IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 2, April 2026
Impact Factor: 8.2

Automated Guided Vehicle System

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Abstract: *Automated Guided Vehicle (AGV) systems are widely used in industries for material handling and logistics automation. These vehicles operate without human intervention and follow predefined paths using technologies such as sensors, cameras, and navigation algorithms. This review paper presents a comprehensive study of AGV systems, including their working principles, types, navigation techniques, advantages, limitations, and applications in modern industries. The paper also discusses recent advancements and future trends in AGV technology, highlighting its importance in Industry 4.0 and smart manufacturing environments*

Keywords: AGV, Automation, Material Handling, Sensors, Industry 4.0, Robotics.

I. INTRODUCTION

Automated guided vehicles (AGVs) are self-driven vehicles. Early types of AGVS were introduced around 1954. They are used to transport material from one location on the facility floor to another without any accompanying operator, and are widely used in material handling systems, flexible manufacturing systems, and container handling applications. With the advance of technology, more sophisticated machines. are available, which considerably reduce machining and internal setup time [1]. The aim of production planning includes along with fast production, efficient transportation of material between the workstations and in and out of storage. Flexible material handling systems are required to perform an efficient routing of material with random handling capability. The use of AGVs increases flexibility, since the flow path can easily be selected from number of alternative paths, or, can be reconfigured to accommodate new locations. The design of material handling guide path has a significant implication on the overall system performance and reliability, since it has a direct impact on the travel time, the installation cost, and the complexity of the control system software.

Automation has revolutionized the industrial sector by enhancing productivity, reducing operational costs, and improving safety. One of the most significant innovations in this field is the development of Automated Guided Vehicles (AGVs). AGVs are mobile robots designed to transport materials and goods within a facility without human intervention.

Traditionally, industries relied heavily on manual labor and conveyor systems for material handling. However, these methods were time-consuming, error-prone, and less flexible. The introduction of AGVs has addressed these challenges by providing a more efficient and adaptable solution.

AGVs are widely used in industries such as manufacturing, warehousing, healthcare, and logistics. With the rise of Industry 4.0, AGVs are becoming smarter and more autonomous, capable of making real-time decisions and interacting with other systems.

II. PROBLEM STATEMENT

In industrial environments, material handling is often performed manually or using semi-automated systems, which leads to inefficiencies, increased labor costs, and higher chances of human error. Traditional transportation methods are time-consuming and lack precision, especially in large warehouses and manufacturing units. Therefore, there is a need for an automated system that can transport materials efficiently, reduce human intervention, and improve overall productivity. The Automated Guided Vehicle (AGV) system is designed to address these challenges by providing accurate, safe, and reliable material handling.

III. LITERATURE REVIEW

1.Broadbent et al. (1985) first introduced the concept of conflict-free routing. The routing procedure described is based on Dijkstra's. shortest path algorithm. Potential conflicts. among the vehicles are detected by comparing path occupation times, and thereby avoided in advance.

2. Glover et al. (1985) developed a polynomial bounded shortest path algorithm, called the partitioning shortest path (PSP) algorithm, which finds the shortest distance from one node to another in a network,

3. Kim et al. (2002) presents a construction algorithm for designing a guide path of an AGV system. The total travel time is used as a decision criterion and the direction of the path segments on a unidirectional path layout is determined.

4. Huang et al. (1989) proposed a polynomial time labeling algorithm to find the shortest time path for routing a single vehicle in a bi-directional path network. This algorithm allows the path segments to be shared within their free time windows.

IV. ADVANTAGES

The Automated Guided Vehicle (AGV) system offers numerous advantages in industrial and commercial applications, making it an essential component of modern automation. One of the primary benefits of AGVs is the reduction in human labor. By automating material handling tasks, industries can minimize the need for manual work, thereby reducing labor costs and improving overall productivity.

Another major advantage is high accuracy and precision. AGVs follow predefined paths using sensors and programmed algorithms, ensuring consistent and error-free operation. This reduces the chances of product damage and enhances the reliability of transportation processes within warehouses and manufacturing units.

AGVs also significantly improve safety in the workplace. They are equipped with obstacle detection sensors such as ultrasonic or infrared sensors, which help avoid collisions and accidents. This reduces risks associated with manual handling and ensures a safer working environment for employees.

The system provides continuous operation, as AGVs can work for long hours without fatigue, unlike human workers. This leads to increased efficiency and faster completion of tasks. Additionally, AGVs can operate in hazardous environments where human presence may be risky, such as areas with high temperatures or toxic substances.

