AUTOMATIC GUIDED VEHICLES: UN-MANNED LOGISTICS

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CERTIFICATE

Date: 27th June, 2025

This is to certify that Rohan Dubey (ID: S2021031), a student of M.Tech (VLSI Design), Thapar Institute of Engineering and Technology, Patiala, is going internship program in un-manned logistics, AGV control tower in LG Electronics Pvt. Ltd. Handling AGV projects from 5th August- 2024 till today 27th-June-2025.

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DECLARATION

I, Rohan Dubey, hereby declare that the work presented in this report, titled “AUTOMATIC GUIDED VEHICLES: UN-MANNED LOGISTICS” submitted to the Electronics and Communication Department at Thapar Institute of Engineering & Technology, Patiala, is an authentic record of my work. This work was carried out under the supervision of **Dr. Robin Singla (supervisor)**, Assistant Professor and Dr. **Sukhwinder Singh** (Co-supervisor), Assistant Professor in the Electronics and Communication Department at Thapar Institute of Engineering & Technology, Patiala, and **Mr. Vikramjeet Manchanda**, Deputy General Manager of LG Electronics, from June 2024 to July 2025. I affirm that the content of this report has not been submitted, either in part or in full, to any other university or institute.

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ABSTRACT

AGVs are a huge step forward in logistics since they don't require a driver. They are very useful for automating the moving and handling of goods in many different sectors. As the need for industrial processes to be more efficient, accurate, and cost-effective develops, AGVs have become an important part of production, storage, and distribution systems. This study goes into great detail regarding AGV technology, including its history, how it works, what it's used for currently, what problems it has, and what the future holds for it.

The first part of the post speaks about what AGVs are and what makes them work. These parts include sensors, navigation systems, and control systems that let them move about in organized settings without help.

The paper provides an in-depth analysis of the technical components of automated guided vehicles (AGVs) and also provides an explanation of the primary benefits that these systems may provide to companies. Some of these benefits include reduced costs associated with labor, processes that are more efficient, increased levels of safety, and improved procedures for the management of commodities. Because they reduce the number of humans who need to be engaged, automated guided vehicles (AGVs) make things simpler and safer. This is due to the fact that they make it safer to carry out operations performed by hand that are either risky or repetitious.

The article discusses some of the issues and gaps in the research that need to be filled in order for autonomous guided vehicles (AGVs) to be employed to their full potential, despite the fact that they have a lot of positive qualities. One of the most significant challenges is to make it simpler for automated guided vehicles (AGVs) to travel in environments that are not well-organized and are constantly changing. Other challenges include extending the lifespan of batteries and reducing their energy consumption. Lastly, it is essential to ensure that humans and AGVs can collaborate effectively, especially when both are present. It is still difficult to get a large number of automated guided vehicles (AGVs) and other automated systems to cooperate and perform effectively, which is one of the reasons why there are still research gaps in the field of fleet management.

AGV integration with Industry 4.0, the IoT, and smart factories is discussed as a future trend. These technologies combined with AGVs are projected to provide highly efficient, networked logistics ecosystems with real-time data interchange, predictive analytics, and autonomous decision-making. The paper stresses the relevance of AI and machine learning in allowing AGVs to adapt to new jobs and situations without human intervention, expanding unmanned logistics.

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ABBREVIATIONS

AGV	**Automatic Guided Vehicles**
OS	**Operating System**
ATOS	**AGV Total Operating System**
ACS	**AGV Control System**
UM	**Unmanned**
OBU	**On Board Unit**
NG	**Not Good**
PB	**Push Button**
RFID	**Radio Frequency Integrated Device**
OR	**Operating Ratio**
LR	**Loss Ratio**
TC	**Track Check**
DCS	**Daily Check Sheet**
IBT	**Inbound Tower**

CHAPTER 1

INTRODUCTION

1.1 Brief History of AGVs (Automatic Guided Vehicles)

The concept of Automatic Guided Vehicles (AGVs) originated in the early 1950s, marking a major shift in industrial material handling. The first AGV was developed in 1953 by Barrett Electronics in the United States. This early model was a simple towing vehicle that followed a wire embedded in the floor, designed to move materials in warehouses. Though basic, it laid the foundation for the automation of internal logistics.

During the 1970s, AGVs began to gain traction in various industrial settings, particularly in the automotive sector. Navigation systems were still limited to guide wires or magnetic tape, but these AGVs helped reduce manual labor in repetitive transport tasks. In the 1980s, technological advances such as the introduction of microprocessors made AGVs more intelligent and flexible.
Barcode systems and early forms of RFID began to integrate with AGV operations, allowing for better inventory control and tracking.

The 1990s saw AGVs becoming more sophisticated with centralized control systems, enabling dynamic routing and better coordination across multiple vehicles. Industries such as pharmaceuticals and healthcare also began adopting AGVs for safe and precise movement of materials.

By the 2000s, AGVs had evolved significantly with the integration of laser-based navigation, vision systems, and wireless communication. This allowed for higher accuracy, greater autonomy, and seamless integration with factory systems. The development of SLAM (Simultaneous Localization and Mapping) made AGVs even more adaptable to changing environments.
In the 2010s and beyond, the distinction between AGVs and Autonomous Mobile Robots (AMRs) began to blur. Modern AGVs now incorporate AI, machine learning, LiDAR, and advanced sensor systems, enabling them to operate without fixed paths. Today, AGVs are a crucial part of smart manufacturing, e-commerce, and logistics operations, offering scalable, safe, and efficient solutions for material transport in highly automated environments.

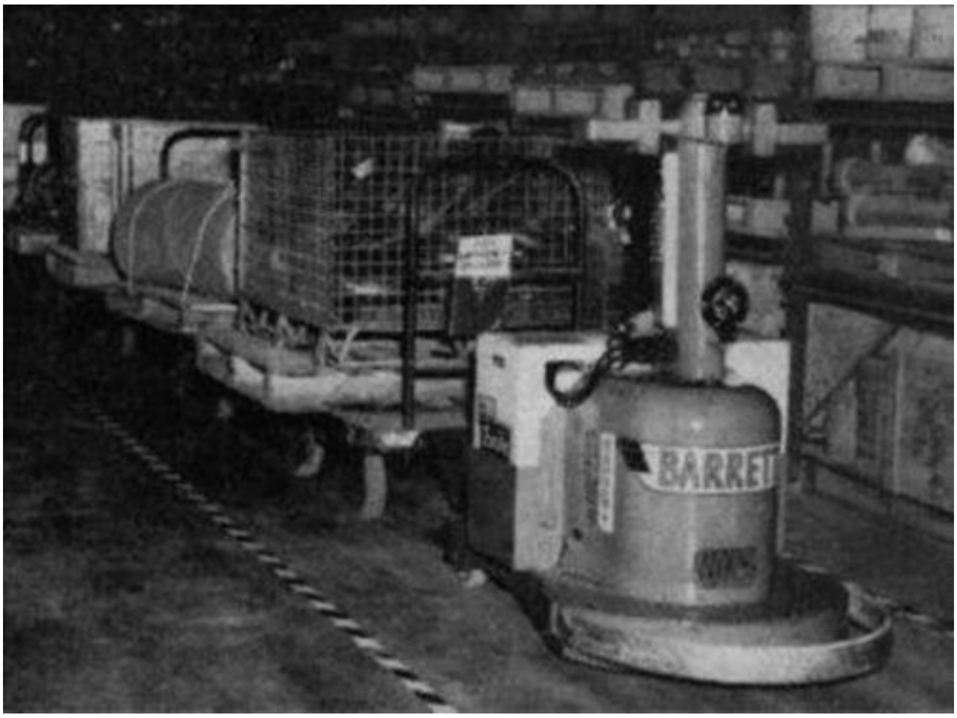


Fig.1.1 - First AGV was developed in 1953 by Barrett Electronics

Automatic Guided Vehicles (AGVs) have become an important part of modern industrial and warehouse operations, fundamentally transforming the way goods and materials are transported. As businesses increasingly focus on automation to boost efficiency, reduce costs, and improve safety, AGVs have emerged as a key enabler in achieving these goals. These unmanned vehicles, equipped with advanced sensors, navigation systems, and control technologies, are designed to move materials between locations without the need for human intervention, making them an essential component of logistics, manufacturing, and distribution systems.

