Design and Methodology of Automated Guided Vehicle

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Abstract- In manufacturing, logistics, and warehouse distribution, AGV is the cutting-edge, visionary solution that offers autonomous transportation that carries all types of products without involving humans. The terms "laser guided vehicle" and "self-guided vehicle" can also be used to refer to an AGV. In this paper we study the design and different methodology of AGVs systems. This paper provides an overview of automated guided vehicle technology and also small overview of the impact of AGVs during the Covid-19 times.

Keywords- AGV, Guidance Methods, Path Decision, Charging Method.

I. INTRODUCTION

A mobile robot that employs vision, laser, or wires or markers in the floor is known as an automated guided vehicle (AGV) or automatic guided vehicle (AGV). The majority of the time, they are employed in the industrial setting to transport items inside of factories or warehouses. By helping to automate a manufacturing plant or warehouse, automated guided vehicles boost productivity and cut expenses. In trailers to which they may autonomously attach, the AGV can pull items behind them. Finished goods or raw materials can be transported using the trailers.

By turning the conveyors around, the items may be put on them and subsequently pushed off. To raise goods for storage, some A GVs employ forklifts. In almost every sector, including pulp, paper, metals, newspapers, and general production, AGVs are used. In hospitals, it is also done to move items like food, bedding, and medication. Another name for anAGV is a laserguided or selfgu iding vehicle (LGV) (SGV). Automated Guided Carts (AGCs), which use magnetic tape as guidance, are the name for cheaper va riants of AGVs.AGCs come in several different versions and may be used tocarry loads to and from stretch wrappers and roller co nveyors as well as move items along assembly lines, move products within a facility or warehouse, and move loads between locat ions.

With capabilities ranging from a few kilogrammes to hundreds of tonnes, AGV applications are essentially limitless.

II. COMPONENTS OF AGV

A. *AGVs Safety System:*

Several E-stops, a collision detection sensor, driving contactors, and brakes are all included in the AGV safety system, which is controlled by a safety controller device. The implementation of the safety system takes place in a way that ensures the necessary safety criteria are met. The wiring for the range sensor and the ESTOP Actuators is dual channel. It is carried out diagnostic monitoring. The feedback from power contactors is tracked.

To prevent collisions and to shut down the AGV in circumstances when its behavior can jeopardize the safety of people and things around, the AGV is outfitted with a number of safety devices installed on its exterior. On each of the AGV's four sides, there are emergency stop pushbuttons. The E-stops are positioned to be easily accessible in an emergency. The AGV is equipped with warning lights. To signify various operating modes, they can either emit a constant light or flash at various frequencies. The AGV has a beeper attached on it for auditory warning. It may be set to play a sound when appropriate or to play a sound while the AGV is moving.

A collision avoidance system is common equipment on AGVs. This technology will identify a front-facing barrier (such a human) while the vehicle moves along the guiding path. The car will slow down to a lesser speed at a configurable distance from the obstruction. The car will use its brakes and come to a halt before making contact if the barrier is identified within a certain distance of the car. Approximately two seconds after the obstruction is eliminated, the car will start up again.

B. AGVs Power and Charging System:

The onboard charger for the battery is already installed in the AGV. The wall mounting socket may be used to charge the AGV. When the charging is ON, the AGV mobility is stopped and the brakes are deployed. On UCI and the warning system, the proper indicators or warnings are sent

C. *AGVs* Drive System:

The AGV is moved along the path by this major subsystem. Two independently controlled Brushed (PMDC) motor drives are used to provide electrically controlled differential steering for the AGV's traction and steering. They are positioned on either side of the AGV. The motors have encoders, integrated brakes, and a gearbox with a 1:32 ratio. Furthermore, a twin channel high performance drive controller is employed, which transforms commands from the AGV controller into high voltage and high current output for operating the AGV drive motors. The Drive Controller and motor brakes' power inputs are connected to ensure that the necessary levels of safety requirements are met.