Another important benefit is flexibility and scalability. AGV systems can be easily reprogrammed or modified to adapt to changes in layout or operational requirements. Multiple AGVs can be integrated into a single system, allowing large-scale automation and coordinated operations.

Furthermore, AGVs contribute to cost-effectiveness in the long term. Although the initial setup cost may be high, the reduction in labor costs, improved efficiency, and decreased errors lead to significant savings over time.

Overall, the AGV system enhances productivity, safety, and operational efficiency, making it a valuable solution for industries moving towards automation and smart manufacturing.

V. FLOW CHART

The flowchart represents the working of an Automated Guided Vehicle (AGV) path tracking system designed to ensure accurate and efficient navigation along a predefined route. The process begins with system initialization, followed by defining the vehicle’s route, which consists of multiple reference points or waypoints. The system then obtains the current reference position using sensors such as GPS, RFID, or vision systems. It estimates time delays caused by processing, communication, or mechanical response to improve control accuracy. Based on this data, the system predicts the vehicle’s future position using mathematical models, which helps in minimizing tracking errors. Next, appropriate control actions like steering and speed adjustments are executed, allowing the vehicle to move along the path. A decision is then made to check whether the reference point has been reached; if not, the process loops back and

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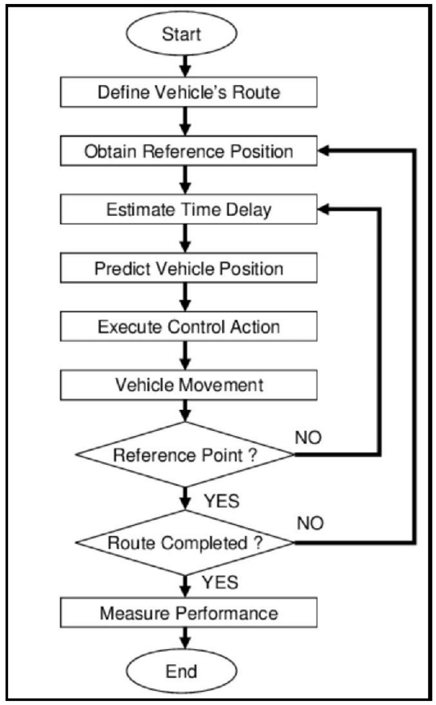
continues tracking. Once a reference point is achieved, the system checks if the entire route is completed. If the route is not finished, it proceeds to the next point. After successful completion, the system evaluates performance metrics such as accuracy, time efficiency, and error rate, and finally, the process ends**.**



VI. RESULT AND DISCUSSION

Man/vehicle functions

1. Inputs made via operator panel with its keyboards...
2. Destination input to the vehicle.

Data exchange:

1. Infrared.
2. Radio

Guidance Methods

1. Wire-Embedded in floor: A slot is cut in to the floor and a wire is placed approximately 1 inch below the surface. This slot is cut along the path the AGV is to follow. This wire is used to transmit a radio signal. A sensor is installed on the bottom of the AGV close to the ground. The sensor detects the relative position of the radio signal being transmitted from the wire. This information is used to regulate the steering circuit, making the AGV follow the wire.

2. Guide tape (magnetic or colored): AGVs use tape for the guide path. The AGV is fitted with the appropriate guide sensor to follow the path of the tape. One the major advantage of tape over wired guidance is that can be easily removed and relocated if the course needs to change. Colored tape is initially less expensive, but lacks the advantage of being embedded in high traffic areas where the tape may become damaged or dirty. The flexible magnetic bar can also be embedded in the floor like wire but works under the same provision as magnetic tape and so remains unpowered or passive. Another advantage of magnetic guide tape is the dual polarity.

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3. Inertial (Gyroscopic) navigation: Another method of AGV guidance is inertial navigation. With inertial guidance, a computer control system directs and assigns tasks of the vehicles. Transponders are embedded in the floor of the work place. The AGV uses these transponders to verify that the vehicle is on course. A gyroscope is able to detect the slightest change in the direction of the vehicle and corrects it in order to keep the AGV on its path. The margin of error for the inertial method is 1 inch. Inertial can operate in nearly any environment including tight aisles or extreme temperatures. Inertial navigation can include use of magnets embedded in the floor of the facility that the vehicle can read and follow.

