heat signatures emitted by objects within their field of view, allowing them to identify potential hazards such as pedestrians, cyclists, or debris on the roadway. By augmenting traditional optical sensors with IR technology, vehicles gain enhanced visibility in low-light conditions, adverse weather, and other scenarios where visual detection may be compromised.

However, the true power of IR sensor integration lies in its ability to translate raw sensor data into actionable insights through advanced data processing algorithms. Upon detecting a potential hazard, the system engages in real-time analysis to assess the risk level and determine the appropriate response.

This analysis considers various factors such as the object's size, speed, and trajectory, as well as contextual variables like road conditions and traffic flow. By continuously refining its understanding of the environment through machine learning algorithms, the system can distinguish between benign heat sources and genuine collision threats, minimizing false alarms and ensuring the accuracy of its warnings.

In addition to providing early warnings to drivers, IR sensor technology enables proactive collision avoidance measures to be implemented in real-time. By interfacing with the vehicle's on board computer systems, IR sensor data can trigger automatic braking, steering adjustments, or other evasive maneuvers to prevent accidents before they occur. This seamless integration of detection and response mechanisms empowers drivers with the information and assistance needed to navigate safely through dynamic traffic environments, ultimately reducing the risk of collisions and saving lives.

Furthermore, the data collected by IR sensors has broader implications for traffic management and urban planning initiatives. By analyzing aggregated sensor data from a fleet of vehicles, transportation authorities can gain valuable insights into traffic patterns, accident hotspots, and pedestrian behavior, allowing them to implement targeted interventions to improve overall road safety and efficiency.

In summary, the integration of IR sensors into automobiles represents a significant step forward in the ongoing quest to improve vehicle safety. By leveraging advanced sensor technology, data processing algorithms, and responsive vehicle systems, IR sensor technology offers a comprehensive solution to the complex challenges of accident detection and prevention, paving the way for safer and more efficient transportation systems in the future.

7. Result and Discussion

The research paper delves extensively into the intricate process of designing, constructing, and deploying a line-following robot, with a specific focus on integrating an 8051 microcontroller and infrared (IR) sensors. This investigation is propelled by the recognition of the immense potential of such robots to address real-life challenges across various industries in the 21st century. By meticulously examining each component, addressing challenges encountered during development, and envisioning potential applications, the paper offers comprehensive insights into the practical implications and transformative possibilities of deploying such robots in diverse contexts.

The selection of the 8051 microcontroller as the central processing unit of the line-following robot is driven by its well-documented reputation for reliability and versatility in embedded systems. A pivotal feature of the 8051 microcontroller is its Harvard architecture, characterized by separate instruction and data memory spaces. This architectural design ensures efficient execution of instructions, enabling the robot to rapidly process sensor data and execute precise maneuvers essential for navigating dynamic environments encountered in real-life situations. By harnessing the computational power of the 8051 microcontroller, the line-following robot can autonomously navigate complex paths, making it suitable for a wide range of practical applications.

Furthermore, the integration of IR sensors represents a critical advancement in enhancing the perception and navigation capabilities of the line-following robot. In real-life scenarios, IR sensors play a pivotal role in enabling the robot to detect subtle changes in surface contrast, such as lines on the ground. By analyzing the contrast between the path and its surroundings, the robot can autonomously follow predefined routes with precision and accuracy, even in environments where traditional navigation methods, such as GPS, may be unreliable or impractical. The sophisticated functionality of IR sensors underscores their potential to revolutionize robotic navigation in various industries, from logistics and manufacturing to surveillance and security.