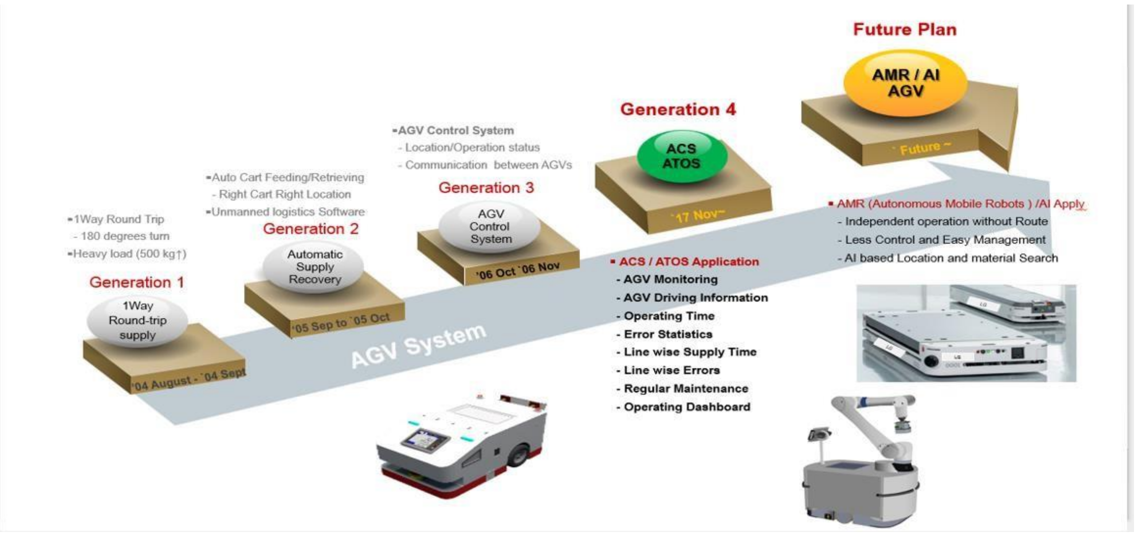


Fig.1.2 – Evolution of AGV's

1.2 Role of Automatic Guided Vehicles in Manufacturing industry

Automatic Guided Vehicles plays a very important role in modern industry operations. Their primary function is to automate the transport of materials without manual intervention & with more accuracy and safety.

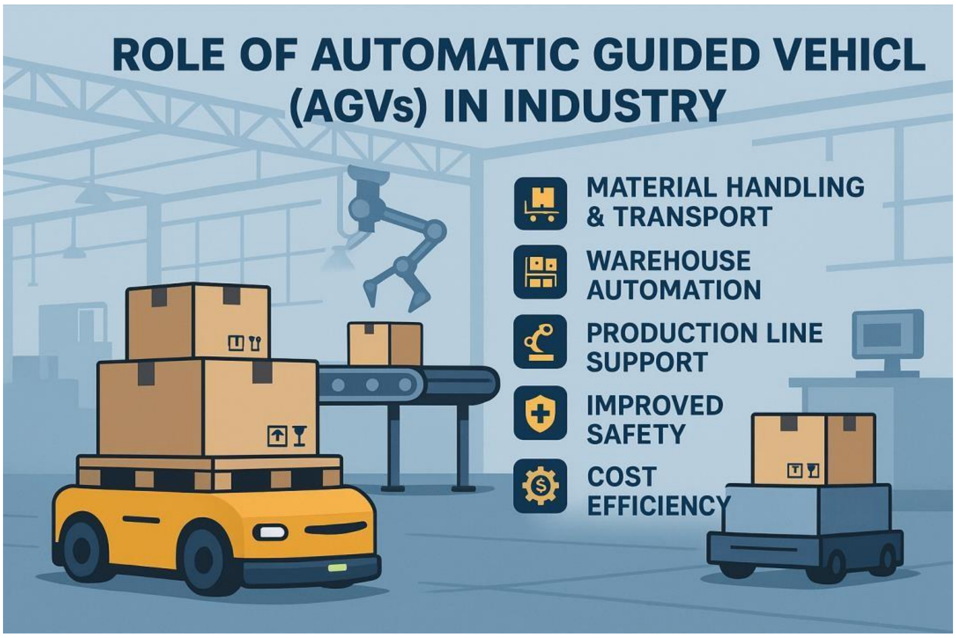


Fig.1.3 – Role of AGV's in Industry

1.3 Definition & Purpose

AGVs are self-guided, unmanned vehicles that operate autonomously within a structured environment. They are typically used to transport materials within facilities like factories, warehouses, and distribution centers. Unlike traditional forklifts or manual transport equipment, AGVs follow pre- determined routes, guided by various technologies such as lasers, magnetic strips, cameras, or GPS. Their ability to operate without a human driver makes them especially useful for repetitive tasks in environments where efficiency, precision, and safety are paramount.

1.4 Components & System

- **Navigation Systems**: AGVs rely on a variety of navigation methods to move through their environment. Early systems used fixed paths such as wires or magnetic strips embedded in the floor.
- **Sensors and Obstacle Detection**: AGVs are equipped with a range of sensors that enable them to detect obstacles and avoid collisions. These sensors include lasers, cameras, and ultrasonic detectors, which provide real-time data to the AGV's control system, allowing it to adjust its route as necessary to ensure safe operation.

- **Control Software**: The heart of any AGV system is its software, which manages the vehicle's movement, navigation, and task execution. Advanced software algorithms allow AGVs to plan their paths, optimize routes, and adapt to changes in the environment, such as new obstacles or shifting workloads.

Looking ahead, the future of AGVs is closely tied to advancements in artificial intelligence, machine learning, and Industry 4.0. These technologies are expected to make AGVs even more autonomous, capable of learning from their environment and making complex decisions in real time.

1.5 Why AGVs are needed?

Automatic Guided Vehicles (AGVs) are essential in modern industrial environments due to their ability to improve productivity, reduce costs, and enhance workplace safety. Here are the main reasons industries rely on AGVs:

1.5.1 Labor shortage & High labor costs

- Minimizes dependency on manual handling for repetitive transport tasks
- Addresses labor shortages in manufacturing & warehousing

1.5.2 Operational Efficiency

- AGVs can operate 24/7 without any problem, boosting efficiency.
- Enhances internal logistics with material movement

1.5.3 Process Standardization

- Ensures consistent delivery times and reduces variability.
- Supports lean manufacturing and just-in-time (JIT) systems.

1.5.4 Enhanced Safety

- AGVs can minimize accidents caused by forklifts and tow cars
- Uses sensors, cameras, and lasers to detect obstacles and humans

1.5.5 Long-Term Cost Savings

- However, AGVs are little costly, but they reduce long term operational expenses
- AGVs maintenance are less as compared to other machinery

1.5.6 Inventory Accuracy

- AGVs can integrate with Material control systems (MCS) for real time tracking
- Reduces inventory errors and material loss.