D. AGVs Chassis and Body Panels:-

A chassis covered with panels serves as the foundation of the AGV. A ladder-welded steel framework known as the chassis is designed to pull or carry the cargo as needed. The chassis of the AGV carries the bulk of the load. The panels help to safeguard the AGV's components as well as the operators who work nearby when the AGV is in operation.

III. DIFFERENT TYPES OF AGVs

Fork trucks, large load carriers, and towing are the three categories of AGVs. Each is made to carry out routine activities including supplying raw materials, maintaining the stability of loads, and finishing easy jobs. AGVs function continually, unlike human laborers, only pausing when they need to be recharged or fixed.

a) *Fork Lifts AGVs*:

These specialized AGVs carry out the same duties as conventional forklifts without the need for an operator, albeit some may have a manual driving control. Forklift AGVs, as an illustration, are able to stock, transport, stack, and put items as well as pallets. Vehicles, engines, and other substantial items of equipment may all be moved using a heavy-duty AGV forklift.

These AGVs may replace lift trucks and operators, who occasionally need expensive training, and are an efficient and cost-effective way to carry finished goods to storage or shipping.

b) *Towing Truck*:

A tugger automated guided vehicle, sometimes referred to as a tow tractor AGV, pulls load-carrying, non-powered machinery behind it like a train. These vehicles, often known as autonomous trains, run on wheels and can transport big cargo of up to several tones over long distances with pauses for pickup and delivery. A tug travels along a predetermined course to different areas around a warehouse and is capable of hauling machine parts, subassemblies, equipment, and other things.

c) *Heavy Load Carriers*:

Despite the fact that towing and fork AGVs can manage heavy loads, several sectors, like the aircraft, major construction vehicle, and shipbuilding, want AGVs that can manage enormous weights of up to 250,000 pounds. AGV manufacturers have designed devices with substantial bases, sturdy wheels, and broad platforms for various operations. This type of AGV frequently has to be specially created to meet the demands of the customer's business.

A unit load Totes, pallets, commodities, and racks that are too heavy to be moved by conventional methods can only be transported by AGVs, which have a single, specific role. In a warehouse or storage facility, they are intended to transfer products and bulky things. Unit load, or unit load decks, differs from fork and towing AGVs in that they are flat tables that may transport one or more individual units to and from conveyors, stands, automated storage, and other types of retrieval systems. They frequently go in two directions along a single course, repetitively and without change, very much like a flatbed.

Hospitals, workplaces, and other public spaces frequently have light duty AGVs outside of manufacturing facilities. Littler than 500 pound weights may be moved by them. Small AGVs are particularly helpful in areas that must be clean and where people's presence might taint the environment. They distribute patient charts and daily medicines, for instance, at hospitals.

IV. AGV NAVIGATION

In order to direct AGV navigation, one or more of the following methods may be used: -

- *Magnetic guide tape* :-

Automated guided vehicles have magnetic sensors and go along a predetermined path created by a magnetic tape track. On the floor's surface, a magnetic tape is used to create the guided course. AGV magnetic sensor recognizes magnetic field from tape and directs AGV to follow course. Magnetic tape is simple to apply. For placing the magnetic rails, high-bond adhesive is employed.

- *Wired navigation* :-

A wire is inserted about an inch below the surface into a groove that has been made in the floor. Along the AGV's intended route, this slot was cut. Radio signals are sent through this line. On the AGV's bottom, near the ground, a sensor is attached. The sensor is able to determine the relative location of the radio signal coming from the wire. The steering circuit is controlled using this information, causing the AGV to follow the wire.

- *Laser target navigation* :-

Reflective tape is attached to poles, buildings, and other objects with this technique. Laser transmitters and receivers are included with AGVs. The angle and distance of the item from the AGV are determined by the lasers' reflections off the tape that is in the line of sight.

- *Inertial (gyroscopic) navigation* :-

Inertial navigation is a different kind of AGV guiding. The vehicles are guided using inertial guidance under the supervision of a computer system. The office floor has transponders buried in it. These transponders allow the AGV to confirm that the vehicle is on the right track. In order to maintain the AGV on its intended course, a gyroscope is able to detect even the smallest shift in the direction of the vehicle. The inertial approach has a 1inch margin of error.