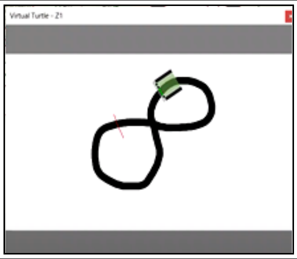
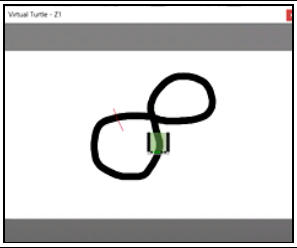
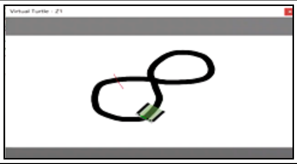
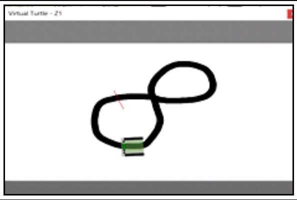
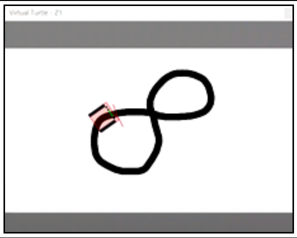
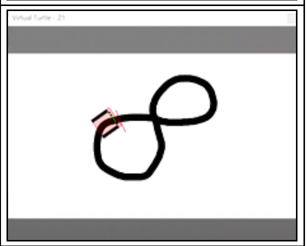
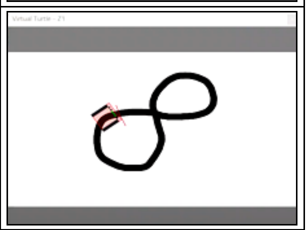
The schematic diagram outlined in the research paper serves as a detailed blueprint for constructing a functional line-following robot capable of autonomous navigation. It delineates the intricate connections and components necessary for the seamless integration of the 8051 microcontroller with IR sensors, motor drivers, and supporting circuitry. This comprehensive design approach ensures robustness and reliability in varied operating conditions, laying the foundation for successful deployment of such robots in real-life scenarios. The meticulous attention to detail in the schematic design is crucial for optimizing the performance and functionality of the line-following robot, thereby maximizing its potential in practical applications.

In terms of real-life applications, line-following robots equipped with IR sensors offer versatile solutions to address a myriad of challenges across diverse domains. In surveillance and security applications, these robots can patrol designated areas autonomously, monitoring for intruders or suspicious activities along predefined routes. The ability of line-following robots to navigate autonomously makes them invaluable assets in enhancing situational awareness and response capabilities in security operations. Additionally, in logistics and manufacturing, these robots can streamline material handling processes by autonomously navigating through warehouses or assembly lines, optimizing workflow efficiency and reducing operational costs.

Moreover, in environments where human presence poses risks, such as hazardous industrial sites or disaster zones, line-following robots can play a crucial role in reconnaissance and inspection tasks. By autonomously traversing through inaccessible or dangerous areas, these robots provide valuable data without endangering human lives, thereby enhancing safety and efficiency in critical operations. Furthermore, in the healthcare sector, line-following robots can assist in patient care by autonomously delivering medications or medical supplies within hospitals or assisted living facilities, thereby optimizing resource utilization and improving patient outcomes.

Therefore, the research paper provides a comprehensive exploration of the design, implementation, and potential applications of line-following robots equipped with IR sensors. By leveraging advanced technology and innovative design approaches, these robots offer scalable and cost-effective solutions to address real-life challenges across various industries. The meticulous attention to detail in the design process, coupled with a forward-thinking approach towards practical applications, underscores the transformative potential of line-following robots in shaping the future of automation and robotics in the 21st century.

Table 1: Compare the Distancer Travelled on a path with and without obstruction on a vehicle with IR sensor

Time (seconds)	Path without obstruction (meters)	Path with obstruction (meters)	Difference (meters)	Location (with obstruction)
0	0	0	0	
2	2	2	0	
4	4	4	0	
6	6	6	0	
8	8	6	2	
10	10	6	4	
12	12	6	6	

8. Conclusion

Creating a line follower robot using Proteus software is indeed a challenging and complex endeavor that demands meticulous planning and execution. The process encompasses several critical steps, starting from the selection of sensors, microcontroller, motor driver, and power supply, followed by circuit design, microcontroller programming, and rigorous testing and refinement.