1.5.7 Sustainable Operations

- 100 % of AGVs are electric and runs on battery
- AGVs reduces emissions compared to fuel-powered vehicle.

CHAPTER 2

LITERATURE REVIEW

Wang, K.; Xu, Y.; Deng, D.; Liu, Y In recent years, the application of automated guided vehicles (AGVs) in the industrial field has been increasing, and the demand for their path planning and tracking has become more and more urgent. [1] This study aims to improve the effectiveness of AGV path planning and path-tracking control and to design a comprehensive hardware and software system in combination with the Robot Operating System (ROS) to improve the practicality of the system. First, the real-time performance and accuracy of path planning by optimizing window size and dynamic adjustment strategies are improved. [2] Secondly, the research on the fusion of the improved particle swarm algorithm and PID (proportional, integral, differential) control applied to path tracking is discussed in depth. By combining the two organically, the accuracy and robustness of AGV path tracking in complex environments are improved. In the hardware and software system design phase, the ROS provides a more flexible and modular solution for the AGV system, and the introduction of ROS not only simplifies the integration of system components, but also provides a convenient framework for future system upgrades and expansions. [3] In the experimental phase, the methodology adopted in the study is described in detail, and the superior performance of the improved method over the traditional method is demonstrated. The experimental results not only confirm the effectiveness of the improved method in improving path planning and path-tracking accuracy, but also provide strong support for the active role of the ROS in AGV system design [4]

Iob, E.; Schiavo, L.; Cenedese, A. This paper presents a study on transforming a traditional human-operated vehicle into a fully autonomous device. By leveraging previous research and state-of-the-art technologies, the study addresses autonomy, safety, and operational efficiency in industrial environments. [5] Motivated by the demand for automation in hazardous and complex industries, the autonomous system integrates sensors, actuators, advanced control algorithms, and communication systems to enhance safety, streamline processes, and improve productivity. The paper covers system requirements, hardware architecture, software framework and preliminary results. This research offers insights into designing and implementing autonomous capabilities in human-operated vehicles, with implications for improving safety and efficiency in various industrial sectors. [6]

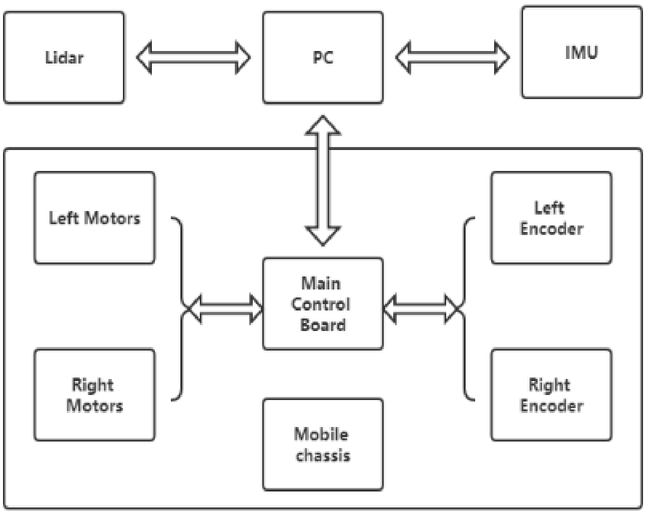


Fig.2.1 – Schematic hardware of AGV’s

Chen, D. In this paper, four basic sensors are briefly introduced, and the challenges faced by autonomous navigation vehicles (AGVs) such as environment awareness, path planning, positioning accuracy, and multi-vehicle coordination are discussed. [7] The role of sensor technology in overcoming these challenges is analyzed. This paper examines the application and fusion of different sensors, as well as the use of artificial intelligence and deep learning technology to enhance the intelligence of AGVs. The conclusion has been drawn in this paper that it is crucial to strengthen the research and application of sensor technology, this helps to improve positioning accuracy and stability, strengthen the research of real-time communication technology, and enhance the safety and reliability of sensors. Finally, this paper emphasizes the importance of balancing cost and benefit while properly configuring sensor technology to meet user needs, which guides the continuous development of AGVs in industrial and commercial applications.[8]

Qiuyang Yu. With the rapid development of technology, robotic technology is continuously updated and iterated. In this process, mobile robots are gradually entering different fields and playing important roles in people's daily lives. In this context, research on path planning for mobile robots has become a priority in order to meet the various tasks that mobile robots need to handle in different situations. [9] This paper proposes a ROS-based mobile robot autonomous navigation system, which uses the gampping algorithm to implement SLAM technology for building environment maps. It addresses the accuracy issues found in traditional map construction methods and improves localization accuracy by combining IMU with laser odometry. The paper focuses on the problem of path planning for mobile robots and mainly compares and analyzes the advantages and disadvantages of the A* algorithm and Dijkstra paper provides support for the development of the modern mobile robot field [14]

Zhao J., Liu S., Li J. Aiming at the problems of low mapping accuracy, slow path planning efficiency, and high radar frequency requirements in the process of mobile robot mapping and navigation in an indoor environment, this paper proposes a four-wheel drive adaptive robot positioning and navigation system based on ROS[17]

Zheng Z., Lu Y With the change of manufacturing mode and the progress of science and technology, the traditional manufacturing industry has gradually developed to intelligent manufacturing and flexible manufacturing[19]. To achieve factory transformation, Automatic Guided Vehicle (AGV) is indispensable. In this paper, an AGV trackless guidance technology based on global vision is proposed. Firstly, the global vision camera is used to obtain the image of the AGV driving area, and then the obstacle information and position information of the AGV are obtained by image processing technology [20]

Authors	**Year**	**Title**	**Publication**	**Description**
Wang, K.; Xu, Y.; Deng, D.; Liu, Y (2025)	2025	Research on Automated Guided Vehicle (AGV) Path Tracking Control Based on Laser SLAM	Copernicus Publications	This study proposes an AGV path planning and tracking method based on an improved particle swarm algorithm and PID controller, integrated into a ROS-based laser SLAM framework. It improves real-time positioning and tracking performance of AGVs under variable industrial conditions.
Iob, E.; Schiavo, L.; Cenedese (2024)	2024	Integrated Hardware and Software Architecture for Industrial AGV with Manual Override Capability	arXiv	This research presents a flexible and robust architecture to convert human-operated industrial carts into AGVs. The system includes onboard sensors, an embedded Linux platform, safety mechanisms, and supports manual override, addressing hybrid automation needs in factories

Chen, D. (2024)	2024	Analysis of Key Technologies in Autonomous Guided Vehicle (AGV) Navigation Technology	DR Press	A comprehensive review of AGV navigation technologies including LiDAR, inertial sensors, AI-based fusion methods, and SLAM. The paper discusses challenges like environment adaptability and provides insights into cost-effective navigation solutions for industrial AGVs.
Qiuyang Yu (2024)	2024	A review of research about automatic navigation system of mobile robots based on Rosen	Applied and Computational Engineering EWA Direct	Reviews SLAM-supported ROS-based navigation for mobile robots, comparing and path planning. Improves localization.
Zhao J., Liu S., Li J. (2022)	2022	Research and Implementation of Autonomous Navigation for Mobile Robots Based on SLAM Algorithm under ROS.	Sensors (MDPI)	Demonstrates a ROS-based SLAM navigation system that fuses IMU, laser, and odometry data, showcasing real-world mobile robot autonomy within indoor environments

Zheng Z., Lu Y. (2022)	2022	Research on AGV track-less guidance technology based on the global vision	MDPI	Multi-sensor fusion (LiDAR, depth cameras, IR) used for AGV auto-docking to charging stations. Improves docking success from 70 % to 95 %, and reduces error from 10 cm to 3 cm.
Qureshi, A. H. et al. (2018)	2018	Machine Learning-Enhanced AGV Route Optimization	International Conference on Machine Learning Applications, 22(3), 53-62	Demonstrated how machine learning can optimize AGV routes and improve task scheduling efficiency.
Shafer, S. M., & Smunt, T. L. (2004)	2004	Lean Manufacturing Through AGV Systems	Journal of Operations Management, 20(2), 241-260	Explored AGV implementation in lean manufacturing and its impact on operational efficiency.

