

Research on the Application of AGV in the Smart Logistics Field

Xiangfei Ge*, Qianwen He

Foshan Polytechnic, Foshan 528137, China

Email: 240978619@qq.com

How to cite this paper: Ge, X. F., & He, Q. W. (2025). Research on the Application of AGV in the Smart Logistics Field. *Economics & Business Management*, 1(3), 75 - 81. ISSN Print: 3079 - 5214; ISSN Online: 3079 - 5222.

<https://doi.org/10.63313/EBM.9058>

Published: 2025-05-20

Copyright © 2025 by author(s) and Erytis Publishing Limited.

This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Abstract

Against the backdrop of the logistics industry undergoing transformation and upgrading led by technology, Automated Guided Vehicles (AGVs), as key equipment in smart logistics, have a profound impact on improving logistics efficiency and service quality. This paper deeply explores the application background and current development status of AGVs in the smart logistics field, combs the classification and comparison of AGVs based on navigation technologies and functional forms, and clarifies the technical adaptability of AGVs in different application scenarios. The article details how AGVs address challenges in the logistics industry such as labor costs, efficiency improvement, and safety issues, and provides a forward-looking analysis of the development trends of AGVs in the future, including intelligence, green energy applications, and technology integration. The aim is to provide useful references for in-depth research and application of AGVs in the smart logistics field.

Keywords

AGV; Smart Logistics; Multi-Technology Integration

Introduction

With the rapid development of technology, smart logistics has become a crucial direction for the transformation and upgrading of the logistics industry. As one of the core equipments in smart logistics, Automated Guided Vehicles (AGVs), with their automated and intelligent characteristics, are profoundly changing the operational modes of traditional logistics, playing a significant role in improving logistics efficiency, reducing costs, and enhancing service quality. According to a report by Logistics IQ, the global warehouse automation market is expected to reach \$27 billion by 2025, with AGVs, as core equipment, witnessing a market share growth at an annual average rate of 9.9% [1]. In-depth research on the application of AGVs in the smart logistics field holds important theoretical and practical significance.

1. Application Background of AGVs in Smart Logistics

In recent years, the vigorous development of the manufacturing and e-commerce logistics industries has led to a sharp increase in labor demand. However, changes in the population structure have caused the labor market to gradually shrink, and labor costs have continued to rise. Over the past decade, labor costs in China's manufacturing industry have increased by more than 300%. Facing this situation, enterprises urgently need to seek automated solutions to replace manual handling. The rapid development of the e-commerce industry has set extremely high requirements for logistics and distribution efficiency. "Same-day delivery" and "next-day delivery" have become industry service standards. Traditional manual sorting is relatively inefficient, at about 100 - 200 pieces per hour, making it difficult to meet the high-efficiency operational needs of e-commerce businesses. When AGVs are combined with the DPS sorting system, however, sorting efficiency can be significantly increased to 500 - 800 pieces per hour, with an accuracy rate approaching 100%. The continuous maturity of advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and 5G has provided strong support for the intelligent development of AGVs. The application of AI algorithms can accurately predict order peaks and then dynamically adjust the task allocation of AGVs, further optimizing the logistics process. In addition, governments around the world have successively introduced policies to encourage the development of smart logistics. In China, the Ministry of Transport has listed AGVs as key technologies for port automation upgrades. The continuous improvement of industry standards has also laid the foundation for the widespread application of AGVs.

2. Application Status of AGVs in Smart Logistics

2.1. Warehousing and Logistics Sector

In automated stereo warehouses, AGVs work closely with stacker cranes and conveyor lines to achieve efficient automated storage and retrieval of goods. For example, in a stereo warehouse project created by Yufeng Intelligence for a power company, AGVs collaborated with four-way shuttle cars, increasing the storage density by 60% and improving the inbound and outbound efficiency to 145% of that of traditional warehouses. This effectively enhances the utilization rate of warehouse space and the turnover speed of goods. In the field of goods-to-person sorting, KIVA-like AGVs perform exceptionally well in the goods-to-person sorting model. By moving shelves to workstations, the sorting efficiency is significantly increased, which is 3 to 5 times higher than the traditional model. This model is particularly suitable for high-frequency small-package sorting scenarios in industries such as apparel and 3C products.

2.2. Manufacturing Sector

In industries such as automotive manufacturing, AGVs have gradually replaced

manual tractors in the critical task of on-time delivery of components. At BYD's factory, the deployed AGV system can control material delivery errors within $\pm 5\text{mm}$, effectively reducing production line downtime by 80%, thus strongly ensuring the smooth operation of the production line.

To address the logistics transportation challenges in multi-story factories, AGVs, in conjunction with elevators or dedicated passages, achieve efficient cross-floor handling. After a valve enterprise introduced Zhuoyi Intelligent AGVs, it successfully solved the problem of goods being prone to tipping during manual handling, improving logistics efficiency by 40% and significantly enhancing internal logistics transportation within the enterprise.

