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# Automated Guided Vehicle (AGV)

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**A B S T R A C T**

Automated Guided Vehicles (AGVs) have become integral components in modern industrial environments, streamlining material handling processes and enhancing operational efficiency. Among the various navigation methods employed by AGVs, line following stands out as a straightforward yet effective approach for guiding vehicles along predefined paths. In recent years, the integration of infrared (IR) sensors for line following has gained considerable traction due to its reliability, adaptability, and cost-effectiveness. This paper presents a comprehensive examination of AGVs equipped with IR sensors for line following, aiming to elucidate the underlying principles, implementation strategies, and performance implications. The study explores the fundamental concepts of IR sensor technology, emphasizing its capability to detect changes in reflectivity and accurately track lines under diverse environmental conditions. By leveraging IR sensors, AGVs can navigate complex layouts with precision, facilitating seamless material transport within industrial facilities. Moreover, the potential applications and future directions of IR sensor-based AGVs are discussed, highlighting opportunities for innovation and advancement in autonomous transportation systems. From warehouse logistics to automotive assembly lines, IR sensor-guided AGVs have the potential to revolutionize material handling operations across diverse industries, driving productivity gains and cost savings. In conclusion, this paper contributes to the autonomous navigation systems, offering valuable insights into the design, implementation, and optimization of IR sensor-based line following. By addressing key challenges and identifying areas for further research, it lays the groundwork for the continued evolution of AGV technology and its widespread adoption in industrial automation.

Keywords: Automated Guided Vehicles (AGVs), Line Following, IR sensors, Autonomous navigation system, Industrial

## 1. Introduction

Nowadays day Robotics is part of the advancement of technology. Autonomous Navigation has been developed in recent years such as Line-following, Laser navigation, Magnetic spot navigation system, human following, and obstacle-avoiding robots. The project is designed to build a cost-effective Automated Guided vehicle using infrared sensors for its movement. The behavior of a robot is dependent on the program running on the robot, the physical hardware of the robot, and the terrain. A robotic vehicle is built, using an Arduino Uno. It utilizes IR sensors and algorithms to perceive its environment, make decisions, and control its movement along the predefined path

Automated Guided Vehicles (AGVs) have emerged as a critical component in modern industrial and logistics operations, offering efficient and automated material handling solutions. The effectiveness of AGVs largely depends on the navigation systems employed, which enable them to navigate through dynamic environments while ensuring safety and precision. In the field of logistics, 80% is still manually operated. Problems of unfavorable demographic developments and the associated declining number of employees can be replaced by robotic workplaces in some logistics activities.

However, line following is just one among several navigation methods employed by AGVs. Other techniques include magnetic tape guidance, laser-based navigation, vision-based systems, and inertial navigation. Magnetic tape guidance systems utilize magnetic markers embedded in the floor to guide AGVs along predetermined paths. Laser-based navigation systems utilize lasers to scan the environment and identify obstacles or landmarks for navigation. Vision-based systems rely on cameras and image processing algorithms to interpret visual cues and navigate the surroundings. Inertial navigation systems utilize sensors to measure the vehicle's acceleration and orientation, enabling navigation without external references.

Each navigation method has its unique strengths and limitations, depending on factors such as cost, complexity, environmental conditions, and application requirements. While line following excels in simplicity and reliability, other techniques offer advantages in terms of accuracy, flexibility, or robustness in challenging environments.

### *1.1 Objective*

The main objective of an Automated Guided Vehicle is to autonomously navigate along a pre-defined path like trajectory or specific route, typically marked by the physical guide, such as a line on the ground or a magnetic strip.

### *1.2 Problem statement*

The problem is the need for an efficient and reliable automatic robot system that can navigate along a designated path, to improve transportation methods in logistics that are often suffering from inefficiencies, delays, safety risks, and high labour costs. This automatic robot system aims to optimize logistics processes, enhance productivity, reduce costs, ensure reliable goods or passenger transportation.