4. Laser: Triangulation from reflective target: The navigation is done by mounting reflective tape on walls, poles or fixed machines. The AGV carries a laser transmitter and receiver on a rotating turret. The laser is transmitted and received by the same sensor. The angle and (sometimes) distance to any reflectors that in line of sight and in range are automatically calculated. This information is compared to the map of the reflector layout stored in the AGV's memory. This allows the navigation system to triangulate the current position of the AGV. The current position is compared to the path programmed in to the reflector layout map. The steering is adjusted accordingly to keep the AGV on track. It can then. navigate to a desired target using the constantly updating position.

Path Decision

AGVs have to make decisions on path selection. This is done through different methods: frequency select mode (wired navigation only), and path select mode (wireless navigation only) or via a magnetic tape on the floor not only to guide the AGV but also to issue steering commands and speed commands.

1. Frequency select mode: Frequency select mode bases its decision on the frequencies being emitted from the floor. When an AGV approaches a point on the wire which splits the AGV detects the two frequencies and through a table stored in its memory decides on the best path. The different frequencies are required only at the decision point for the AGV. The frequencies can change back to one set signal after this point. This method is not easily expandable and requires extra cutting meaning more money.

2. Path select mode: AGV using the path select mode chooses a path based on preprogrammed paths. It uses the measurements taken from the sensors to values given to them by programmers. When an AGV approaches a decision point it only has to decide whether to follow path 1, 2, 3, etc. This decision is rather simple since it already knows its path from its programming. This method can increase the cost of an AGV because it is required to have a team of programmers to program the AGV with the correct paths and change the paths when necessary. This method is easy to change and set up.

3. Magnetic tape mode: The magnetic tape is laid on the surface of the floor or buried in a 10mm channel; not only does it provide the path for the AGV to follow but also strips of the tape in different combinations of polarity, sequence, and distance laid alongside the track tell the AGV to change lane, speed up, slow down, and stop.

Charging Method

1. Standard Charging (Battery swap): Battery swap technology requires an operator to manually remove the discharged battery from the AGV and place a fully charged battery in its place after approximately 8-12 hours about one shift of AGVs operation 5-10 minutes is required to perform this with each AGV in the fleet.

2. In-Vehicle (Opportunity) Charging: Automatic and opportunity battery charging allows for continuous operation. On average an AGV charges for 12 minutes every hour for automatic charging and no manual intervention is required.

If opportunity is being utilized the AGV will receive a charge whenever the opportunity arises. When a battery pack gets to a predetermined level the AGV will finish the current job that it has been assigned before it goes to the charging station.

DOI: 10.48175/IJARSCT-32478

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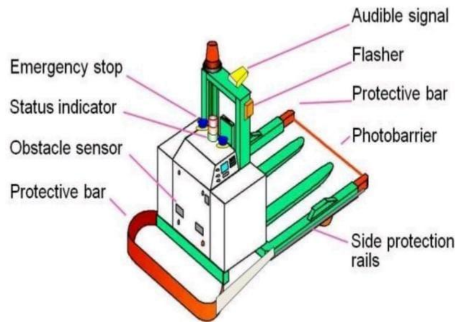
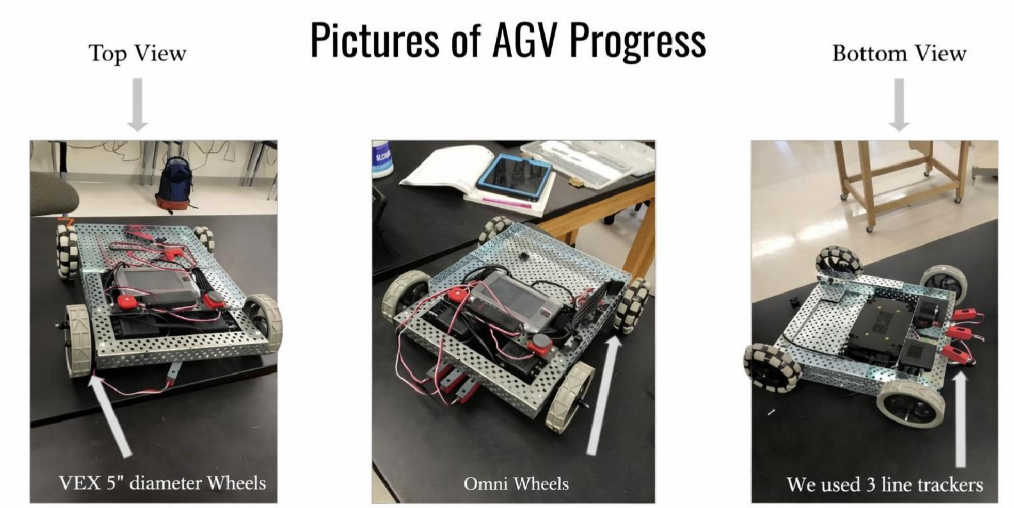