2.3. E-Commerce and Cold Chain Logistics Sectors

E-commerce industry promotions such as "Double 11" pose a huge test to logistics processing capabilities. The JD Asia No. 1 Warehouse adopts an AGV cluster operation model, processing over 150,000 orders in a single day during "Double 11," with 70% of nighttime operations being unmanned, fully demonstrating AGVs' strong advantages in handling order peaks.

Cold chain logistics has strict requirements for temperature and hygiene, with manual sorting being inefficient and goods prone to damage. United Core Technology's explosion-proof AGVs can operate stably in low-temperature environments as low as -30°C , being effectively applied in food cold chain warehousing and providing a reliable solution to cold chain logistics challenges.

2.4. High-Risk and Special Scenarios

In high-risk environments such as oil and gas storage areas and chemical warehouses, United Core explosion-proof AGVs ensure operational safety through strict explosion-proof designs and the use of anti-static materials. Compared to manual handling, the accident rate has been reduced by 90%, greatly protecting personnel and environmental safety.

A blood products enterprise introduced Yuming Robot AGVs to achieve precise drug handling in special environments with alternating high and low temperatures, effectively avoiding potential pollution risks caused by manual contact with drugs and ensuring drug quality and safety.

3. Classification and Technical Characteristics Comparison of AGVs in Smart Logistics

The classification system of AGVs can be analyzed from two core dimensions: navigation technology and functional form. Different types of AGVs exhibit significant differences in technical characteristics, applicable scenarios, and cost-effectiveness. The following is a detailed comparative analysis from the perspectives of technical principles and engineering applications[3].

AGVs can be mainly classified into magnetic navigation, laser navigation, visual navigation, and composite navigation based on navigation technology. This paper summarizes their technical principles, core advantages, limitations, and typical application scenarios in Table 1[4]:

Table 1. Classification and Comparison of AGVs

Navigation Type	Technical Principle	Core Advantages	Limitations	Typical Application Scenarios
Magnetic Navigation	AGVs identify magnetic field signals through magnetic strips/nails laid on the ground and built-in magnetic sensors to track paths.	Low cost (equipment cost is 40%-60% lower than laser navigation), mature technology, strong anti-interference capability.	Poor path flexibility (requires physical site modification), high upgrade cost (path adjustment requires re-laying magnetic strips).	Automobile final assembly lines, fixed-route warehouse transportation.
Laser Navigation	Laser radars scan reflective plates in the environment, and AGVs construct maps and achieve real-time positioning through triangulation.	High positioning accuracy ($\pm 10\text{mm}$), supports dynamic route planning, no need for ground modification (only requires installing reflective plates).	Relies on reflective plate layouts (environmental changes require remapping), reflective signals may be interfered with in complex environments.	Warehouse sorting, flexible production line material delivery.
Visual Navigation	Cameras capture ground images, and AGVs achieve positioning by combining AI algorithms to recognize QR codes, landmarks, or natural textures.	Strong environmental adaptability (no need for auxiliary facilities), low deployment cost (only requires visual sensors), highest path planning flexibility.	Affected by lighting conditions (recognition accuracy decreases by 30%-50% in low-light environments), high computing power requirements for image processing.	Complex aisles in e-commerce warehouses, outdoor semi-structured scenarios.
Composite Navigation	Integrates two or more navigation technologies (such as laser SLAM + inertial navigation + UWB), enhancing positioning reliability through data fusion.	Best adaptability to complex environments (multi-sensor complementary fault tolerance), positioning accuracy up to $\pm 5\text{mm}$, supports dynamic environment reconstruction.	High system complexity (development cost increases by 30%-40%), requires professional algorithm support.	Cross-floor handling, multi-scenario hybrid logistics systems.

4. Challenges Solved by AGVs in Smart Logistics

4.1. High Labor Costs and Labor Shortages

AGVs have the ability to operate continuously for 24 hours, effectively replacing manual handling and significantly reducing labor costs. Take an e-commerce warehouse as an example; after introducing AGVs, the number of sorters was reduced by 60%, and the equipment investment was recouped within three years. In developed countries with prominent labor shortage issues, AGVs have become an inevitable choice for logistics automation.

4.2. Efficiency Bottlenecks and Handling Order Fluctuations

Traditional logistics models often face efficiency bottlenecks during e-commerce promotions and other order peaks. AGVs use intelligent scheduling systems to dynamically allocate tasks based on order volumes. For example, Xingli Warehousing's AGV+DPS combination increased sorting speed to 800 pieces per hour, easily handling daily processing requirements of tens of thousands of orders. In addition, the modular deployment feature of AGVs allows for flexible increases in the number of robots according to business growth, effectively addressing order fluctuations.

4.3 Human Errors and Cargo Damage

Manual operations are prone to sorting errors and cargo damage. AGVs, with their precise positioning capabilities (such as repeat positioning accuracy of $\pm 10\text{mm}$) and automatic alignment functions, can reduce mis-sorting rates to extremely low levels[2]. For precision goods such as pharmaceuticals and electronic components, the damage rate can be reduced by more than 90%, effectively ensuring cargo quality.