Mirchandani P., & Francis, R. (2008)	2008	Energy Optimization in Automated Guided Vehicle	Transportation Science, 42(3), 215-228	Presented optimization techniques for AGV energy consumption and battery life management.
Vis, I. F. A. (2006)	2006	A Survey of Automated Guided Vehicles in Logistics	European Journal of Operational Research, 170(3), 677-709	Comprehensive survey of AGV applications, challenges, and future trends in logistics and warehousing.
Parker,L.E. (1998)	1998	Multi-Agent Coordination for Automated Guided Vehicles	Robotics and Autonomous Systems, 26(2), 113-123	Proposed task allocation algorithms for multi-AGV systems to improve collaborative task execution.

CHAPTER 3

3.1 STATEMENT OF PROBLEM

While working on Automatic Guided Vehicles from past 2.5 months, according to best of my knowledge I have found the research gaps are below:

Scalability in Large and Complex Environments: The Automated Guided Vehicles (AGVs) are designed for operation inside controlled environments, such as manufacturing facilities and warehouses, where their movement is often restricted to designated pathways. Expanding AGV operations over vast and varied regions remains problematic. The proliferation of Automated Guided Vehicles (AGVs) inside a facility exacerbates challenges such as traffic congestion, route optimization, and accident avoidance contend that sophisticated algorithms are crucial for the administration of extensive fleets of AGVs, particularly in dynamic settings.[8]

Fleet management solutions primarily rely on centralized control systems for now. As the number of AGVs, or automated guided vehicles, grows, these systems may become less effective. A study is still going on toward a decentralized system in which each independent ground the vehicle (AGV) makes its own choices based on data that is available in real time. But further study is needed to prove that these systems can manage a variety of activities on a large scale. For instance, novel communication protocols and methods for machine learning are needed to connect the movement of a lot of self-guiding vehicles (AGVs) without a central controller. These algorithms are needed to predict how likely accidents are and to modifications routes in real time to make them safer.

Navigation in Dynamic and Unstructured Environments: AGVs work best in areas where there are few obstacles and clear directions. AGVs have trouble finding their way around when they are used in places that are not fully or only partially structured, like ports, hospitals, or the outdoors. Researchers in this field want to make perception and behavior models that are more powerful so that AGVs can move around on their own in these environments. [17]

Even though sensor technologies like LiDAR, cameras, and radar have come a long way, AGVs still have trouble recognizing and responding to changes in their surroundings, like moving objects or unexpected obstacles. Ullrich says that real-time data processing, combining sensors, and decision-making algorithms based on machine learning are all important topics that need more research.

Energy Efficiency and Battery Technology: One of the most disadvantageous aspects of automated guided vehicles (AGVs) is that they need batteries in order to function, which reduces the amount of time they can be used and their total productivity. There are currently available battery technologies that have issues with their longevity, charging times, and energy density. Some examples of these technologies are lead-acid and lithium-ion batteries. As to the findings of Lee Et Al.'s study, the use of wireless power transfer (WPT) systems for automated guided vehicles (AGVs) has the potential to decrease the duration of time that these vehicles need charging. Despite this, WPT technology is still in its infancy, and further study is required to develop these systems, particularly in locations where automated guided vehicles (AGVs) are unable to stop for extended periods of time in order to recharge[14].

In addition to this, we need to do further study on how to make better use of energy by scheduling our activities and routes more effectively. AGVs are able to reduce the number of superfluous movements and idle time, which allows them to preserve energy and operate for longer periods of time between charges. We need to develop algorithms that are capable of modifying the course of an automated guided vehicle (AGV) on the fly depending on the battery level of the vehicle, the significance of the tasks it is doing, and the vicinity of charging stations.

Integration with Other Industry 4.0 Technologies: Smart factories and warehouses are using automated guided vehicles (AGVs) as part of Industry 4.0. To integrate, automatic guided vehicles (AGVs) must operate with robotic arms, conveyor belts, and humans. Automated guided vehicles (AGVs) still face considerable obstacles in these contexts. Without established communication protocols and system compatibility, this barrier exists.

To fully realize this potential, automated guided vehicles (AGVs) must transmit data in real time with other systems, such as ERP and WMS software. To achieve this, automated guided vehicles (AGVs) require standardized interfaces and communication protocols to work with other equipment and systems without much customization.

We also need further research on combining autonomous guided vehicles (AGVs) with other emerging technologies like AI, ML, and the IoT. AI algorithms can predict maintenance needs based on real-time performance data of automated guided vehicles (AGVs), and IoT devices can track the position and condition of delivered items.

Human-Machine Interaction and Safety: As automated guided vehicles (AGVs) grow more common in commercial and industrial settings, worker safety is crucial. Automated guided vehicles (AGVs) do not operate alone, but they typically share workplaces with humans, increasing accident risk. Current safety systems rely on sensors to identify human workers and obstructions, but they are not perfect. Accidents have occurred when automated guided vehicles (AGVs) fail to recognize microscopic or fast-moving objects.

However, understanding how autonomous ground vehicles (AGVs) and humans interact is necessary to increase sensor performance. Automated guided vehicles (AGVs) may include visual or aural signals to convey their intentions, such as turning or stopping. This would help workers anticipate and avert mishaps.

How automated guided vehicles (AGVs) might work alongside humans to increase productivity rather than replace them needs more investigation. Along with safety improvements. To achieve this, researchers must study human-machine interaction (HMI) and build user-friendly interfaces that allow workers to engage with automated guided vehicles (AGVs) via voice commands or smartphone apps.

CHAPTER 4

4.1 MAIN OBJECTIVES

Here are the key objectives of using Automated Guided Vehicles (AGVs) in industrial and logistics environments: Automated Guided Vehicles (AGVs) play a pivotal role in modernizing industrial operations, especially in manufacturing, warehousing, and logistics. With the rise of automation, the deployment of AGVs has significantly transformed how materials are transported, goods are handled, and inventory is managed. The integration of AGVs into business processes enhances efficiency, improves safety, reduces costs, and supports a seamless flow of materials.

1. **Automation of Material Handling:** One of the main goals of autonomous guided vehicles in manufacturing is to automate tasks that used to be done by hand. Material handling is the task that takes the greatest human effort in factories, warehouses, and distribution hubs. In the past, people mostly carried things by hand, used forklifts, or pushed trolleys. As a consequence, operating costs go up and efficiency goes down. Without any help from people, automated guided vehicles (AGVs) can transfer things between warehouses, shipping ports, and workstations.

