



Design and Fabrication of Automated Guided Vehicle

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I. INTRODUCTION

The Evolution and Importance of Automated Guided Vehicles (AGVs) Among the various automation solutions, Automated Guided Vehicles (AGVs) stand out as one of the most transformative technologies in modern logistics. An AGV is a mobile robot that uses various technologies to follow predetermined paths, typically through sensors or magnetic strips, without the need for a human driver.

The AGV concept was first introduced in the 1950s, where basic vehicles followed simple guidance systems such as magnetic tape or wired tracks. Over the decades, AGVs have evolved to incorporate a variety of advanced navigation technologies, such as infrared (IR) sensors, ultrasonic sensors, and even vision-based systems. These advancements have greatly increased the flexibility and intelligence of AGVs, allowing them to function in dynamic environments without fixed paths. In logistics and warehousing, AGVs offer significant advantages over manual material handling. They can operate 24/7, reducing labor costs and enhancing productivity. AGVs are also capable of reducing the risk of workplace accidents, as they eliminate human involvement in hazardous or repetitive tasks, improving both efficiency and safety.

Abstract— With the advancements of robotic technologies, the industrial environments are adopting more and more aspects of automation to enhance product quality and accuracy and to reduce product cost. One of these aspects is the use of Automated Guided Vehicle (AGV) which is gaining importance in industrial logistics and transportation systems. Automated Guided Vehicles are the essential parts of all automated factories.. No human intervention is required for its normal functioning during task-execution stage. In this paper, automated guided vehicle is interfaced with Programmable logic control, which is a new concept in the field of automation and replacement of traditional electro-mechanical control system. In steel plants, a lot of transporting is required inside the plant to help in production, such as, steel coils are transported from one location to another. For this purpose automated guided vehicle systems are very useful.



II. LITERATURE REVIEW

R. Biniwale et al.,[1] These days because of the exceptionally expanding requests on assembling parts, these regions have left their delivery distribution centre in ruin. In like manner, the human errors adversely influence security, capability. Subsequently these vehicles are exact in work, proficient and errorless. In this manner the right idea of an AGV can be introduced that, it is a driverless vehicle wherein the necessary material is gotten by the mechanization itself and afterward circulated to the allotted goal in the distribution centre. Therefore this makes circulation easy, inside as far as possible and furthermore with legitimate precision not creating any harm. Along these lines right now, is extremely vital for any assembling or a substantial stacked plant to utilize this trend setting innovation so as to build efficiency.

L. Dammacco et al.,[2] Complex manufacturing systems are recently undergoing a green revolution due to manufacturing customization towards sustainable products. A key enabler for the implementation of green and energy efficient production is simulation-based design, which supports system engineers and designers in making decision choices aimed at enhancing the performance of smart and sustainable production. In this context, this work proposes a simulation approach to support the design of the layout and operation of automated guided vehicles (AGVs) in complex production lines. In particular, a case study related to the assembly of electric axles for heavy-duty vehicles is presented: a scenario analysis implemented in the Plant Simulation platform is used to determine the optimal configuration of AGVs in terms of number of vehicles and operation (e.g., definition of charging strategies, scheduling of charging stops, routing). The simulation results first show that the reduction of the AGVs' energy consumption and the increase of production throughput are competing criteria; second, the choice of AGV charging strategies has a significant influence on the energy consumption as well as on the productivity performance.

Md Masuduzzaman et al.,[3] work presented an innovative and secure approach to using industrial intelligence of things (IIoT 2.0) devices for designing an automated smart factory management system. Firstly, a blockchain-based secure order placement technique is proposed in a smart factory management system to store the production record permanently and avoid third-party interaction. This work also introduces cooperative autonomous product tracking and maintenance systems using automated guided vehicles (AGVs) and unmanned aerial vehicles (UAVs) to minimize human interaction inside a smart factory. Moreover, a deep learning model-based automated anomaly detection and prevention approach is demonstrated to take proactive action by the UAV and AGV inside a smart factory. Finally, to address the security issue among IIoT 2.0 devices, a secure data transfer approach based on public-key infrastructure (PKI) is utilized. Result analysis of the proposed system shows that the blockchain network can form the blocks very rapidly using the private blockchain network. Furthermore, PKI implementation confirms that the proposed smart factory management system's IIoT 2.0 devices can swiftly transfer secure data and instructions from one device to another.

