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Research on Analysis of China's Logistics Robotics Industry

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Abstract

This paper delves into the application of logistics robots in the industrial sector, with a specific focus on conducting an industrial chain analysis that includes upstream, midstream, and downstream components. As technology advances and the demand for automation rises, logistics robots are becoming increasingly essential in the industrial sector. Mobile robots, equipped with navigation systems, sensors, and intelligent algorithms, have the capability to autonomously move and transport items. In environments such as warehouses and production lines, logistics robots demonstrate automation by efficiently handling tasks such as goods management, assembly, and sorting. This automation enhances both production efficiency and workplace safety. The paper concludes by offering insights into future trends, anticipating the development of logistics robots to involve heightened intelligence, greater adaptability to diverse scenarios, and enhanced collaboration with humans. The trajectory indicates that logistics robots are poised to deliver more efficient, reliable, and secure logistics solutions to the industrial sector, shaping the future of industrial automation.

Keywords

Logistics robots, mobile robots, industrial chain analysis, production efficiency, industry scale

1. Introduction

1.1 Definition of the Logistics Robotics Industry

Logistics robotics belongs to a category of service robots that are developed and produced using artificial intelligence, automation technology, and machine vision technology. It provides comprehensive automation solutions for the logistics industry. The focal points of logistics robotics in the industrial sector are primarily centered around improving efficiency, reducing costs, enhancing safety, and increasing accuracy [1]. The goal is to achieve a higher level of logistics automation and intelligence. Logistics robots are highly integrated and combine various functions such as transportation, warehousing, sorting, distribution, and information services. They play a crucial role in extending the industrial chain, enhancing the value chain, and building the supply chain. With the continuous expansion of the application scope of logistics robots, the market size of the logistics robotics industry is also steadily increasing. More and more enterprises are entering this field, presenting both market opportunities and challenges.

1.2 Classification of Logistics Robotics Industry

The logistics robotics industry can be categorized based on industrial application scenarios into warehouse robots, delivery robots, and production line robots (see Figure 1).

(1) Warehouse Robots: Primarily used in warehouse operations, these robots are involved in tasks such as handling, stacking, picking, and storage. Through automated and intelligent technologies, warehouse robots can enhance the efficiency and accuracy of warehouse operations, reduce labor costs, and minimize errors and losses.

(2) Delivery Robots: Delivery robots are automated devices designed to transport and deliver goods or items. They typically possess functions such as navigation, perception, planning, and execution, enabling them to autonomously move in designated environments and deliver goods from one location to another along predefined paths.

(3) Production line robots are primarily employed in the production lines of manufacturing enterprises to carry out various repetitive, tedious, or hazardous tasks in industrial production processes. They can perform tasks such as component processing and product assembly, improving production efficiency and quality. Generally characterized by high precision, speed, and stability, production line robots can replace manual operations on the production line.

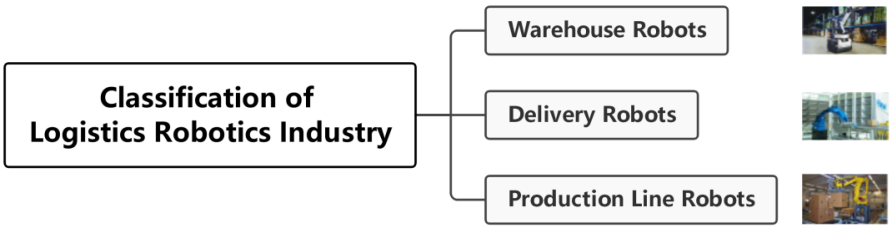

Figure 1. Classification of Logistics Robotics Industry.

1.3 Characteristics of the Logistics Robotics Industry

Guided by national policies, the logistics robotics industry exhibits characteristics such as automation, intelligence, efficiency, safety, and sustainable development [2]. In terms of automation, the industry emphasizes the application of automation technology to enhance operational efficiency and reduce costs. Regarding intelligence, logistics robots possess intelligent sensing, decision-making, and learning capabilities to adapt to complex environments and changing demands [3]. The focus on efficiency involves optimizing path planning and task scheduling to achieve rapid and precise goods transportation. Safety measures include the integration of sensors and collision avoidance devices to prevent accidents and ensure the safety of surrounding personnel. Concerns for sustainable development involve environmentally friendly practices and resource conservation, incorporating energy-efficient designs and optimized route planning to minimize environmental impact. These characteristics collectively constitute the core values of the logistics robotics industry, driving the digital transformation and enhancement of the logistics sector, in alignment with national industrial policies and sustainable development goals.