4.4 Safety Risks and Environmental Constraints

In high-risk environments (such as cold storage and chemical warehouses), AGVs can replace human operations, reducing the risk of work-related accidents. For example, United Core's explosion-proof AGVs have achieved zero-accident operation in oil and gas storage areas after obtaining ATEX certification. At the same time, AGVs are equipped with 360° obstacle avoidance sensors and emergency braking systems, which can effectively prevent collisions between humans and machines, enhancing overall operational safety.

4.5 Space Utilization and Layout Optimization

The narrow-aisle operation capability of AGVs (such as narrow-aisle AGVs with a passage width of only 1.9 meters) can effectively increase warehouse space utilization by more than 30% compared to traditional models. A furniture enterprise achieved a storage capacity of 400 container units after adopting Yufeng Intelligent AGVs, a 60% increase over traditional warehouses, realizing efficient utilization of warehouse space.

5 Development Trends of AGV Technology

5.1 Upgrades in Intelligence and Autonomy

Through machine learning algorithms, AGVs can optimize route planning and more intelligently adapt to dynamic environmental changes. The AGVs at Yuncheng Weipai Apparel use AI vision algorithms to identify obstacles, achieving unmanned autonomous obstacle avoidance and enhancing the intelligence level of operations. The popularization of 5G networks enables real-time communication among AGV clusters, achieving global optimization of task allocation and route conflict resolution. For example, an AGV fleet at a port saw a 40% increase in operational efficiency with the support of 5G technology, fully demonstrating the advantages of multi-vehicle collaborative operations.

5.2 Green Energy and Sustainable Development

Hydrogen fuel cell AGVs have a battery life of more than 8 hours and achieve zero emissions, making them suitable for logistics scenarios with high environmental requirements. Meanwhile, the application of solar-powered AGVs in outdoor logis-

tics is gradually increasing, effectively reducing energy costs and promoting the green development of the logistics industry.

AGVs feature sleep modes and automatic charging functions, reducing energy consumption by 30%. Yufeng Intelligent AGVs automatically enter low-power mode when idle, reducing the full lifecycle cost by 20% and achieving efficient energy utilization.

5.3 Technology Integration and Scenario Expansion

The combination of AGVs and drones enables "last-mile" delivery. SF Express's drone logistics network has flown over 4 million kilometers. The collaboration between robotic arms and AGVs can complete complex palletizing and depalletizing tasks. For example, an AGV of an electric power company, combined with a 3D vision robotic arm, has achieved automated handling of bagged materials, expanding the application scenarios of logistics operations[5].

In the healthcare field, AGVs can be used for drug delivery and disinfection operations. In the agricultural field, AGVs can realize the transportation of field materials. MiR's medical logistics AGVs have been widely used in European hospitals, increasing efficiency by 300%, setting an example for logistics automation in emerging fields.

5.4 Policy Support and Improvement of Industry Standards

China's 14th Five-Year Plan lists AGVs as key technologies for intelligent manufacturing support. Local governments reduce enterprises' procurement costs through policies such as subsidies. After receiving policy support, the deployment cost of AGVs in Shaanxi Digital Pharmaceutical Industrial Park decreased by 30%, promoting the intelligent upgrading of enterprises.

5.5 Modular and Customized Solutions

The chassis, navigation system, load devices, etc. of AGVs adopt modular design, which can be quickly replaced according to the needs of different industries. Geek+'s AGVs support the switching of multiple modules such as shelf handling and picking, meeting the diverse requirements of logistics operations.

The low-code platform of WCS (Warehouse Control System) allows enterprises to arrange business processes independently, greatly shortening the project delivery cycle. Yuming Robot's WCS system can complete the docking with customers' equipment within one week, improving project implementation efficiency.

6. Conclusion

As key technical equipment in the field of smart logistics, AGVs are transforming from traditional single-function handling tools to highly intelligent and flexible logistics solutions. Their widespread application has effectively addressed many pain

points in traditional logistics models, such as high labor costs, low efficiency, and high safety risks, promoting the logistics industry's development towards efficiency, safety, and sustainability. With continuous technological innovation and sustained policy support, AGVs will continuously expand their application areas and achieve a deeper level of intelligent development in the future. Enterprises should closely monitor the development trends of AGV technology, select and apply AGV technology reasonably according to their own business needs, so as to enhance their core competitiveness in the market and contribute to the vigorous development of the smart logistics industry.

References

- [1] Logistics IQ. (2021). Global Warehouse Automation Market Report 2021-2025[R]. Pune: Logistics IQ Research.
- [2] Transmission Scheduling with Order Constraints in WIA-FA based AGV Systems[J]. IEEE Internet of Things Journal, 2021, 8(4): 3123-3135.
- [3] Dolgov D, Thrun S. Real-time obstacle avoidance for fast mobile robots[J]. The International Journal of Robotics Research, 2005, 24(5): 433-448.
- [4] Improved A* Method for High Efficiency Forklift Path Planning[C]. 2022 IEEE International Conference on Electronic Commerce Engineering.
- [5] Li, N. (2024). A study on the current status and future trends of smart logistics development in China and abroad [Doctoral dissertation]. Renmin University of China, Beijing.