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Efficiency of Unmanned Storage in Intelligent Logistics: A Case Study of Jingdong Logistics Kunshan Sorting Center

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Abstract: With the rapid development of Internet of Things technology, the number of parcels in circulation on the market has soared, and people's response speed requirements for commodity supply are getting higher and higher. Intelligent logistics unmanned sorting systems have proposed new solutions to speed up the response speed of the supply chain. Taking Jingdong Logistics Kunshan unmanned sorting center as an example, this paper introduces the workflow of the unmanned sorting center and explores the reasons for the high efficiency of automatic warehousing in Jingdong Logistics Kunshan unmanned sorting Center, involving automatic guided vehicle (AGV), radio frequency identification (RFID) and other technologies. It extends from the Kunshan unmanned sorting Center to the whole unmanned sorting field and puts forward optimization suggestions for the possible problems in the current unmanned sorting field. This study provides ideas for the technological transformation of relevant small and medium-sized logistics enterprises and provides suggestions for the development of the unmanned sorting field of intelligent logistics.

Keywords: intelligent logistics, unattended sorting, AGV, RFID.

1. Introduction

In recent years, with China's rapid economic development, people's growing need for a better life increased, the response speed of commodity supply directly affects consumers' consumption experience, related to people's quality of life, logistics warehousing sorting link has become a crucial link. With the rapid development of the Internet in the 21st century, sorting efficiency can be effectively improved and labor costs reduced with the help of digital intelligent equipment. In the Guiding Opinions of The State Council on Actively promoting the "Internet +" action, it is proposed that the use of IoT technologies such as two-dimensional code and radio frequency identification (RFID) should be actively promoted in the process of warehousing to improve operational efficiency, simplify the processing steps of complex orders by enterprises, and build intelligent warehousing systems. With the development of e-commerce, the amount of parcels circulating in society continues to increase, and traditional manual sorting cannot adapt to the era of parcel surge. Some scholars have proposed that smartness in the "3S" feature of the new generation of logistics systems represents wisdom, that is, unmanned operation and decision-making wisdom. Unmanned will become the only way for enterprises to develop [1]. In view of the need for intelligent logistics automated warehousing systems in the environment, Jingdong Logistics launched the Kunshan unmanned sorting center, in the entire unmanned sorting process, automatic guided vehicle (AGV), radio frequency identification

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(RFID) and other technologies are widely used. AGV can run along the set route and deliver goods to the designated area during the sorting process. Jingdong Logistics uses AGV for unmanned sorting on a large scale to improve automation efficiency [2]. RFID has become a powerful support technology for supply chain management and is also widely used in unmanned sorting processes to identify goods and monitor trends in real time [3]. Compared with the traditional sorting mode, the sorting capacity of Kunshan unmanned sorting center is significantly improved and the staff is greatly saved, which is mainly related to factors such as technology-driven and data-enabled. Forming an efficient and intelligent logistics environment, freeing human hands from logistics management and operation, unmanned will become the only way for enterprise development, and Jingdong Logistics warehousing and sorting has stepped into the intelligent door.

This paper summarizes the operation core process of Jingdong Logistics Kunshan's unmanned sorting Center, the reasons for high efficiency, possible problems and optimization suggestions. The significance of this review is to provide ideas for the technological transformation of relevant small and medium-sized logistics enterprises, and at the same time to make suggestions for the development of intelligent logistics unmanned sorting field.

2. Case Introduction

JD Logistics had seven domestic logistics centers in 2017, covering more than 1,000 districts and counties. The unmanned sorting mode "Asia No. 1" launched by Jingdong Logistics sorting Center in Kunshan, Jiangsu Province, is also the first unmanned sorting center in the world to successfully land and operate. In 2023, the second phase of the Kunshan unmanned Sorting Center was newly completed, and dozens of automatic sorting lines and tens of thousands of sorting equipment were added throughout the park, which can reach 24-hour uninterrupted operation. The operation process of Jingdong Logistics Kunshan sorting center is mainly divided into seven parts: automatic unloading, automatic bag supply, automatic separation, automatic scanning, automatic sorting, automatic bag drop, automatic pick-up and automatic loading. In the automatic unloading stage, the AGV will forklift the cage from the inside of the car and transport it to the dumping area, the cargo is sent to the single-piece separation area, and the empty cage is sent to the empty cage storage area. When a single piece is separated, adding image recognition equipment can track the video surveillance system can track the goods in real time, visualize the path of the goods, and ensure the safety of the property. Compared with the sorting mode in which most logistics sorting equipment only used top-side scanning or single-side scanning for goods in the past, Kunshan unmanned sorting Center realizes six-side accurate scanning of goods information, which is more accurate and efficient [4]. But at the same time, it is found that the whole process needs to be optimized, such as the processing method when the AGV navigation QR code is damaged and the security of RFID information collection. The continuous optimization and improvement of the process to solve the problems in the actual application process is not only the problem that Jingdong Logistics Kunshan unmanned sorting center needs to deal with but also the risk that relevant small and medium-sized logistics enterprises need to avoid in the transformation process.