(1) Automation: The logistics robotics industry emphasizes the application of automation technology, allowing real-time adjustments to task assignments and collaborative work with other logistics robots to enhance overall efficiency and reduce labor costs.

(2) Efficiency: Logistics robots can handle various tasks in the logistics field, including transportation, sorting, labeling, etc. They can adapt to different factory, warehouse, and logistics scenarios. In comparison to other robots that focus on specific tasks, logistics robots efficiently complete diverse operations, improving the speed and accuracy of logistics operations. For instance, optimization of path planning and task scheduling enables rapid and precise goods transportation.

(3) Safety: Logistics robots are equipped with safety protection mechanisms to prevent accidents and ensure the safety of surrounding personnel. For example, they are fitted with sensors and collision avoidance devices that enable timely detection and avoidance of obstacles, reducing the risk of accidents.

(4) Sustainable Development: The logistics robotics industry places a strong emphasis on environmental friendliness and resource conservation to promote sustainable development. This includes the adoption of energy-efficient designs and optimized route planning to minimize environmental impact. For instance, the use of rechargeable batteries contributes to reducing the industry's overall environmental footprint.

2. Analysis of Logistics Robotics Industry Chain

The upstream of the logistics robot industry chain consists of automation hardware equipment and software systems. The hardware equipment mainly includes sensors, controllers, electronic components, servo motors, and batteries. The software equipment primarily involves third-party WCS/RCS software vendors, with software suppliers predominantly offering supporting services to hardware or system integrators [4]. This helps reduce enterprises' research and development investment in software, lowering project costs. The midstream involves various types of logistics robots, including AGV handling robots, sorting robots, AMR robots, and production robots. Currently, well-known system integrators have mostly evolved from warehousing logistics equipment suppliers or software developers. Intelligent warehousing integrators' projects are typically customized, leading them to adopt a direct sales model. The downstream, which currently exhibits a high demand for the warehousing automation industry, includes industries such as new energy, automotive, 3C,

home appliances, semiconductors, e-commerce, food, and clothing. Industries with diverse products and high standardization are more inclined towards automation while emerging industries mostly favor logistics warehousing automation, influenced by automation investment costs and demands.

Despite the current robust development momentum of the warehousing logistics automation industry, as a nascent industry, it faces challenges. On the one hand, from upstream components to logistics robot products, there is a lack of unified industry standards. On the other hand, the shortage of long-term application experience in logistics robot products leads to issues such as uneven product quality, increasing the operational maintenance costs for downstream customers. Therefore, with the gradual maturation of the hardware form of logistics robot products, leading enterprises are increasingly focusing on improving product quality, with high stability becoming a crucial direction for enhancing products [5]. As highly stable logistics robot products are widely adopted, abundant data from logistics processes like handling and sorting also have a stable channel for collection and analysis, providing an essential foundation for downstream customers' digital transformation.

2.1 Upstream

The upstream components include sensors, controllers, electronic components, servo motors, servo drives, reducers, intelligent controllers, calculators, sensors, end effectors, batteries, and other parts. The prices and supply of these components have a significant impact on the cost and production of logistics robot products. Leading logistics robot manufacturers often share common core component suppliers, with lithium battery module manufacturers like Feimaotui, Desai, and Toshiba becoming the main battery suppliers for top logistics robot manufacturers.

In the cost composition of logistics robots, precision reducers, servo motors, and controllers account for approximately 30%, 20%, and 17% of the logistics robot cost, respectively, totaling about 70%. In terms of revenue, the three major components have gross profit margins of 40% (reducers), 35% (servo controllers), and 25% (controllers), higher than the 15% for midstream robot bodies and 25% for downstream system integration.