## 2. Literature Survey

1. Muhammad Aizat, Ahmad Azmin, and Wan Rahman conducted a comprehensive survey titled "Navigation Approaches for Automated Guided Vehicle Robots in Dynamic Environments." Their paper provides an in-depth exploration of the diverse navigation systems utilized in AGVs and underscores the potential enhancement in AGV performance through the integration of artificial intelligence technologies.
2. Robert J.G. and Fataneh Taghaboni introduced a model approach for optimizing flow paths for Automated Guided Vehicles (AGVs), incorporating virtual flow paths. Their method, based on linear integer programming, is applicable to both loaded and unloaded vehicle travel scenarios. However, it overlooks crucial factors such as vehicle interactions within the system, including issues like vehicle blocking and traffic congestion.
3. Suman Kumar Das and M.K. Pasan delved into the study of a model aimed at adhering to predefined path patterns on the ground, with the capability to dynamically adjust movements during loading and unloading operations.
4. Gaskins and Tanchoco put forward a model designed to minimize total travel distance for loaded vehicles, assuming a given facility layout and fixed pickup/delivery stations. While their mathematical programming approach offers valuable insights, it neglects considerations such as unloaded vehicle travel and congestion effects.
5. According to Sarmad Riazi, Kristofer Bengtsson, and Bengt Lennartson, the proposed method offers an efficient optimization solution for automated guided vehicle (AGV) systems, targeting performance criteria like make span, maximum lateness, and tardiness. It highlights the significance of factors like cruise velocities and traveled distances in energy consumption and demonstrates how optimizing productivity criteria can lead to energy savings. Experiments show a 38% reduction in energy consumption while maintaining superior performance compared to existing traffic controllers, validated with real data from a large-scale manufacturing plant.
6. Ankit M. Talekar, Anushri P. Bhoyar, Krunal A. Katkar, and Priya B. Zade presented “An Automated Guided Vehicle for a Small-Scale Industry”, This paper describes the primary goal of the AGV was to travel between stations. Observations proved in every part of the testing procedure the AGV was able to get the commands, follow the line, find the appropriate route, recognize the station, stop, and report its position. The secondary goal of this thesis was to increase flexibility.
7. Arbazkhan Pathan, Parthiv Akbari, Jigar Patel, and Anuj Dev introduced the concept of the "Automated Guided Vehicle" as an intelligent decision-making vehicle. This innovative system exhibits robust capabilities to efficiently lift and transport heavy loads while maintaining precise path adherence. Additionally, they underscored the significance of AS/RS (Automatic Storage/Retrieval System) for warehouse operations, highlighting its effectiveness in storing and retrieving goods. Notably, they emphasized the convenience brought about by recording the coordinates of goods upon placement in the warehouse, facilitating seamless retrieval by simplifying location identification.

## 3. Methodology

We studied various types of Navigation Systems for our AGV and the line-following navigation system was easy to implement and cost-effective compared to other navigation systems.

After studying all the navigation systems, we discussed which navigation system is suitable for our cost-effective AGV project. Advanced navigation systems are better but they are very complex and high cost which cannot offered by small businesses.

Our team explored several ideas aimed at improving the AGV navigation system. After careful consideration of factors such as cost, maintenance, and implementation complexity, we have selected the line-following technique as our preferred navigation system for our AGV. This decision was made because of its ease of implementation and comparatively low cost when compared to other options. The detailed working of this navigation system is elaborated below.

We have decided on the AGV design. If we design the AGV to move only in the forward direction, it will need an extra path to return to its destination, as illustrated in Fig. 3.1. Therefore, we have attached sensors to both the front and back of the AGV. By doing this, it will use a single path for its movement between the loading station and the unloading station, as shown in Fig.3.2.