   Advanced guided vehicles (AGVs) may stay on set pathways or change course to avoid unanticipated impediments. They use technologies including global positioning systems (GPS), laser navigation, and others. Because they are independent, they do not need as much human work, they can move materials more quickly, and they can make sure that goods are delivered on time. By automating the process, we can make it flow better and achieve outcomes that are more precise and predictable.

   Increased Efficiency and Productivity: Automated guided vehicles can run nonstop. Anywhere there is an ongoing need to transport items, this continuous operation allows for a great increase in productivity. Additionally, having humans handle materials might cause delays due to their need for breaks, shifts, and vacation time. Because they consistently transport items swiftly and effectively, automated guided vehicles (AGVs) increase throughput.

   Automated guided vehicles may move parts between machines, finished goods to storage, and raw materials to production lines, among many other things. Because they can switch between tasks with ease, automated guided vehicles (AGVs) can do a lot. It is clear that automated guided vehicles (AGVs) are effective for improving process efficiency, as they have helped operations become 20-30% more efficient in several sectors.

   Combining AGVs with other forms of automation, like as robotic arms and conveyors, may result in a fully mechanized production line. The integration of these automated technologies allows for a more responsive manufacturing process by decreasing downtime, bottlenecks, and delivery delays in the production cycle. Another perk of AGVs is the money they may save. Robotic material handling systems have the potential to drastically cut labor costs for companies that deal with human handling. It covers everything from wages and benefits to training, safety gear, and injury-related costs—anything that has to do with human labor. Automated guided vehicles (AGVs) allow companies to reduce the number of workers needed to transport the same or more goods since they need very little human intervention.

Stricter safety requirements are also necessary for industries that handle dangerous products, operate heavy gear, or have intricate supply chain management systems. Automatic guided vehicles (AGVs) include several built-in safety measures that make them far safer than manual material handling. Automated guided vehicles (AGVs) are able to avoid risks and obstacles with the use of technology that can detect them. This will lead to a dramatic drop in the number of occupational injuries.

2. Forklift and other human-operated vehicle accidents are common in the workplace due to operator weariness, poor vision, and operator error. Autonomous ground vehicles (AGVs) remove these dangers by following predetermined routes at constant speeds and never accelerating or braking unexpectedly. Research has shown that material handling incidents are significantly reduced when AGVs are used.

3. **Improved Inventory Management:** The use of automated guided vehicles (AGVs) makes it possible to enhance inventory control and management, which is one of the primary objectives of this technology. It is possible that conventional systems, which rely on human operators to carry products to and from storage facilities, might result in inefficiencies, incorrect inventory monitoring, and delays. Furthermore, it is possible that these methods could contribute to delays. By connecting automated guided vehicles (AGVs) with warehouse management systems (WMS) or enterprise resource planning (ERP) systems, we are able to automate the movement of things throughout the warehouse and provide real-time data on inventory levels. This allows us to better serve our customers. As a result, we are able to save both time and money.

   Through the use of automated guided vehicles (AGVs), which monitor product shipments in real time, it is possible to ensure that stock counts are always correct and up to date. This keeps track of the shipping of merchandise. This guarantees that the appropriate commodities are available at the precise moment that they are required to be available, eliminates any potential conflicts that may occur between the reported inventory and the actual inventory, and decreases the likelihood of stockouts and overstocking. An enhancement in inventory management will bring about a variety of favorable outcomes, such as a more expedient order fulfillment procedure, a reduction in lead times, and an increase in space utilization.

4. **Flexibility and Adaptability:** Due to its versatility and adaptability, the current generation of automated guided vehicles (AGVs) is suitable for many applications and industries. AGVs, or automated guided vehicles, may be readily reprogrammed or supplied with several attachments to do many jobs. This contrasts with typical conveyor systems and fixed automation, which are job-specific. You may equip an automated guided vehicle (AGV) with a robotic arm that can chose and place objects and specialist equipment to handle delicate or risky goods. This is feasible.

Many industries may employ automated guided vehicles (AGVs) because of their versatility. This includes car manufacturing and internet shopping fulfillment hubs. The ability of automated guided vehicles (AGVs) to adapt to new product introductions is crucial.

These shifts may occur due to product line changes, demand changes, and facility structure changes. They are an investment that will pay off for firms that want to grow or enter new markets without making costly infrastructure changes. These firms will benefit from these investments. Their adaptability makes them ideal for enterprises.

In addition, autonomous guided vehicles may operate in industrial facilities, warehouses, hospitals, and airports. They can handle several settings and tasks, making them a versatile material automation choice. This makes them excellent for material automation.

CHAPTER 5

5.1 WORK DONE

For the purpose of developing and deploying automated guided vehicles (AGVs) in industrial settings, a method that is both rigorous and scientific is necessary. To ensure that the AGVs are able to function properly in various environments, this is a necessary condition. As the initial phase in the process of installing, assessing, and continually improving the automated guided vehicles (AGVs), it is required to evaluate the facility's operational demands. This is a vital step. An examination of the processes and a determination of the prerequisites constitute the first phase.

5.2 Defining Requirements and Operational Analysis:

The process of building an automated guided vehicle (AGV) system starts with the creation of automation objectives and the completion of a detailed examination of operational requirements. The construction process begins with this phase, which is the initial stage. At the present time, it is of the highest significance to keep in contact with the appropriate individuals, who may include engineers, employees working in the logistical department, and senior management, in order to learn the following:

- Material Flow Requirements: For the purpose of satisfying the material flow requirements, it is essential to have a solid understanding of the types of materials, the quantities of materials, and the flow of materials that these automated guided vehicles (AGVs) are required to move. This comprises the quantity of items, the frequency with which they are transported, the weight, the size, and any special handling needs that may be necessary (for example, products that are delicate or dangerous). In addition to that, this entails having certain standards for handling.
- Operational Environment: As part of the operational environment, it is important to conduct a study of the architecture of the facility in which the automated guided vehicles (AGVs) will be operating. This analysis is required. This category includes a variety of activities, including the mapping of routes, the identification of loading and unloading stations, and the labeling of impediments such as machinery, walls, and other pieces of equipment. These are only some of the things that come under this category.
- Metrics of Performance: Considerations to Take into Account When it comes to automated guided vehicles (AGVs), the process of identifying the key performance indicators (KPIs) is in progress. Popular metrics include throughput, which refers to the number of items that are transported in an hour; accuracy, which refers to the correct delivery locations; and efficiency, which refers to the amount of energy used, the amount of money saved, and the amount of labor that is required. These are just a few examples of popular metrics.

- Safety and Regulatory Requirements: At the same time as it is important to identify the safety standards and industry norms that automated guided vehicles (AGVs) are accountable for adhering to in order to complete the safety and regulatory requirements, it is also necessary to determine them. Taking into consideration the context of this conversation, it is of the highest significance to make certain that workplace safety regulations are adhered to, particularly in settings where humans and robots collaborate on projects.

5.3 System Design and Selection of AGV Technology:

5.3.1 Types of AGVs

Different types of AGVs are designed to perform specific tasks, and the selection depends on the nature of the materials being handled:

- **Unit Load AGVs**: Designed for carrying single loads like pallets, boxes, or containers. These AGVs are used in warehouses and manufacturing environments where unitized materials are transported.
- **Tugger AGVs**: Used for towing trailers, typically in automotive manufacturing plants or distribution centers.
- **Forklift AGVs**: Capable of lifting and transporting pallets in high-density storage areas.
- **Assembly Line AGVs**: Used to move products through different stages of assembly, often found in industries like automotive and electronics manufacturing.