T. Liu et al.,[4] In this article, the problem of optimize autonomous ground vehicle (AGV) parking trajectory is

studied. To speed up the convergence of the optimization algorithm when the problem is established in a constrained environment, a hierarchical optimization framework is proposed. In the first layer, an enhanced A-star algorithm is designed to produce an reference collision-free trajectory. Then, the obtained trajectory is used as the initial guess of the gradient-based optimization algorithm in the second layer. The overall algorithm is tested to plan the optimal parking trajectory, taking account of the AGV mechanical constraints and task-related constraints. Simulation studies were conducted to verify the effectiveness of the proposed scheme. The results show that such a design is able to produce collision-free trajectories for the considered problem.

H. B. Zulkiflee et al.,[5] The COVID-19 mandates an increase in the use of service robots as human replacements in polluted areas. This task encompasses logistics, patient care, and disinfection, all of which limit the danger of human exposure to the extremely infectious and fatal illness. To fulfil the criteria of the World Health organization, the certified sanitizing system is a method for decontaminating individuals and surfaces. In this work, automated sanitizing equipment is designed. The equipment spray a sanitizer solution is the area to be disinfected. The transportable sanitizing unit is mounted to the robot's head. SolidWorks software is used to design the equipment. Design included identifying main parts of the system, deciding about material for different parts, and 3D design of each of the parts. Finally, the assembly of the complete system is presented. The finalized product was then simulated in MATLAB. Analysis of the system included flowrate, pressure, and maximum spray distance. Results obtained are consistent with requirements.

E. S. Lee et al.,[6] As the automated guided vehicles (AGVs) play an important role in automated logistics systems, the wireless power transfer (WPT) technologies become a viable solution to provide the AGV with the automatic power charging service. In order to install the WPT systems to the small confined space in the AGV, a 2-D thin coil design is necessary for the receiver (Rx) system installed in the AGV. To greatly reduce the thickness of the Rx coil, including resonant capacitors, an ac/dc rectifier, and dc-link capacitors, a 2-D coil design for a minimum core loss is newly proposed in this article. Based on a finite-element-method (FEM) 3-D simulation analysis, various coil structures have been comparatively evaluated to find the most appropriate core structure. Furthermore, to obtain the highest coil efficiency at nominal operating condition, the appropriate number of turns design is established. Thus, according to the coil design guideline of the proposed inductive power transfer (IPT) system, the appropriate number of turns for transmitter (Tx) and Rx coils $N_{1,op}$ and $N_{2,op}$ can be appropriately selected for the high efficient operation of the IPT coils. The 2.5-kW prototypes of the IPT systems for wireless charging of AGV were fabricated and verified by simulations and experiments. The results showed that the total thickness of the coil sets including all the components is 32.0 mm for the Rx coil. The measured maximum coil efficiency for $PL=2.5$ kW at 40-mm coil distance was 98.9% by the proposed IPT coil design procedure. The measured temperatures at the ferrite core and coil for the Rx coil were managed below 53.3 °C and 59.3 °C during 2.5-kW wireless charging, respectively, under a 10-min charging and 20-min AGV operation cycle, which provides the thermal-stable operation of the proposed IPT systems.



X. Xiang et al.,[7] Container terminal capacity, as an important indicator of container terminal competitiveness, has become a primary concern of port managers, whereas container flows, which are supported by quay cranes, yard cranes, and automated guided vehicles, have a substantial influence on container terminal capacity. Container flows are analyzed in this article to estimate the performance of an automated container terminal considering traffic congestion, unbalanced task assignment, container batch arrival, and different berth and yard layouts. The operating system is formulated as a closed-queueing network with four stations. Theoretical analysis and the solution method are adopted to determine system capacity. The resource allocation and system design, specifically the number of vehicles, berth and yard layouts, and task assignment strategy, are optimized. Numerical experiments are conducted to provide management insights into port capacity planning, resource optimization, and layout design. Note to Practitioners —The construction of an automated container terminal (ACT) requires a sizable investment. Analyzing the performance of the container terminal with different configurations in the planning stage, which is before the construction of ports, is very important. Thus, planners can select better resource configurations. Generally, simulation is an intuitive way to estimate performance. However, formulating and running the simulation model with different configurations is time consuming. An analytic model for estimating the performance of an ACT is developed to reduce computational time in this article.