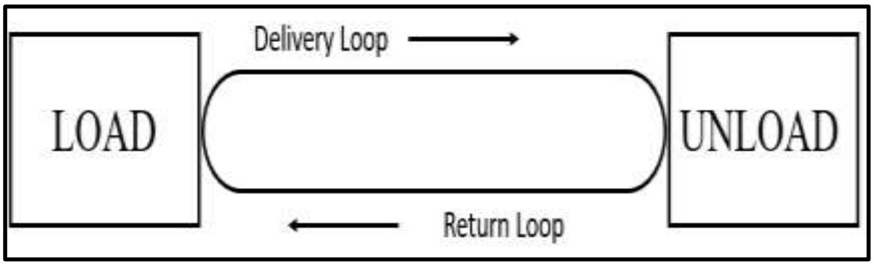


**Fig.3.1 Two different paths for traveling.**

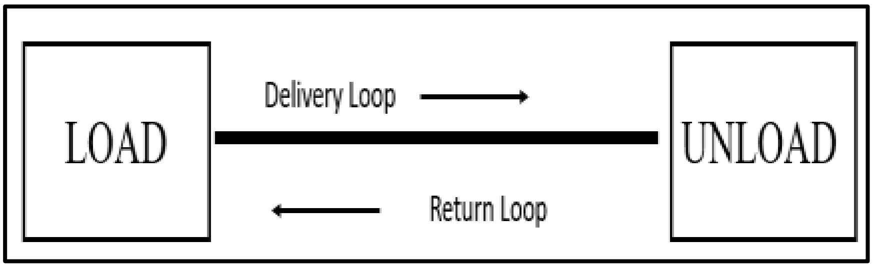


**Fig.3.2 Proposed Methodology**

We have developed the AGV (Automated Guided Vehicle) with programming that enables it to transport materials to specified unloading stations upon loading and pressing the designated button. In this project, a keypad has been incorporated, allowing for the selection of different stations, as illustrated in the provided block diagram. Figure C below illustrates the algorithm flow chart of the proposed system.

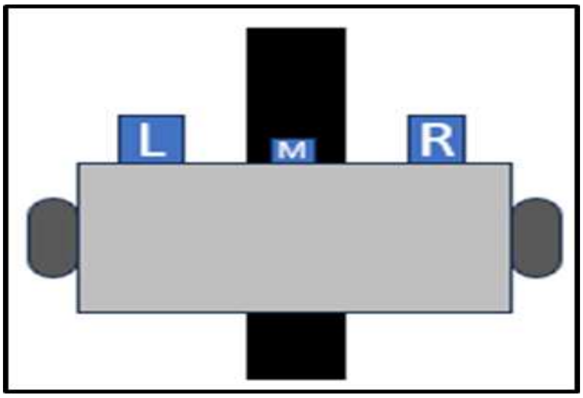


**Fig.3.3 Flowchart.**

The above flowchart provides a comprehensive overview of the functionality and the operational workflow of our AGV system. Let us understand how our AGV follows the predefined path i.e., line on the surface with the help of diagrams.

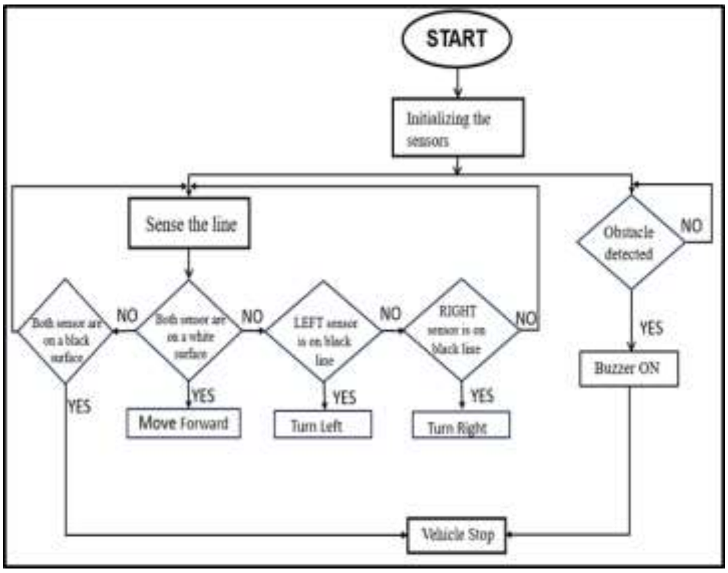


**Fig.3.4 Both sensors on a White surface.**

We've equipped our robot with two IR sensors on each side for line following and to detect the obstacle we used another IR sensor in the middle. When these sensors (L, R) detect the white surface, they send a signal to the Arduino, which then activates the motor driver. Consequently, the DC motors initiate forward movement.