The market size of China's intelligent controller market has grown from 1,171.29 billion yuan in 2015 to 2,382.26 billion yuan in 2020, with a compound annual growth rate of 15.3% from 2015 to 2020. As the demand for terminal automation and intelligence continues to rise, the technical difficulty and cost of intelligent controller products are also increasing. The intelligent controller industry, which was initially dependent on downstream terminal manufacturers, is gradually separating from terminal manufacturers and forming a specialized industry. This further promotes the expansion of intelligent controller products in downstream applications, with an expected year-over-year growth rate of about 10.0% in the next five years. The market size is projected to reach 4,186.71 billion yuan in 2025, with an expected compound annual growth rate of 11.9% from 2020 to 2025. The downstream application areas of intelligent controllers are vast, and with the widespread adoption of intelligence and connectivity, the intelligent controller market is expected to continue growing.

Reducers play a crucial role in industrial robots by reducing speed to the required levels for various joints of industrial robots. Reducers are high-precision products with a long product development cycle, large upfront capital investment, high technical complexity, and production difficulty. The barriers to entry in the reducer industry are extremely high, making it the weakest link in the development of China's industrial robot field. The reducer industry has a high concentration, with the market being monopolized by a few international companies, with international manufacturers having a market share of over 90%. Chinese manufacturers have a relatively low market share. Still, many Chinese companies are involved in research and development in this field and are in a positive growth cycle of technology digestion, product scaling, and capacity expansion. With continuous expansion of downstream demand, it is expected that the domestication rate of reducers will be significantly increased in the future.

The role of reducers in welding robots mainly includes RV reducers and harmonic reducers. RV reducers are mostly installed in heavy-load parts of robots, such as the robot's large arm and base. Harmonic reducers are mainly used in light-load parts such as the robot's forearm, wrist, and hand. The ratio of RV reducers to harmonic reducers is approximately 3:1, but the domestication of RV reducers is still in its early stages. Compared to RV reducers, harmonic reducers have lower technical requirements, and Chinese manufacturers have successfully overcome the technical challenges in this field, gaining a foothold in the market. Lude's harmonic reducer already holds a 20% market share as of 2019, breaking the monopoly of international companies in the Chinese market. With the continuous progress of Chinese companies' technology, the process of domestic substitution will accelerate.

2.2 Midstream

In the midstream, there are various types of logistics robots, including AGV handling robots, sorting robots, palletizing robots, picking robots, AMR robots, and production robots. System integrators play the role of the 'chief director' in warehouse automation, requiring the ability for overall planning, system design, and resource integration. They also need a profound understanding of the scenarios to ensure that various aspects of warehouse operations are reasonable,

economical, and efficient. This places the highest comprehensive requirements on system integrators throughout the entire industry chain. The industrial manufacturing scene is becoming a new blue ocean, with companies such as Jizhijia, Kuai-Cang, Hikvision Robotics, Hairou Innovation, among others, actively venturing into the industrial manufacturing sector.

Looking at the distribution of the number of newly registered companies, from 2017 to 2022, the number of new companies registered in the field of logistics robots in China has been steadily increasing each year. The outbreak of the COVID-19 pandemic in 2020 spurred further demand for warehouse automation and unmanned operations. Simultaneously, the surge in business volume in the e-commerce industry attracted more players optimistic about the development prospects of the segment. This led to a staggering 110.6% year-on-year growth, rapidly expanding the number of newly registered companies from 1,743 in 2017 to 6,340 in 2020. In 2021, the number of newly registered logistics robot companies reached 9,868, with a slightly slower growth rate. As of July 14, 2022, the total number of relevant companies in the Chinese logistics robot industry (in all operating states) has reached 34,420. In 2022, the overall sales of industrial application mobile robots (AGV/AMR) in the Chinese market reached 93,000 units, a 29.17% increase compared to 2021, and the market size reached 18.5 billion yuan, a year-on-year increase of 46.82%. Under the overarching trend of industrial intelligence upgrading, the demand for warehouse and logistics robots, with AGV/AMR mobile robots as the main force, continues to thrive.

