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Design and Implementation of Automated Stereoscopic Warehouse Based on Artificial Intelligence

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Abstract

In recent years, with the rapid development of e-commerce, automated warehouses have become the core component of modern logistics systems and are widely used by major enterprises to improve logistics efficiency and reduce costs. Through the implementation of artificial intelligence technology, the warehouse automation system has achieved automatic identification, planning, scheduling, and control functions. This has greatly enhanced the level of intelligence in the warehouse. This paper will provide a detailed introduction to the design and implementation process of an automated warehouse based on artificial intelligence. First, we will discuss the necessity and advantages of incorporating artificial intelligence technology in the design of automated three-dimensional warehouses. Then, through the analysis of specific cases, this article explains the application of artificial intelligence technology in automated warehouses. This includes automatic identification, automatic planning, automatic scheduling, and automatic control. Finally, this paper summarizes the key steps and methods involved in the design and implementation of an automated warehouse based on artificial intelligence. It also highlights the future research directions and development trends in this field. In short, by incorporating artificial intelligence technology into the design and implementation of automated three-dimensional warehouses, we can achieve intelligent warehouse management, enhance logistics efficiency, and reduce costs.

Keywords

Artificial intelligence, Ant colony algorithm, Automation, Three-dimensional warehouse, Design

1. Introduction

The development of an intelligent automated warehouse system in China is still in its infancy, and the development space is huge. Artificial intelligence technology has powerful computing and reasoning abilities, and its application in three-dimensional warehouse design can improve system efficiency and reduce costs, which is one of the core technologies in the development of intelligent automated three-dimensional warehouse. From the perspective of artificial intelligence, this paper analyzes the necessity of applying artificial intelligence in automated three-dimensional warehouse, puts forward the design framework of automated three-dimensional warehouse system based on artificial intelligence, and analyzes the problems that may exist in the practical application of the system, which provides a useful reference for the design and implementation of intelligent automated three-dimensional warehouse

system.

2. Design and implementation of automated three-dimensional warehouse based on artificial intelligence

2.1 Automated warehouse system

An automated three-dimensional warehouse (AS/RS) refers to a storage equipment system that consists of shelves, tunnel stackers, tunnel shuttles, and scheduling systems. This system enables automatic storage and sorting. An automated three-dimensional warehouse is a crucial component of a modern logistics system. It integrates storage equipment, conveying equipment, sorting equipment, and other logistics equipment to efficiently handle goods, sorting, storage, and other functions. It represents the most intricate form of warehousing in logistics operations. In an automated warehouse, the shelf and tunnel stacker are the core equipment. The shelf serves as a storage unit for goods and is responsible for transporting them to their designated location. The drift stacker is responsible for removing goods from the shelves. The dispatch system is responsible for distributing various types of cargo to different handling equipment, including forklifts and automatic sorting equipment. The automated warehouse system needs to complete the handling, storage, and other operations of the goods. It also needs to classify and sort them according to their type to improve storage efficiency.

The automatic warehouse system is composed of several subsystems, such as a control system, stacker system, scheduling system, etc. These subsystems exchange and share information through control and communication equipment, to realize the management and control of goods in the warehouse. The stacker mainly completes the tasks of cargo handling and storage. The tunnel stacker mainly completes the task of loading and unloading goods; The scheduling system is mainly responsible for coordinating the work among each subsystem to ensure the efficient operation of each subsystem.

2.2 Intelligent storage system design and implementation

Intelligent storage system refers to the intelligent operation of automated three-dimensional warehouses through artificial intelligence technology and Internet of Things technology, and the improvement of data processing and storage capabilities through big data analysis and cloud computing technology. In the intelligent storage system, the ant colony algorithm can be introduced to optimize the storage and distribution of goods and improve the storage efficiency. Ant colony algorithm is a kind of optimization algorithm based on simulating the behavior of ants in the process of finding food in nature, which is widely used to solve optimization problems in logistics and supply chain management.

First, a model based on the ant colony algorithm is built to transform the problem of storage and distribution of goods into an optimization problem similar to that of ants looking for food. In this model, ants choose the optimal path to reach the target goods according to the demand information of the goods and the storage information of the warehouse. At the same time, ants will adjust their selection strategy according to the pheromone concentration on the path and the selection situation of other ants, to find the optimal solution. Secondly, the algorithm is integrated into the design of an intelligent storage system. The Internet of Things technology is used to obtain the demand information of goods and the storage information of the warehouse, and then the ant colony algorithm is used to process and analyze the acquired data, and the optimal storage and distribution path of goods is calculated. Next, according to the calculation results, the automatic identification, classification, storage, and distribution of goods are realized by controlling intelligent storage equipment (such as automated three-dimensional warehouses, robots, etc.). In addition, other swarm intelligence algorithms such as genetic algorithms and particle swarm optimization algorithms can be introduced to enrich and improve the optimization strategy of intelligent storage systems.