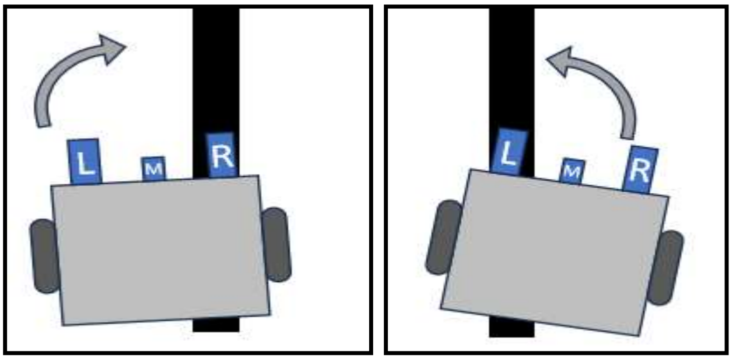


**Fig.3.5 Steer the robot right (Left Image), and steer the robot left (Right Image).**

In this case, only one sensor detects the black line and one sensor detects the white surface. When the sensor on the right side detects the presence of a black line, the robot adjusts its course to the right to stay aligned with the line. Similarly, if the sensor on the left side detects a black line, the robot steers to the left to maintain its path along the line.

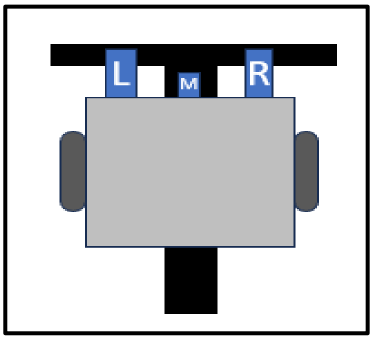


**Fig.3.6 Both sensors are on a black line.**

when each sensor detects a black line, it indicates that it is the destination or endpoint and the robot will stop. The middle sensor will detect the obstacles. When obstacles are detected, the sensor triggers the buzzer and also AGV stops. Another important thing to consider is that the distance between the two sensors which will detect the line on the ground. The stability of a motor is inversely proportional to the distance between the sensors.

$$Robot\ stability\ \ \alpha\ \ \frac{1}{Distance\ between\ the\ sensors} \qquad (1)$$

As the distance or gap between the two sensors increases, the robot or AGV experiences a higher tendency to veer off course. This is due to the abrupt left-right steering response triggered by a single sensor detecting a black line. Optimizing sensor placement and calibration is essential to mitigate this instability and ensure smoother navigation.

The following steps are done to build the operational AGV.

- **Hardware Setup:** Connect the Arduino Uno board to the necessary components, including the IR sensors and two DC motors. Ensure proper wiring and connections are established between the components and the Arduino Uno board.
- **IR Sensor Integration:** Configure the Arduino Uno to read inputs from the IR sensors. Use appropriate digital pins to connect the sensor outputs to the Arduino board. Implement suitable code to read the sensor values and determine if obstacles are detected in front of the robot car.
- **Motor Control:** Connect the DC motors to the Arduino Uno through appropriate motor driver modules or H-bridge circuits(L298N). Assign the required digital pins on the Arduino board to control the motor direction and speed. Develop code to control the motors based on the sensor inputs.
- **Obstacle Detection and Forward Movement:** Program the Arduino Uno to continuously monitor the sensor values. When an obstacle is detected by any of the IR sensors, the Arduino Uno should trigger the motors to move the robot car Forward Right, or Left. Adjust the motor speed and direction as needed to achieve the desired forward movement.

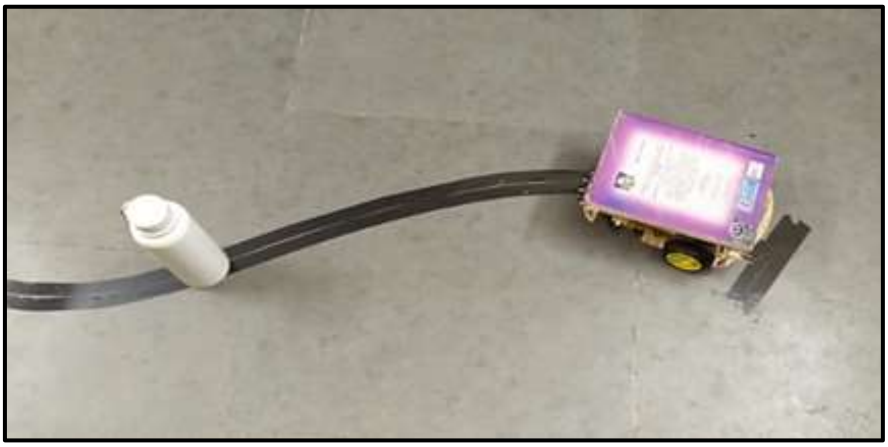

**Fig.3.7 Obstacle Detection.**

- **Fine-tuning and Calibration:** Test the robot car in different environments and adjust the sensor sensitivity thresholds and motor control parameters as necessary. Calibrate the system to ensure reliable obstacle detection and smooth forward movement.
- **Safety Measures:** Implement safety measures such as emergency stop functionality or collision avoidance algorithms to ensure the robot car's safe operation and prevent collisions with obstacles.
- **Testing and Refinement:** Thoroughly test the robot car in various scenarios and iterate on the methodology based on feedback and performance evaluation. Rewrite the code, circuit connections, and hardware setup as needed to enhance the AGV functionality and responsiveness. By following this proposed methodology, the robot will move in the predefined path. Here we used black colour tape to create a path.