3. Analyze

3.1. Core Process

The core technologies mainly used by Jingdong Logistics Kunshan unmanned sorting center are automatic guided vehicle (AGV) and radio frequency identification (RFID) technology, which are also the two core technologies that relevant small and medium-sized logistics enterprises first consider introducing when carrying out automation transformation. In the work process of Kunshan unmanned sorting center, AGV plays the role of "intelligent porter", and realizes the automation of

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handling, obstacle avoidance, task execution and charging with the help of total control mobilization, mainly used for automatic unloading, automatic pick-up and loading, etc., AGV takes out or stores the cage of loaded goods according to the instructions issued by the system, and is transported to the designated storage area when needed. Kunshan Unmanned Sorting Center is also the first sorting center in China to complete the sorting operation using AGV automatic loading and unloading trucks at the front and rear ends. Due to the use of the cage transport mode, the shape of the goods is more regular, the process of AGV forklift goods becomes more convenient, effectively improving the loading efficiency, while the cage transport can also protect the goods in the process of transportation from bumps and wear to a certain extent, reducing the risk of compensation. When the loaded vehicle arrives, the AGV is assigned the task of forklifting the cage from the vehicle and taking it to the temporary storage area or the cargo dumping area as instructed. The use of automatic dumping equipment in the automatic dumping area will dump the package out and along the transport line to the single piece separation area, at which point the AGV will transport the empty cage box to the empty cage storage area for recycling. Kunshan unmanned sorting center is equipped with a number of transport lines, the volume weight of the package is measured at the same time in the process of separating the package, the basic information such as order identification is uploaded to the IPMS system for tracking the sorting of the package in the later stage, the package is classified according to the identified information, and the package is transported to the corresponding cage box, the sensor device in the cage box can monitor the loading of the cage box in real time. When the load is filled, the control system will give instructions to the AGV to pick up the goods, and the delivery process will also pass through the RFID identification area to detect whether there is any wrong order through the radio frequency technology. If there is no abnormality, the AGV will continue to carry out the next loading operation [4].

3.2. Reasons for good efficiency

3.2.1. Technology Driven

Kunshan unmanned sorting center operations rely on the development of the Internet of Things era, the use of technology driven, by a variety of technology integration. Replacing traditional manual operations with intelligent equipment has many advantages. In terms of efficiency, intelligent equipment can continue to operate in accordance with the set procedure, without interference from human factors such as fatigue or emotion, and the sorting speed is far higher than that of traditional manual sorting, which can greatly shorten the package processing time and improve the overall storage sorting efficiency. Secondly, the use of intelligent equipment instead of manual, higher accuracy, with accurate induction, recognition and computing technology, can accurately identify all kinds of package information and classification, greatly reduce the manual sorting prone to misoperation, reduce the misclassification rate, to ensure the accurate delivery of packages. From the cost point of view, although the initial equipment purchase and maintenance need to invest money, but also the cost of one-time purchase of equipment, the latter only bears the maintenance cost. In the long run, it reduces a lot of labor costs, including human compensation, benefits and related management expenses. In addition, the intelligent equipment can work 24 hours a day, can flexibly respond to the mass package sorting task during the peak of logistics, enhance the ability of logistics enterprises to cope with business fluctuations, improve the competitiveness of enterprises and service quality, and promote the rapid development of the logistics industry in the direction of efficiency, precision and intelligence.

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3.2.2. Data Enablement

In the era of developed big data, Jingdong Logistics Kunshan unmanned sorting center adopts information identification technology, collects and processes information in the cloud, and uses data empowerment to accurately identify problems. With the help of data monitoring and analysis tools, Kunshan unmanned sorting centers can gain real-time insight into all aspects of the business process, accurately find existing problems and bottlenecks, such as inefficient links in the sorting process, delay points, etc., and optimize the process in time. When carrying out technology transformation, relevant small and medium-sized enterprises should also rely on the background of The Times and rationally use automation equipment and big data resources to optimize the process.

3.3. Existing Problems

In modern intelligent logistics, RFID technology can be applied to warehousing preparation, goods ordering, vehicle entry, goods inventory and other aspects. In transformation planning, small and medium-sized enterprises can reasonably choose the use of links according to their own warehouse characteristics [5]. In the process of use, it is necessary to pay attention to data security and privacy issues, and there may be a risk of data leakage when RFID systems read label information. If criminals obtain the information on the label through technical means, it may pose a threat to the security of the goods and the business secrets of the enterprise.

The use of AGV may also have some problems, compared with the traditional cross-belt sorting machine, AGV car has a high degree of automation, information and intelligence, so as to achieve the function of replacing manual handling, but through research, it is found that there will be some practical problems in the application of AGV in the logistics industry, resulting in the effect can not meet the expectations. At present, most of the AGV navigation works are carried out by identifying two-dimensional code. If there is no identification of new materials or the two-dimensional code is worn, more efforts may be needed to remedy the situation in the later stage [6].