2.3 Downstream

The downstream application scenarios of logistics robots are mainly divided into two categories: commercial warehouse distribution and industrial manufacturing. The demand and application situations in these fields directly impact the market size and growth of the logistics robot market. The rapid development of commercial warehouse distribution scenarios, represented by e-commerce, has driven the maturity of logistics robot applications and further penetrated into industrial manufacturing scenarios. Various sub-scenes under commercial warehouse distribution, due to their proximity in business and warehousing models, often allow logistics robot manufacturers to quickly expand from one sub-industry to others. On the other hand, various sub-scenes in industrial manufacturing, due to significant differences in production organizational patterns, often lead logistics robot manufacturers to specialize in specific scenes, with a high degree of customization between different scenes.

Specifically, downstream applications of logistics robots are applied in various fields such as e-commerce, express logistics, automobile manufacturing, electronics, food and beverage, pharmaceutical manufacturing, and metal processing. Among these, the main application areas are the automotive industry and home appliance manufacturing, accounting for 24% and 22%, respectively. Following these are e-commerce warehousing and logistics application areas at 15.0%, tobacco manufacturing at 15.0%, 3C electronics at 13.0%, food and beverage at 6.0%, and other application areas at 5.0%. The vigorous development in each field drives the overall industry scale. In 2023, from January to July, China's automobile production and sales reached 15.65 million and 15.626 million vehicles, with year-on-year growth of 7.4% and 7.9%, achieving steady growth in production and sales. In 2022, China's total social logistics value set a new record, reaching 34.76 trillion yuan, achieving stable growth. In recent years, the scale of China's e-commerce transactions has continued to expand, maintaining its position as the world's leading online retail market. According to the statistics of the National Bureau of Statistics, China's e-commerce transaction scale has grown from 26.1 trillion yuan in 2016 to 43.83 trillion yuan in 2022, with a compound annual growth rate of 8.9%.

3. Conclusion and Outlook

In conclusion, the logistics robotics industry represents a dynamic and evolving sector at the intersection of artificial intelligence, automation technology, and machine vision technology. Positioned as a category within service robots, logistics robots are designed to provide comprehensive automation solutions for the logistics industry. The industry focuses on enhancing efficiency, reducing costs, improving safety, and increasing accuracy in industrial settings, with the ultimate goal of achieving higher levels of logistics automation and intelligence. Logistics robots, encompassing functions such as transportation, warehousing, sorting, distribution, and information services, play a vital role in extending the industrial chain and contributing to the overall value and supply chain.

Looking forward, the logistics robotics industry is poised for significant advancements and transformations. Future trends in the development of logistics robots are anticipated to revolve around increased intelligence, greater adaptability to diverse scenarios, and enhanced collaboration with humans. The trajectory indicates a shift towards more sophisticated robotics solutions that integrate advanced navigation systems, sensors, and intelligent algorithms. These advancements will empower logistics robots to autonomously navigate and perform tasks with heightened precision and versatility.

The increased intelligence of logistics robots implies a deeper integration of sensing, decision-making, and learning capabilities, allowing them to adapt to complex environments and changing demands. Greater adaptability to different scenarios will enable logistics robots to seamlessly operate in diverse industrial settings, addressing specific needs and challenges unique to each environment. This adaptability will not only enhance operational efficiency but also contribute

to the versatility of logistics robots in meeting the evolving demands of the industrial landscape.

Moreover, the future holds prospects for enhanced collaboration between logistics robots and human workers. This collaborative approach envisions a harmonious interaction where robots complement human capabilities, contributing to a more efficient and productive work environment. As logistics robots evolve, their collaborative nature will foster a symbiotic relationship with human workers, leveraging the strengths of both to achieve optimal outcomes.

In essence, the outlook for the logistics robotics industry is characterized by a journey towards increased intelligence, adaptability, and collaboration. These trends are indicative of a future where logistics robots become integral partners in industrial processes, offering more efficient, reliable, and secure logistics solutions to meet the evolving demands of the industrial sector. As technology continues to advance, the logistics robotics industry is set to play a pivotal role in shaping the future of industrial automation and intelligent logistics solutions.

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