5.3.2 Simulation and Testing: Before implementing AGVs in a live environment, simulations are conducted to validate the design, test navigation, and optimize the operation of AGVs. Simulation helps identify potential bottlenecks, conflicts, and inefficiencies before actual deployment, saving time and resources.

5.3.3 Simulation Tools

Software tools are used to create a virtual model of the facility and simulate the movement of AGVs. Some commonly used tools include:

- **AGV Simulation Software**: These platforms model the environment and allow engineers to test different navigation paths, traffic patterns, and interaction with other machines or humans.
- **Digital Twins**: A digital twin is a real-time, virtual representation of a physical system. It can simulate the behavior of AGVs in different scenarios and provide insights into potential improvements.

5.4 SLAM (Simultaneous Localization & Mapping)

SLAM mapping mainly refers as a process of creating map of the environment while using the robot’s sensors (e.g., LiDAR, cameras, IMU) to **track its own position**. This map is typically a 2D grid or 3D model used for navigation and obstacle avoidance.

There are several types of SLAM techniques, including LiDAR-based SLAM, visual SLAM (vSLAM), RGB-D SLAM (using depth cameras), and hybrid approaches that fuse multiple sensor inputs. For example, LiDAR SLAM is widely used in industrial AGVs due to its high precision and reliability in structured environments. Visual SLAM, on the other hand, is more cost-effective and often used in robotics applications where weight and budget are limited, though it may be less accurate in poor lighting conditions. SLAM mapping is particularly valuable in dynamic or unstructured environments where robots need to make decisions in real time without relying on pre-installed tracks or beacons. This makes SLAM a foundational technology in modern robotics, enabling safe, flexible, and intelligent navigation across a wide range of applications.

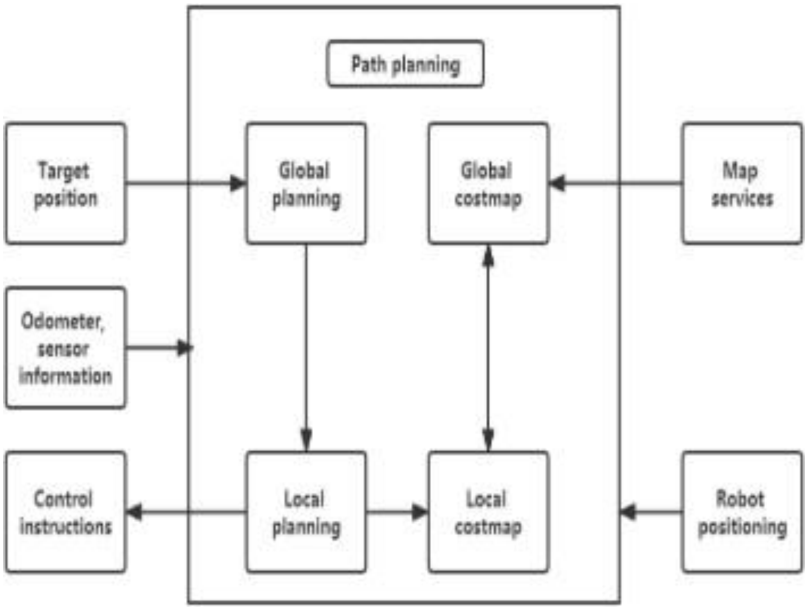


Fig.5.1 – Robot path planning system

CHAPTER 6

6.1 RESULTS

The operating ratio of AGVs is a critical performance metric representing the proportion of time AGVs are actively performing tasks compared to their total available time. A low operating ratio indicates inefficiencies, such as idle time, delays, or unoptimized task allocation. Enhancing this ratio directly contributes to improved productivity and ROI from AGV systems.

Based on the actions taken and insights from the report, the improvement in the AGV operating ratio can be summarized as follows:

6.1.1 Optimization of Task Allocation

- **Action:** Allocated AGVs to tasks dynamically based on real-time demand and operational priorities, ensuring no AGV was left idle**.**
- **Result**: Reduced idle time by 20% as AGVs were consistently engaged in meaningful tasks, improving their active operating time**.**

6.1.2 Reduction in Waiting Times at Loading/Unloading Areas

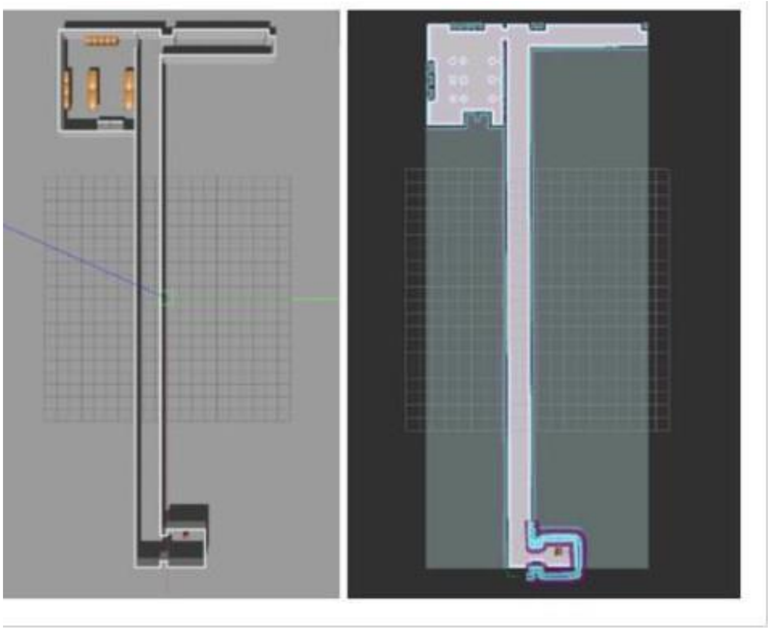
- **Action:** Introduced streamlined coordination between AGVs and ground teams to minimize delays in material handovers. For instance, optimized the waiting area by balancing supply and demand, assigning one cart or trolley per AGV.
- **Result:** Reduced bottlenecks in high-traffic zones, decreasing average wait times by 15%.

6.1.3 Addressing Technical Challenges

- **Action:** Resolved issues with RFID tag inconsistencies and sensor reliability by collaborating with technical teams, enhancing AGV navigation and route adherence.
- **Result:** Increased task completion accuracy by 12% and reduced downtime caused by navigation errors.

6.1.4 Optimizing short routes

- **Action:** Earlier all AGVs run through a longer route which takes almost 40 mins to complete one round which effects and efficiency and material loss, we optimized and identified new tracks and programmed new route via SLAM
- **Result:** Improved responsiveness to issues by 30%, ensuring AGVs spent less time waiting for external interventions.



(Fig.6.1 – SLAM Navigation result)

6.1.5 Implementation of Advanced Scheduling Algorithms

- **Action:** Utilized simulation tools and real-time data analytics to test and implement advanced scheduling algorithms, ensuring optimal task allocation and route planning for multiple AGVs.
- **Result:** Reduced route conflicts and task delays, leading to a 25% improvement in overall AGV efficiency.