N. K. Waghmare et al.,[8] Automated Guided Carts (AGCs) is the finest technique to mechanize a capability with the elasticity of independent material transmission. These carts are perfect for conveyance and assembly line work, with nominal interruption needed. This Research work studies different options of automated carts available in the industry for relocation and shifting of stock in warehouses and industries. Comparing different options, a solution of the devised e-cart which is suitable for small-scale businesses (warehouses, firms) for the relocation of stock is being designed and fabricated. The designed cart is semi-automated and can be controlled by a smart device via Bluetooth. All the details such as different design options all the material requirements with an assembly of the vehicle have been discussed in the Research work. During actual experimental analysis, the design of the chassis is found efficient enough in carrying loads up to 50 kilograms with 5 KMPH speed on different terrain. The simulation analysis conducted on Autodesk Fusion 360, for stress and strain also gives satisfactory results. From the simulation analysis FOS (15), Stress (115MPa), and Strain (0.0007) were obtained.

H. Sasamoto et al.,[9] This work overviews the modeling, implementation, and mechanical characterization of an Automated Guided Vehicle (AGV) devoted to transport materials and tools in smart factories. The design is based on a differential-drive mobile robot configuration for which the mathematical model was obtained. Such model allows the simulation of the AGV's motion and can be used to improve productivity, increase automation, and reduce transportation costs in industrial facilities. The prototype's implementation was conducted with highly resistant materials and automated manufacturing processes. A finite element analysis (FEA) shows that the prototype is capable of transporting 700 kg loads without suffering any structural damage and that critical cases involving collisions might cause only minimal harm. An IoT approach has been considered for the AGV's electronic architecture.

Z. Slanina et al.,[10] This article deals with analysis and design of automated guided vehicle platform for automated parking houses. There is some essential research in this area described, analysis of communication system between smart automated house solution and design of AGV itself in terms of hardware and software point of view.

III. MATERIALS AND METHOD

The key components used in the electronic system are:

- MAIN FRAME
- INFRARED (IR) SENSORS
- ULTRASONIC SENSOR
- CONTROL CIRCUIT(MICROCONTROLLER BASE)
- DC MOTOR
- RELAY UNIT FOR DC MOTOR
- 12 VOLT RECHARGABLE BATTERY

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

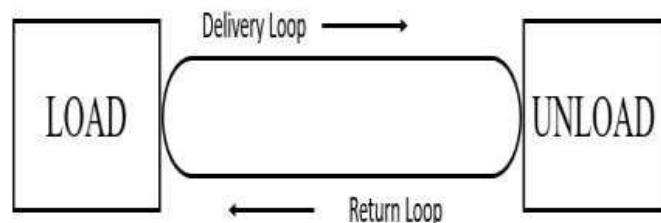


FIG 3.1 TWO DIFFERENT PATHS FOR TRAVELING.

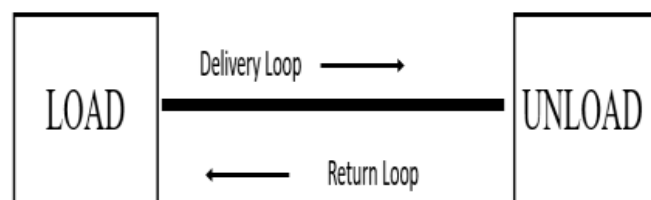


FIG 3.2 SINGLE TRACK FOR TRAVELLING

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

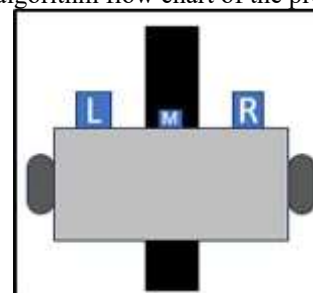


FIG 3.3 FLOW CHART

The above flowchart provides a comprehensive overview of the functionality and the operational workflow of our AGV system. Let us understand how our AGV follows the

predefined path i.e., line on the surface with the help of diagrams.