Selecting appropriate sensors with high sensitivity, accuracy, and response time is crucial for the robot's performance. Similarly, choosing a microcontroller with adequate processing power and memory is essential to handle the tasks efficiently. Compatibility between the microcontroller, motor driver, and power supply ensures seamless integration and operation of the components.

Designing the circuit meticulously to ensure proper connectivity and functionality of all components is a pivotal aspect. Proteus software provides a robust platform for designing and simulating the circuit, facilitating thorough testing and validation before physical implementation.

Programming the microcontroller to interpret sensor input and control motor movement is a critical step in realizing the line follower robot's functionality. Careful attention to detail in coding ensures precise and reliable operation based on sensor feedback.

Assembling the robot requires precision and attention to detail, particularly in mounting sensors at optimal heights and distances and securely attaching motors and wheels to the chassis.

Testing the robot comprehensively across various surfaces and lighting conditions is essential to evaluate its performance and identify any areas for improvement. The refinement process involves fine-tuning sensor positions, motor speeds, and code parameters to optimize the robot's navigation accuracy and reliability.

Moreover, this project draws parallels with the integration of infrared (IR) sensors in cars for collision detection, underscoring the significance of sensor technology in enhancing safety across various applications. By leveraging IR sensors, vehicles can detect potential hazards and preemptively mitigate collision risks, akin to the line follower robot's ability to navigate obstacles based on sensor input.

Therefore, creating a line follower robot using Proteus software is a rewarding endeavor that offers valuable insights into robotics, control systems, and programming. By meticulously following the steps of component selection, circuit design, programming, assembly, and testing, a highly functional and efficient line follower robot can be developed, capable of navigating diverse environments with precision and reliability. This project not only enhances technical skills but also provides a practical application of theoretical knowledge in robotics and automation.

References

1. Line Follower Robot Using a Sophisticated Sensor Approach by Ebiesuwa O. O 1, Adekunle Y. A 2, Akinyemi L. A 3, Oyerinde O. D 41, 2, 4 Computer Science Department. Ojo, Lagos, Nigeria.
2. Z. Huda, I. M. Mehedi, M. N. Ismanto, and K.H. Almitani, Eds., Development of an Autonomous Robot with better Sensing and Accuracy by using an 8051 Microcontroller by. 2023.
3. “Advance Line Following Robot by Shivam Singh,” Prashant Kumar (*International Journal of Engineering and Advanced Research Technology (IJEART)*, 2017, 3.
4. A.V.K.J. Shyamsunthar, K. Raman, and S.J. Raju, Computer Vision Assisted Line Following Robot by Surya prakash.
5. “Design and Development of Smart Vehicle using Microcontroller by Naseem Rao,” International Journal of Advanced Research in Computer and Communication Engineering, 2019, 8(6).
6. E.D. Kumar, “Assistant Professor, Department of Information Technology,” *Dhanalakshmi Srinivasan College of Engineering and Technology Turkish Journal of Computer and Mathematics Education*, 2019, 10(3):1187-1194.
7. K.U.J. Badri Narayan Mohapatra, “Rashmita Kumari Mohapatra Naseem Rao Assistant Professor,” India *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, 2019, 8(9).
8. M. Islam, Cuet, M.R. Bangladesh, and B.S. Aiub, “Department of Mechanical Engineering, CUET, Development of an autonomous line tracking robot with mechanical gripper,” in Proceedings of the International Conference on Mechanical Engineering and Renewable Energy 2013 (ICMERE2013), Chittagong, Bangladesh, 2014, 1-3.
9. “Design And Implementation of IR Based Line Follower Robot for Cooperative Task Sharing,” *Journal of Science & Technology (e-JST) represented by School of Electronics*, 2015.
10. K.U.J. Badri Narayan Mohapatra, “Rashmita Kumari Mohapatra Naseem Rao,” *Journal of Innovative Technology and Exploring Engineering (IJITEE)*, no. 9, 2019.
11. Brandon Schoettle Michael Sivak: "A Survey of Public Opinion about Autonomous and Self-Driving Vehicles in the U.S., the U.K., and Australia.