The below block diagram shows how the arrangement of a components are done. In the block diagram you can see the master and slave connection between the Arduino controllers and also sensor and actuator connection also shown.

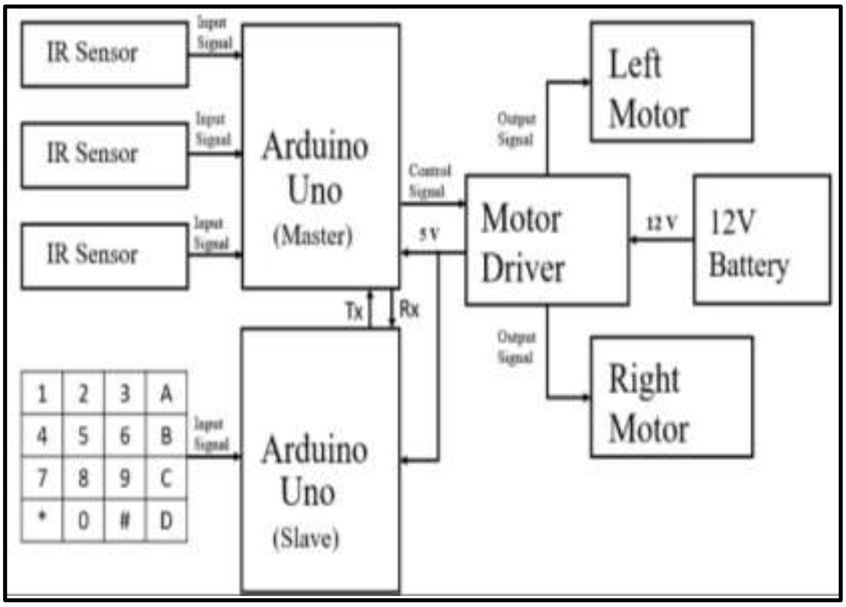


**Fig.3.8 Block diagram of the AGV.**

## 4. Summary

The Automated Guided Vehicles (AGV) project is set to transform material handling and logistics in industries by using self-driving vehicles. Equipped with advanced sensors and computers, these AGVs can move along specific paths accurately and efficiently. The project's success hinges on strong navigation algorithms, allowing AGVs to follow routes while adjusting to changes in the environment. Moreover, a smart communication setup enables smooth coordination between AGVs and existing Warehouse Management Systems (WMS), promising to streamline material flow and boost efficiency. Safety is a top priority in shared workspaces where AGVs operate. Features like obstacle detection, collision avoidance, and emergency stops are crucial for preventing accidents and injuries. Extensive testing is done to ensure the reliability and safety of the AGV system, both in simulations and real-world scenarios. This rigorous process not only improves performance but also builds trust in the system's ability to benefit industrial operations. The AGV project brings several advantages. Automation reduces labor costs, minimizes errors, and improves throughput. Additionally, the system's scalability and flexibility allow it to adapt to changing production needs and layouts, ensuring its usefulness in the long term. Ultimately, by embracing automation and robotics, the AGV project aims to enhance productivity, safety, and competitiveness in industrial settings.

## 5. Conclusion

In conclusion, the Automated Guided Vehicles (AGV) project represents a significant advancement in industrial automation, developed to transform material handling and logistics processes. Through the integration of autonomous vehicles equipped with cutting-edge technology, including advanced sensors, navigation algorithms, and communication systems, this robot system that travels in a pre-defined path represents a significant advancement in robotics and automation, offering opportunities to streamline operations, improve safety, and pave the way for a more efficient and intelligent future. With continued research, technological advancements, and industry collaboration, the system's capabilities will continue to expand, contributing to advancements in various sectors and shaping the future of robotics and automation.

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