- *Vision guidance* :-

Installation of vision-guided AGVs does not need infrastructure or environmental changes. They work by employing cameras to capture features along the path, which the AGV can playback and navigate using the captured features. Without the aid of people, additional special features, landmarks, or positioning systems, the vision-guided AGVs can follow a predetermined course because they employ 360-degree photos to create a 3D map.

- *Geo guidance* -

The same goes for AGVs that employ geo guiding; no changes to the infrastructure are necessary. As they move about the facility, geo directed AGVs identify things in their surroundings to determine their location in real-time.

- *LiDAR*-

LiDAR (Light Detection and Ranging) is an advanced navigational technique that makes use of sensors that send laser pulses to measure the separation between the robot and objects in its environment. Robots can move about the building and avoid obstacles without the aid of extra infrastructure thanks to the 360-degree map of the environment that is made using this data. When a warehouse floor's layout changes, 6 River Systems' AGVs can adapt to new settings without needing to make adjustments to the infrastructure by using LiDAR navigation technology.

V. PATH DECISION –

AGVs have to make decisions on path selection. This is done through different methods:

1. *Frequency Select Mode (wired navigation only)*:

The frequencies being radiated from the floor are what frequency chooses mode uses to make its choice. The optimal path is chosen by the AGV when it detects the two frequencies at a location on the wire where the wire divides and consults a table stored in its memory. Only at the AGV's decision point do the various frequencies need to be present. Once this is accomplished, the frequencies may return to a single fixed signal. This process involves further cutting, which costs more money, and is not readily extensible.

2. *Path Select Mode (wireless navigation only):*

Using preprogrammed pathways as a guide, an AGV in path choose mode selects a path. The measurements obtained from the sensors are used, and they are compared to values input by the programmers. An AGV just needs to choose which path to take when it comes to a decision point- paths 1, 2, 3, etc. Since it already knows its course thanks to its programming, this choice is quite straightforward. Because a team of programmers is needed to programmed the AGV with the proper pathways and alter the paths as needed, this strategy might raise the price of an AGV. This technique is simple to alter and use.

3. Magnetic tape mode:

The magnetic tape, which is placed on the floor or buried in a 10mm channel, directs the automated guided vehicle (AGV) along a path while also directing it to change lanes, accelerate, decelerate, and stop by placing strips of the tape alongside the track in various configurations of polarity, sequence, and distance.

VI. CHARGING METHODS OF AGVs -

The two modes-online charging and offline charging can be separated based on the charging location.

- *Online charging :-*

In order to briefly keep the AGV car for charging, so-called online charging makes use of its sporadic time. The automobile does not need to stray from its intended path, and charging does not need to happen at a specific time. This way of charging a lithium battery might be described as random charging. To improve the AGV's handling efficiency in the real world, lithium battery manufacturers must put the AGV charging pile in the active area and process.

- *Offline charging* :-

As the name implies, the so-called offline charging mode calls for the AGV to be driven into a fixed charge pile for charging while charging and necessitates a certain charging period at this time.

There are three charging modes to choose from: manual charging, automated charging, and AGV lithium battery replacement charging.

- *Manual charging* -

The console will direct the AGV trolley to be driven to a designated charging station when it sounds an alert due to low voltage, and a full-time staff member will manually connect and charge the AGV and charger there. An employee will unplug the charger after the charging is finished to return it to its functional condition.

- *Automatic charging* -

When the automated charging needs to refuel, the AGV car will automatically send a signal requesting charge and travel to the charging location .The charging system and on-board connection will be connected and charged automatically. When the charging process is over, it will automatically detach and drive to the work area to wait for work orders.

- *AGV Lithium battery Replacement* -

The battery can be changed in a less complicated manner. When the AGV's power supply runs out, the crew can swap out the battery if it has been prepared in advance. It is also acknowledged that the AGV charging mode may be split into touch charging and wireless charging according to the connection method, and random charging and periodic charging according to the charging duration. According to the various charging characteristics, they are differentiated.