3. Automatic battery swap: Automatic battery swap is an alternative to manual battery swap. It requires an additional piece of automation machinery, an automatic battery changer. to the overall AGV system. AGVs will pull up to the battery swap station and have their batteries automatically replaced with fully charged batteries. The automatic battery changer then places the removed batteries into a charging slot for automatic recharging. The automatic battery changer keeps track of the batteries in the system and pulls them only when they are fully charged. While a battery swap system reduces the manpower required to swap batteries, recent developments in battery charging technology allow batteries to be charged more quickly and efficiently potentially eliminating the need to swap batteries.



The developed Automated Guided Vehicle (AGV) system was successfully designed and tested for material handling applications. The robot was able to follow a predefined path accurately using line tracking sensors.
The AGV demonstrated smooth movement with the help of omni wheels, allowing better directional control.
The use of three line trackers improved path detection accuracy compared to a single sensor system.
The system responded efficiently to path deviations and corrected its movement in real time.
The chassis design provided stability and supported all components effectively.
The overall system showed reliable performance in indoor environments such as laboratories or warehouses.

VII. FUTURE SCOPE

The Automated Guided Vehicle system offers significant potential for future enhancements and advancements. One of the major improvements can be the integration of Artificial Intelligence (AI) and Machine Learning (ML) algorithms to enable intelligent decision-making and adaptive navigation. This would allow the AGV to learn from its environment and optimize its path dynamically.

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Advanced sensors such as LiDAR, GPS, and camera-based vision systems can be incorporated to improve accuracy in navigation and obstacle detection. These technologies will help the AGV operate efficiently in complex and dynamic environments. The use of Internet of Things (IoT) can enable real-time monitoring and remote control of the AGV system, improving operational flexibility and management.

Additionally, multiple AGVs can be coordinated to work collaboratively in large-scale industrial setups, increasing productivity and efficiency. Improvements in battery technology and wireless charging can enhance operational time and reduce downtime. The system can also be expanded into applications such as hospitals, airports, and smart warehouses.

Thus, with continuous technological advancements, the AGV system can evolve into a fully autonomous and intelligent solution for modern industrial automation.

VIII. APPLICATION

Efficient, cost-effective movement of materials is an important and common element in improving operations in many manufacturing plants and warehouses, because automatic guided vehicles (AGVs) can deliver efficient, cost-effective movement of materials, AGVs can be applied to various industries in standard or customized designs to best suit an industry's requirements.

Industries Application:

1. Manufacturing.
2. Chemical.
3. Pharmaceutical.
4. Paper and print.
5. Food and beverage.
6. Hospital.
7. Warehousing.
8. Theme parks.

Common applications:

Automated Guided Vehicles used in a wide variety of applications to transport many different types of material including pallets, rolls, racks, Curts, and containers. AGVs excel in applications with the following characteristics:

1. Repetitive movement of materials over a distance.
2. Regular delivery of stable loads.
3. Medium throughput/volume.
4. When on-time delivery is critical and late deliveries are causing inefficiency.
5. Operations with at least two shifts.
6. Processes where tracking material is important.

Handling raw materials, Work-in-process movement, Pallet handling, Finished product handling, Trailer loading, Roll handling, Container handling.

IX. CONCLUSION

In conclusion, the Automated Guided Vehicle system presents an efficient and reliable solution for automated material transportation in industrial environments. The system successfully integrates hardware and software components to achieve autonomous navigation and obstacle detection. It reduces the dependency on manual labor, thereby minimizing human errors and improving productivity.

The project demonstrates how automation can enhance operational efficiency and safety in industries. The AGV is capable of performing repetitive tasks with high precision and consistency, making it a valuable asset in modern manufacturing and warehouse management systems. Additionally, the system is cost-effective and easy to implement, making it suitable for small and medium-scale industries.

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Overall, the AGV system achieves its intended objectives and proves to be a practical application of embedded systems and automation technology. It highlights the potential of intelligent systems in transforming traditional industrial processes into smart and efficient operations..

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