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

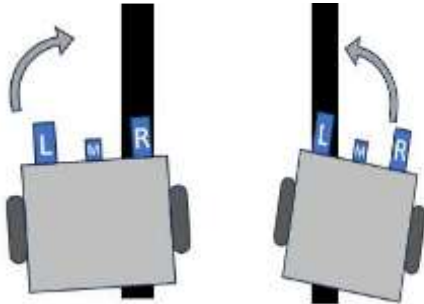


Fig.3.4 STEER THE ROBOT RIGHT (LEFT IMAGE), AND STEER THE ROBOT LEFT (RIGHT IMAGE).

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

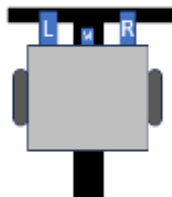


FIG 3.5 OBSTACLE SENSOR & IDEAL WHEEL

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

In addition to these functional requirements, performance criteria were also established to guide the design process, including:

- Navigation Accuracy: The AGV must be able to follow a black line on a white surface with an accuracy of at least 90
- Obstacle Detection: The AGV should detect obstacles within a distance of 30 cm and stop to prevent collisions.
- Payload Capacity: The AGV should be able to carry up to 500 grams of payload.
- Power Efficiency: The AGV should operate for at least 30 minutes on a single charge.

IV. RESULT

- The results from the testing phase provide a clear roadmap for future improvements. Possible upgrades include:
- Advanced Navigation: Implementing advanced navigation algorithms, such as those based on LIDAR or vision, could improve the AGV's ability

to navigate dynamic environments and follow paths more accurately.

- Energy Efficiency: Upgrading the power system with a more efficient motor and a higher capacity battery could increase the AGV's operational time.
- Enhanced Obstacle Detection: Incorporating additional sensors, such as infrared or cameras, could extend the obstacle detection range and improve performance in more complex environments.
- Wireless Communication: Adding wireless communication capabilities (e.g., Wi-Fi or Bluetooth) could allow for remote monitoring and control of the AGV.

A Prototype Fabrication And Experimental Setup



Fig.4.1 Design And Fabrication Of Automated Guided Vehicle System.

V. DISCUSSION

AGVs have a wide range of applications in various industries, from warehousing and logistics to healthcare and retail. The most significant applications include automated material handling, inventory management, and supply chain optimization.

1) Warehousing and Logistics: AGVs are widely used in warehouses and distribution centers to transport goods, optimize inventory management, and enhance operational efficiency. Xu et al. (2017) conducted a study on the impact of AGVs in warehouses, highlighting their ability to reduce labor costs, increase throughput, and improve inventory accuracy. The study found that AGVs are particularly beneficial in environments where high throughput and efficiency are required, such as e-commerce fulfillment centers.

2) Healthcare Applications: In healthcare settings, AGVs are used to transport medical supplies, pharmaceuticals, linens, and other materials within hospitals. These AGVs help reduce the burden on hospital staff and ensure the timely and accurate delivery of materials. Huang et al. (2020) explored the role of AGVs in hospital logistics, noting that they can improve operational efficiency and reduce human error, particularly in high-pressure environments such as emergency rooms and operating theaters.



VI. CONCLUSION

This research focused on the design, development, and testing of an Automated Guided Vehicle (AGV) intended to automate material handling tasks in store management environments. The AGV was designed to follow a predefined path using infrared (IR) sensors for line detection and ultrasonic sensors for obstacle avoidance. Through a comprehensive development process involving requirement analysis, design, assembly, and programming, the AGV was successfully created and tested.

The AGV demonstrated reliable line-following capabilities, maintaining a path accuracy of approximately 90 %. Despite these successes, there were a few challenges that were identified during the testing phase, including the AGV's stability on carpeted surfaces and slight inaccuracies in line-following during sharp turns. These issues highlight areas for improvement in future versions of the AGV, such as optimizing the sensor calibration, improving the motor system for better traction, and upgrading the battery for enhanced energy efficiency.

The findings from this project demonstrate that AGVs can be a viable solution for automating material handling in controlled environments such as stores and warehouses. The ability of AGVs to reduce human labor, increase efficiency, and improve safety makes them a valuable asset for logistics and supply chain operations.

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