VII. APPLICATION –

Improving operations in many factories and warehouses often involves the efficient, economical circulation of commodities. AGVs, or autonomous guided vehicles, may be used in a variety of sectors because they can transport items efficiently and affordably. AGVs can be standard or customized to better meet the needs of a particular business.

- *Industrial application*:

i. Automobile industry
ii. Commercial print
iii. Hospitals
iv. Chemical industry
v. Food handling
vi. Manufacturing
vii. Pharmaceutical industry
viii. Warehouse distribution

- *Common application*:

i. Repeated transport of objects across a distance.
ii. Activities including at least two shifts.
iii. Procedures where monitoring materials is crucial.
iv. Working with raw materials.
v. Active projects.
vi. Stable loads delivered regularly.
vii. Handling of the finished product.
viii. Handling of pallets.

ix. Container handling.

VIII. ADVANTAGES OF AGVs –

- *Reduced Labor Costs*:

An AGV installation by a business is a one-time expense that, with modest upkeep, can last up to a year. Long-working AGVs can provide several options for businesses to save labor costs. Instead of the ongoing expenditures related to a new hire, such as health insurance, a salary rises, payroll taxes, vacation time, etc., a corporation just pays a single fee for the equipment - the original investment.

- *Increased safety*:

Keeping safety in mind, AGVs are created. They don't traverse operator paths because they have their own tracks to go on. Wearable technology also allows for control of them. When material handling devices are in use, this lessens the chance of human mistake.
Human-operated machinery, such as forklifts, on the other hand, relies on human input, which may be compromised in a number of different ways, and lacks numerous built-in safety precautions. AGVs carry no such risk in comparison to human operators, who are always in danger of colliding with something or losing focus due to fatigue.
Additionally, AGVs can work in conditions that people cannot, such as extreme heat or cold or the presence of hazardous chemicals. Reduced expenses and fewer downtimes as a result of higher safety standards can help many organizations become more profitable.

- *Increased Accuracy:*

People commit errors. AGVs can remove some of the human element's susceptibility for flawed procedures, leading in waste reduction and production growth that improves operations' accuracy and productivity. In addition, unlike human employees who have a set workday, AGVs may operate continuously.
Along with the apparent improvements in accuracy and efficiency, using AGVs in conjunction with a warehouse management system or warehouse control system may speed up processes like inventory management and material ordering.

- ***Increased productivity and output:***

The advantages of AGVs, including reduced direct labor expenses, less indirect costs, fewer mistakes, and enhanced safety conditions, increase total productivity. AGVs can operate continuously, around-the-clock, seven days a week, unlike people who must take breaks and who become weary or distracted. AGVs can be set up to take the quickest path or finish a particular job. If a company has two shifts, management may think about reorganizing operations and carrying out duties during an "automatic" second night shift.
By integrating AGVs with a warehouse management system or a warehouse control system, managers may also expedite processes like inventory management and material ordering.

- ***Increased modularity/scalability:***

AGVs are less complicated to scale than permanent equipment. Management can increase the number of AGVs as needed as the company expands.
Although scalability is possible with manual cars, this is not a noteworthy benefit. AGVs are far more scalable than stationary equipment. AGVs provide you the option to start small with a small fleet and add more as needed, as opposed to investing in a huge fixed conveyor (for instance). Without doing any physical labor, businesses may increase system productivity by adding more AGVs

IX. What Effect Does COVID-19 Have on Touch less Processing Using AGVs?

Positive effects of COVID-19 have been seen in the touch less processing sector. The virus has raised the requirement for physical separation, which has multiplied the demand for automated solutions.
For instance, contactless delivery vehicles like delivery and logistics robots reduce human contamination. These machines may provide meals as well as other necessities. They can accomplish jobs while avoiding collisions because to cameras, sensors, and a powerful motor that was used in their creation. Other, comparable robots can work in hazardous locations or even clean public areas.
Additionally, there are robots that may accompany and aid the elderly and those who are unwell. Since the robots can carry essential items and provide treatment, their skills have proven particularly ground-breaking during the epidemic.
Autonomous manufacturing provides enormous benefits for industrial automation during COVID-19. AGVs can decrease the number of personnel near manufacturing units through remote and real-time control as well as predictive maintenance, which promotes social distance. These devices also provide variable production rates.
Overall, the industry is looking forward to the post-pandemic age with a focus on safe, intelligent contactless processing that retains connectedness and humanization.