Unmanned sorting centers are often in a complex environment with multiple AGVs working at the same time, which requires AGVs to have high precision to avoid obstacles, but AGVs have limited adaptability to complex environments: In the face of some special situations, such as the irregular placement of goods and the identification of new types of goods, AGV will be difficult to take into account the avoidance of static and dynamic obstacles, and it is necessary to further improve its adaptability to complex environments and intelligent recognition ability.

3.4. Optimization Suggestions

Encryption technology: The high-strength encryption algorithm is used to encrypt the data of the RFID tag to ensure that the data will not be stolen or tampered with during transmission.

Security authentication mechanism: The introduction of multiple authentication mechanisms, such as authentication and access control, to ensure that only authorized personnel can read or modify the information of RFID tags. At the same time, ensure that all reading devices are certified to avoid data leaks.

Regular audit and monitoring: Strengthen the regular audit and monitoring of the RFID system, timely discover and repair potential security vulnerabilities, and ensure data security.

Multiple navigation systems: In addition to QR code navigation, a combination of laser radar (LiDAR), visual navigation, inertial measurement unit (IMU) and other navigation technologies can be introduced to improve the adaptability of AGVs in complex environments.

Quality and maintenance of QR code: Optimize the use of QR code labels, selecting durable and non-abrasive materials. Check and replace the QR code regularly to ensure its clarity and readability, and avoid the navigation effect due to wear or damage to the label.

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Deep learning technology: The self-learning and adaptive capabilities of AGVs can be enhanced by introducing more advanced artificial intelligence and deep learning technologies. For example, the AGV's image recognition system can be trained to recognize multiple types of cargo, different placement patterns, and environmental changes.

Cross-platform data sharing: Through data sharing and collaboration with other AGVs and systems, AGVs are able to adapt to new types of cargo and special environments. Multiple AGVs can share information, learn and adapt to complex work scenarios.

Regular system updates and optimizations: The AGV's operating system and intelligent recognition algorithms are regularly updated to ensure that it can keep pace with technological developments and respond to new logistics challenges in a timely manner.

Some scholars have proposed a privacy protection model that can use label ownership transfer and selected a label ownership transfer prototype protocol based on public key encryption to protect label privacy, effectively prevent information disclosure, and ensure information security [7]. Some scholars also suggest using a fusion algorithm to improve the AGV obstacle avoidance function, which can effectively avoid dynamic and static obstacles and find the optimal path to speed up work efficiency [8]. AGV has high requirements on the ground and needs a relatively flat ground during operation. If the ground is uneven, cracked or has debris accumulation, it may affect the AGV's driving stability and navigation accuracy, and even lead to the vehicle stalling, derailing or damage. Therefore, relevant small and medium-sized enterprises should consider in advance whether to choose to re-modify the ground when carrying out transformation planning to prevent cost losses such as equipment damage in the later stage.

In order to improve the operator's understanding and use efficiency of the intelligent logistics system, the operating system interface should have a high degree of visualization. For example, big data visualization technology can be used to display RFID data flow, inventory status, real-time location and status of AGVs, etc., to help operators more intuitively understand the operation of the system, so as to manage it more effectively.

With the popularization of technologies such as AGV and RFID, enterprises can regularly train employees to master the operation skills, troubleshooting ability and safety awareness of new technologies, and ensure the efficient and safe operation of intelligent logistics systems.

4. Conclusion

The successful operation of Jingdong Logistics Kunshan unmanned sorting Center has created a pioneer in the field of intelligent logistics unmanned sorting, and provided a feasible idea for the automatic transformation of relevant small and medium-sized logistics enterprises. In the process of automation transformation, you can refer to the working steps of Kunshan unmanned sorting center for process design, but at the same time, it is also necessary to consider the background factors of the enterprise itself and carry out the risk assessment, such as whether the environment meets the conditions for the introduction of intelligent equipment. The detailed problems in the optimization process, such as solving the problem of AGV operation sign deficiency, optimizing the AGV obstacle avoidance function, and strictly requiring RFID security technical standards, are not only problems that Jingdong Logistics needs to pay attention to but also the entire logistics industry. At present, labor shortages, rising costs, the rapid development of e-commerce and the express delivery industry, manual sorting make it difficult to meet the demand, and its accuracy is poor, high loss, and the trend of intelligent logistics also promotes the advancement of unmanned sorting. The future development prospect of the unmanned sorting field is broad, the technical sorting efficiency and identification accuracy will continue to improve, will be more intelligent, flexible, intelligent decision-making, adapt to diverse needs, will also deeply integrate multi-technology to achieve system integration, the

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industrial chain cooperation of all links to build ecology, promote industry innovation and development, bring new changes and efficient operation in the field of logistics.

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