Several key issues need to be noted in the implementation process. First of all, the accuracy and timeliness of information acquisition are crucial to the optimization results of algorithms, so it is necessary to ensure the stability and reliability of IoT technology. Secondly, although the ant colony algorithm has a strong global search ability, it may fall into local optimal solutions when solving large-scale problems. Therefore, it is necessary to improve the global search ability of the algorithm by setting reasonable algorithm parameters and adjusting algorithm policies. In addition, the implementation of intelligent warehousing systems also needs to consider the integration and compatibility with existing systems, as well as the security and stability of system operation.

3. Design and implementation core of automated three-dimensional warehouse based on artificial intelligence

3.1 Requirement Analysis

The automated warehouse is an important part of the logistics system, which can realize high-density storage and efficient operation. At present, most of the warehouse enterprises in our country adopt the traditional manual operation mode. Although this method can ensure the high-density storage of goods, there are still shortcomings in some aspects. First, manual work is inefficient and can only handle a limited amount of goods. Secondly, manual operation requires a lot of manpower and material support. In addition, due to relatively high labor costs, warehousing costs are relatively high.

Therefore, automated three-dimensional warehouses should be optimized and upgraded in conjunction with artificial intelligence technology. Efficient classification and sorting of goods can be achieved through the use of intelligent algorithms, which can help reduce the number of warehouse workers. Additionally, automatic planning and scheduling can be implemented using artificial intelligence technology, which can further reduce the need for staff. Intelligent algorithms can also be utilized to locate and navigate goods, thereby improving the efficiency and accuracy of warehousing operations.

3.2 Implementation Plan

This design adopts a three-layer structure, of which the first layer is "artificial shelf", the second layer is "stacker", and the third layer is "conveying line". Each of the three levels consists of an "artificial shelf", a stacker and a conveyor, which are connected by signal interfaces. The robot (AGV) is responsible for reading the data from the outside and sending it to the goods in the "artificial shelf" to complete the automatic access work. In the whole system, all the equipment is controlled by PLC. The whole system is implemented by computer programming, and various intelligent devices such as sensors, robotic arms, photoelectric sensors, and motors are used to improve the intelligent level of the system.

The system mainly includes the following functional modules: (1) storage and handling; (2) Transmission and control; (3) Monitoring and management.

3.3 System Architecture

The automated warehouse consists of several operating units, each of which is equipped with corresponding intelligent equipment, such as intelligent forklift trucks, intelligent AGVs and intelligent robots. Among them, AGV is the core of the whole system. AGV is an automated device that can drive and plan its own path. It consists of handlebars and a drive motor. The AGV receives information through sensors mounted on the chassis, and sends instructions to the computer according to the instructions while receiving the commands issued by the computer [1].

Tasks are performed by robots. Among them, the robot is the key equipment in the automated three-dimensional warehouse, which is used to complete various tasks such as warehousing, warehousing, picking, handling, and storage. In the whole system, AGV plays an important role.

3.4 Project plan and budget

(1) Project planning includes demand analysis, design scheme, construction scheme, equipment selection, control system design, etc. Project planning should consider the integrity of the entire project and master plan the entire project to avoid waste.

(2) Budget: The project budget mainly includes equipment procurement, civil construction, software development, etc. According to the system function, the equipment we need will be selected according to different models, and then the corresponding price will be determined. In the process of software development, we need to divide the software according to its functions, and then divide the software into different modules.

4. Design and implementation strategy of automated three-dimensional warehouse based on artificial intelligence

4.1 Strengthen top-level design and promote technological innovation

It is suggested to enhance the top-level design of intelligent automated three-dimensional warehouses at the

national level. This includes clarifying development goals, strengthening overall planning, and ensuring a well-executed top-level design [2]. On the one hand, it is important to fully utilize the potential of industry associations and other industry organizations. These organizations should coordinate with key enterprises in different regions and industries, as well as scientific research units, colleges, and universities, to conduct surveys on the development status, challenges, and demands of intelligent automated three-dimensional warehouses. This will help to gain insights into market demands and technological trends, and provide industry enterprises with market consulting and technical training services. On the other hand, research and development work on intelligent automated three-dimensional warehouse technology is being conducted at the national level and is included in the national major science and technology special fields. At the same time, it is necessary to clarify the research and development responsibilities and division of labor between scientific research units and enterprises. Support should be provided to universities, research institutes, and enterprises to closely collaborate on research and development work. Encouragement should be given to scientific researchers and enterprises to conduct joint technical research, thereby promoting the development of key technologies for intelligent automated three-dimensional warehouse systems.

4.2 Emphasize system integration and build a technical system

In the design of a traditional automated warehouse system, a layered technical system is used. This system consists of three main parts: the logistics system, the information system, and the control system. The logistics system further includes the sub-functions of cargo storage, cargo handling, and cargo delivery. There are some flaws in the practical implementation of this system. With the increase in order volume, the complexity of tasks is also increasing. This can potentially result in operational errors during the logistics operation process. The data interaction between the logistics system, information system, and control system is not smooth enough, and the degree of data sharing is low. Additionally, the construction period of automated warehouses is longer, and the investment cost is higher. Artificial intelligence technology can optimize the logistics operation process, reduce the error rate of manual operations, and improve working efficiency. Therefore, when designing an intelligent automated warehouse, it is important to emphasize integration. This involves integrating different functional modules into the same physical space and building a comprehensive technology system for the warehouse. At the same time, modular technology should be adopted to improve the flexibility and scalability of automated warehouses, allowing them to adapt to the needs of different types of enterprises.