X. CONCLUSION -

A group of cooperative driverless vehicles called Automated Guided Vehicles (AGV) are used on factory floors and are managed by a distributed, centralized computer-based management system. The primary purpose of this utilization is to make industrial task automation easier. The usage of AGVs in industrial fields, warehouses, material fields, etc. is met when the prototype is put into service. There are now more options of AGVs available to consumers thanks to significant technical improvements. They primarily deal with navigation system modularity, standardization, and automation, as well as energy concepts. AGVs can deliver efficient, cost-effective movement of materials in various industries in standard or customized designs to best suit an industry's requirements, such as the pharmaceuticals, chemical, manufacturing, and automotive industries effectively. Even in the times of pandemic the benefits of AGVs is clearly visible in many areas especially in hospitals and warehouses

XI. REFERENCES

1. Hassan Haleh, Arman Bahari, Automated Guided Vehicles Routing 2014 TJEAS Journal-2014-4-2/60-66. INT

2. Broadbent AJ, Besant CB, Premi SK, Walker S P. 1985, Free ranging AGV Systems: Promises, Problems and Pathways, Proceeding of the 2nd International Conference on Automated Materials Handling, (IFS Publication Ltd., UK), pp. 221-237.
3. Glover F, Klingman DD, Phillips NV. 1985, A New Polynomials Bounded Shortest Path Algorithm, Operations Research, 33(1) pp. 65-73.
4. Kim CW, Tan Choco JMA. 1991, Conflict Free Shortest Time Bi- Directional AGV Routing, International Journal of Production Research, 29 (12), pp. 2377-2391
5. S. PREMI and C. BESANT, A review of various guidance techniques that can be used by mobile robots or AGVs. Proc. 2nd Int. Conf. on AGVS, Stuttgart, p. 195. IFS Publications (1983).
6. T. MUELLER, in Automated Guided Vehicles (International Trends in Manufacturing Technology) (edited by R. H. Hollier) p. 277. IFS Publications/Springer Verlag (1987).
7. F. GenaaL and G. PRODO, Guided vehicle system at Renault. Proc. 1st Int. Conf. on AGVS, Stratford upon- Avon, p. 60. IFS Publications (1981)
8. J. M. Evers and S. A. J. Koppers. Automated guided vehicle traffic control at a container terminal. Transportation Research Part A: Policy and Practice, 30:2134, 1996.
9. Qiu L, Hsu WJ. 2001, A bi-directional path layout for conflict free routing of AGVs, International Journal of Production Research, 39(10), pp. 2177-2195.
10. M.A. Rahaman Design and Fabrication of Line Follower Robot Asian journal of applied science and engineering voluem2 2013
11. Bajestani, S.E.M., Vosoughinia, A., Technical Report of Building a Line Follower Robot International Conference on Electronics and Information Engineering (ICEIE 2010), vol 1, pp. v1-1 v1-5, 2010 11. Lothar Schulze, Sebastian Behling Automated Guided Vehicle System: A Driver for Increased Business Performance IMECS 2008 19-21 March 2008 Hong Kong.
12. Malhotra Rajiv, Sarkar Atri; Development of a Fuzzy Logic Based Mobile Robot for Dynamic Obstacle Avoidance and Goal Acquisition in an Unstructured Environment; Proceedings of IEEE/ASME, International Conference on Advanced Intelligent Mechatronics, pp.235-247, 2003.
13. K Kishore Design of Automated Guided Vehicle, IJARC Volume 3, Issue 1, January- April (2012).
14. 6river.com/what-are-automated-guided-vehicles.
15. https://www.industrialautomationindia.in/article.