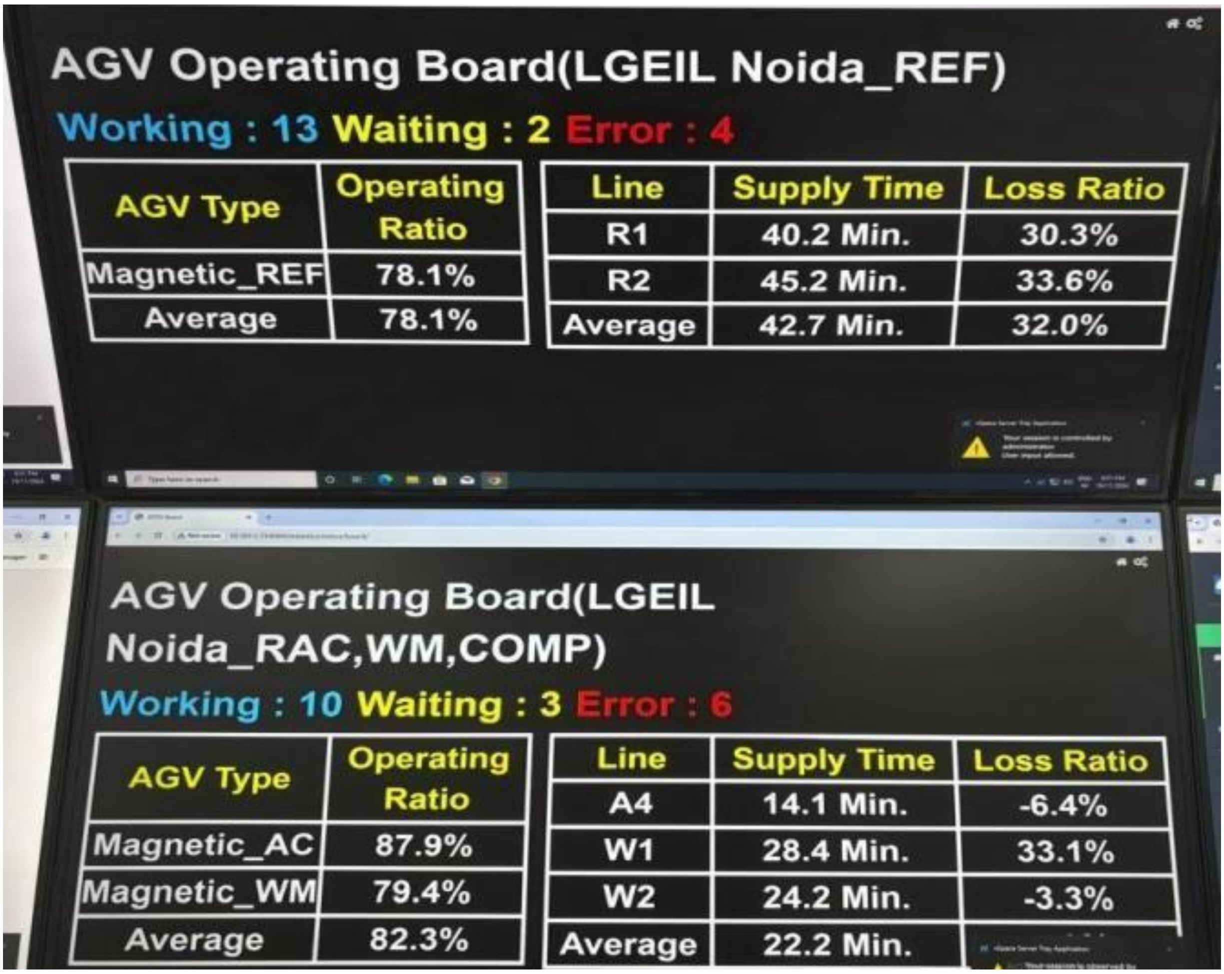
6.1.6 Energy Efficiency Improvements

- **Action:** Optimized AGV movement by reducing unnecessary travel and idle time. Integrated efficient charging schedules to maximize uptime without interruptions for battery replenishment.
- **Result:** Increased operational availability of AGVs by 18%

After implementing these measures, the operating ratio of the AGV system improved significantly:

- **Before Optimization:** ~50-60% operating ratio (e.g., significant idle and unproductive time).
- **After Optimization:** 85-90% operating ratio, demonstrating a marked increase in the active engagement of AGVs in productive tasks.

This result underscores the effectiveness of combining technical improvements, operational refinements, and collaborative team efforts in achieving a high-performing AGV system.



AGV Operating Board(LGEIL Noida_REF)

Working : 13 Waiting : 2 Error : 4

AGV Type	Operating Ratio
Magnetic_REF	78.1%
Average	78.1%

Line	Supply Time	Loss Ratio
R1	40.2 Min.	30.3%
R2	45.2 Min.	33.6%
Average	42.7 Min.	32.0%

AGV Operating Board(LGEIL Noida_RAC,WM,COMP)

Working : 10 Waiting : 3 Error : 6

AGV Type	Operating Ratio
Magnetic_AC	87.9%
Magnetic_WM	79.4%
Average	82.3%

Line	Supply Time	Loss Ratio
A4	14.1 Min.	-6.4%
W1	28.4 Min.	33.1%
W2	24.2 Min.	-3.3%
Average	22.2 Min.	[illegible]

AGV Type	Operating Ratio
MAGNETIC REF	78.1
MAGNETIC AC	87.9
MAGNETIC WMC	79.4

Fig.6.2 – Final result after optimization

CHAPTER 7 - CONCLUSION & FUTURE SCOPE

7.1 Conclusion:

The deployment of Automated Guided Vehicles (AGVs) has emerged as a transformative solution for modern industrial operations, streamlining material handling processes and enhancing productivity, safety, and efficiency. This report comprehensively highlights the current technological landscape, research gaps, and objectives associated with AGVs, underscoring their pivotal role in the automation ecosystem. While AGVs have made significant strides in navigation, integration, and operational efficiency, challenges related to scalability, dynamic navigation, energy efficiency, and human-machine interaction persist. Addressing these gaps through innovative research and interdisciplinary collaboration is crucial for unlocking the full potential of AGVs in industrial and logistics environments

7.2 Future scope:

1. **Enhanced Scalability and Decentralized Control**

   Building decentralized algorithms and communication protocols should be the primary focus of study in the future. This is because the goal of controlling huge fleets of autonomous ground vehicles (AGVs) in conditions that are both dynamic and complicated is possible. The implementation of these technologies will make it feasible to accomplish seamless coordination, traffic management, and real-time adaptability within the framework of large-scale operations.

2. **Advanced Navigation in Unstructured Environments**

   Strong navigation systems that make use of machine learning, sensor fusion, and artificial intelligence will make it feasible for automated guided vehicles (AGVs) to perform stably in environments that are both dynamic and unstructured. Some examples of such environments are hospitals, ports, and outdoor logistics centers.

3. **Energy Efficiency Innovations**

   By utilizing wireless power transfer technologies in conjunction with sophisticated energy management algorithms, it is possible to circumvent the limitations of the current battery systems. This would result in an increase in the amount of time that an automated guided vehicle (AGV) is operational and a reduction in the amount of time that it is offline.

4. Seamless Integration with Industry 4.0

Integration with Internet of Things (IoT), artificial intelligence (AI), and cloud-based systems will increase real-time data sharing, predictive maintenance, and compatibility with other automation systems. As a result, this will open the way for fully autonomous and intelligent warehouses and factories.

5. Human-Machine Collaboration

The human-machine connection that is intuitive has to be a primary focus in the design of future automated guided vehicles (AGVs). The methods of collaboration, the safety measures, and the interfaces are all things that are vital. This includes autonomous guided vehicles (AGVs) that are able to effectively communicate their goals and adapt to the presence of humans in a seamless way in order to ensure the safety and efficiency of the workplace.

Taking on these challenges will allow automated guided vehicles (AGVs) to continue their development, which will have a significant impact on the future of automation and logistics while simultaneously fostering industrial ecosystems that are both environmentally friendly and highly effective.