4.3 Pay attention to standards and norms and implement practical application

The application of artificial intelligence technology needs standardized guidance, especially in the application of automated three-dimensional warehouses, system design, integration and operation need to be standardized. At present, in the field of automated warehouse, there is no standard specification for the design, integration and operation of intelligent automated warehouse. Therefore, the whole process from system design to actual operation needs to be guided by corresponding standards [3].

The design of an intelligent automated warehouse system is a complex and huge system engineering, which involves many disciplines. When artificial intelligence technology is applied to the three-dimensional warehouse system, it is necessary to have a complete top-level design and carry out the overall planning from the top level. At the same time, in the process of specific project implementation, it is necessary to pay attention to details and specific links to ensure the implementation effect of the project. For example, an automated warehouse system usually contains multiple subsystems and equipment, and there should be clear specification requirements for each subsystem and equipment. Only in this way can we ensure that each subsystem and equipment can be designed and implemented by a unified standard specification.

The construction of an automated warehouse system involves many disciplines, so we should pay attention to the formulation and application of standards. In the construction of an automatic three-dimensional warehouse system, technical requirements such as intelligence, digitalization, and information technology should be fully considered, and construction work should be carried out by relevant national standards and norms to ensure that the project meets relevant national standards [4].

4.4 Pay attention to personnel training and consolidate the technical foundation

The application of artificial intelligence technology needs knowledge of computer technology, control theory,

information processing and so on. The development of intelligent automated three-dimensional warehouse cannot be separated from the support of talents, the research of artificial intelligence technology needs composite talents, the need for artificial intelligence technology professionals to have a deep understanding of information processing technology, intelligent control technology, robot system control and programming and other aspects of knowledge, and have a deeper understanding and understanding of related technologies. It is necessary to cultivate compound talents with both computer knowledge and logistics knowledge, and pay attention to the training mode of compound talents [5].

The application of artificial intelligence technology in an intelligent automated three-dimensional warehouse system needs to upgrade the existing robot equipment and combine the existing robot equipment with artificial intelligence to improve the efficiency and automation of the warehouse. Therefore, it is necessary to add intelligent modules based on existing robot equipment and integrate artificial intelligence modules into robot equipment. At the same time, the upgrading of the existing automated warehouse system should be strengthened to ensure its intelligence level. In addition, we should increase research and development efforts for a new automated three-dimensional warehouse system to better meet the evolving needs of the logistics industry. The intelligent automated warehouse system can better fulfill its functions and meet performance requirements.

4.5 Carry out pilot demonstrations to enhance industry impact

To conduct a pilot demonstration of an intelligent automated three-dimensional warehouse application, a logistics enterprise (referred to as the company) constructed a pilot warehouse that integrates warehousing, transportation, sorting, packaging, and other functions into one automated three-dimensional warehouse. The application of artificial intelligence technology in the automated three-dimensional warehouse system enables automatic identification of goods, automatic picking, and automatic warehousing, thereby improving work efficiency. At the same time, RFID (radio frequency identification) technology is utilized in the pilot warehouse to achieve automatic identification and sorting of goods. This enables quick and accurate selection of goods while reducing errors that may occur during manual operation [6].

The completion and operation of the pilot warehouse have solved numerous issues related to the storage and sorting of goods within the enterprise. This has significantly enhanced the level of automation and efficiency within the company. The enterprise utilizes the data accumulated in the pilot warehouse to analyze and summarize a set of intelligent automated three-dimensional warehouse system operation modes that are suitable for the enterprise. After implementing the intelligent automated three-dimensional warehouse system, a company adopted an intelligent management mode for operations management, resulting in significant achievements.

The intelligent automated warehouse, as a new model formed in the development of modern logistics, has the characteristics of low cost and high efficiency. With the continuous development and improvement of artificial intelligence technology and intelligent automated warehouse system technology, more enterprises will apply them to actual production.

5. Conclusion

With the continuous development of artificial intelligence technology, the application of artificial intelligence technology in the field of logistics, particularly in automated three-dimensional warehouse systems, is becoming increasingly extensive. This includes intelligent three-dimensional warehouse planning, automatic storage and transportation of goods, and automatic sorting of goods. In this paper, we analyze the connotations and characteristics of intelligent automated three-dimensional warehouses and propose a design framework for an automated three-dimensional warehouse system based on artificial intelligence. The design framework consists of a control layer, a management layer, and a human-computer interaction layer. The control layer is composed of a motion control module, a PLC control module, and a data acquisition module. The management layer is composed of a three-dimensional warehouse system, a data acquisition module, and a data processing module. The man-machine interaction layer includes warehouse operators, managers, data acquisition personnel, and so on. This design framework provides a useful reference for designing and implementing intelligent automated warehouses.

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