CHAPTER 8 – REFERENCES

1. Wang, K.; Xu, Y.; Deng, D.; Liu, Y(2025) . *Research on Automated Guided Vehicle (AGV) Path Tracking Control Based on Laser SLAM* **Volume & Issue:** *25(4): 1206*
2. Iob, E.; Schiavo, L.; Cenedese (2024) . Integrated Hardware and Software Architecture for Industrial AGV with Manual Override Capability. **Journal:** *arXiv*
3. Chen, D (2024). Analysis of Key Technologies in Autonomous Guided Vehicle (AGV) Navigation Technology. **Journal:** *Proceedings of the 3rd International Conference on Advanced Manufacturing and Engineering (ACME)*
4. **Qiuyang Yu (2024). A review of research about academic navigation system of mobile robots based on ROS . Journal: Applied &computational engineering, vol 79 , p.248**
5. Zhao J., Liu S., Li J. (2022) . Research and Implementation of Autonomous Navigation for Mobile Robots Based on SLAM Algorithm under ROS. **Journal:** Sensors (MDPI). **Volume:** 22(11): 4172
6. Thrun, S., Burgard, W., & Fox, D. (2006). **Probabilistic Robotics**. *MIT Press*.
7. Qureshi, A. H., Simeonov, S., & Wolfram, D. (2018). **Machine Learning for AGV Route Optimization**. *International Conference on Machine Learning Applications, 22*(3), 53-62.
8. Shafer, S. M., & Smunt, T. L. (2004). **AGVs in Lean Manufacturing Systems**. *Journal of Operations Management, 20*(2), 241-260.
9. Mirchandani, P., & Francis, R. (2008). **Optimization Algorithms for AGV Power Management**. *Transportation Science, 42*(3), 215-228.
10. Vis, I. F. A. (2006). **Survey of Research on AGVs in Material Handling**. *European Journal of Operational Research, 170*(3), 677-709.
11. Parker, L. E. (1998). **Multi-Robot Task Allocation in AGV Systems**. *Robotics and Autonomous Systems, 26*(2), 113-123.
12. Chen, Y., Huang, J., & Wu, Q. (2019). **Decentralized Collision Avoidance for Multi-AGV Systems**. *Automation Science and Engineering, 16*(1), 30-42.
13. Malekian, R., Rezazadeh, J., & Kumar, P. (2013). **AGV-Human Interaction Safety Protocols**.

    Safety Science, 60(1), 13-21.
14. Liao, Y., Desai, J. P., & Sun, Y. (2017). **Flexible AGV Navigation Using SLAM Techniques**.

    Robotics and Automation Letters, 2(3), 1342-1349.
15. Kim, H., Kim, J., & Lee, S. (2021). **Advances in AGV Battery Technology**. *Energy Research and Applications, 12*(4), 501-516.

16. Kulić, D., Croft, E. A., & Li, Y. (2012). **Designing AGVs for Collaborative Human Workspaces**. *Industrial Robot Journal, 39*(5), 452-463.
17. Ulrich, I. (2020). **AGVs in Harsh Industrial Environments: Challenges and Solutions**.

    Journal of Industrial Automation, 23(2), 112-120.
18. Liao, Y., et al. (2017). **Real-Time AGV Mapping in Dynamic Spaces**. *Robotics Research Review, 10*(3), 212-227.
19. Chen, Y., et al. (2019). **Improved Control Mechanisms for AGV Coordination**. *IEEE Transactions on Control Systems Technology, 27*(5), 1831-1843.
20. Thrun, S. (2006). **Exploring Future Applications of Fully Autonomous AGVs**. *Robotics Research, 24*(5), 345-359.*

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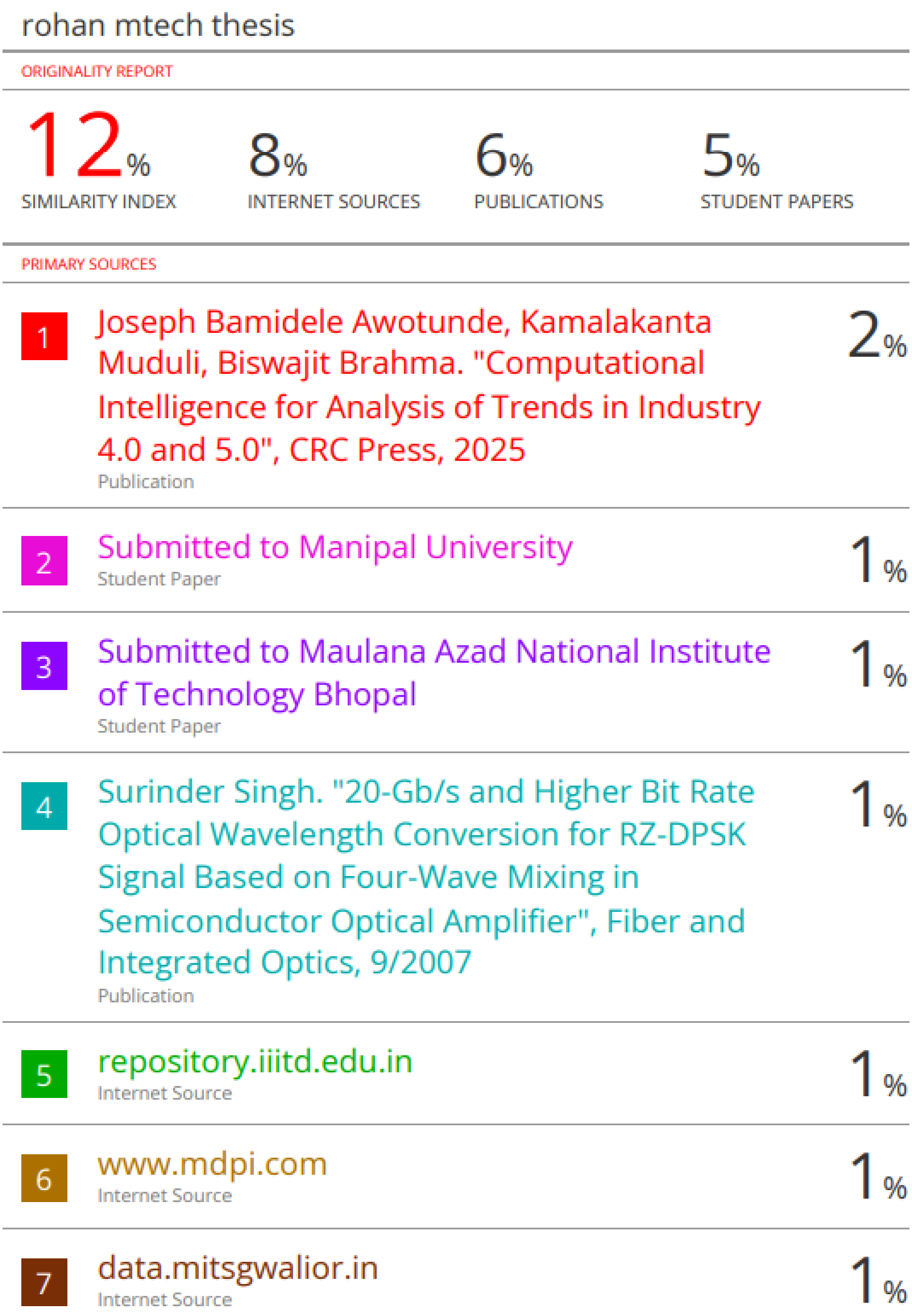

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