

## Intelligent Analysis of Storage

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### Abstract

With the rapid development of Internet technology, big data and Internet of things technology, traditional warehouse management technology has become ineffective. This article gives an overview of warehousing and its development trends and warehousing intelligence, and then introduces the current status of warehousing, and then expounds the technology application and implementation strategies for realizing warehousing intelligence. Finally, Jingdong's warehousing and logistics construction was used for case analysis.

### Keywords

Storage, Intelligent Storage, Jingdong Warehouse.

## 1. Overview of Intelligent Storage and Storage

### 1.1 Overview of Storage

Warehousing is the core of logistics process. Warehousing is the act of storing and storing goods that are not used in time. In other words, warehousing is the act of storing goods in a particular place. The main functions of warehousing can be divided into 4 parts: storage, handling, sorting and packaging[1]. The development of warehousing functions must closely follow the footsteps of the logistics industry. However, with the development of science and technology, the traditional warehousing functions can not meet the needs of the development of modern logistics industry, and gradually turn to the direction of intelligence and information.

### 1.2 The Development Trend of Storage

The development process of China's warehousing industry is mainly divided into five stages, Artificial warehousing, mechanized warehousing, automated warehousing, integrated automated warehousing and intelligent automated warehousing. In the early stage of artificial storage, the transportation, storage, management and control of materials are mainly realized by human labor. For mechanized warehousing, the main functions are replaced by mechanical equipment, such as conveyors, stackers, elevators, etc., and Automated warehousing has introduced AGV robots, automatic identification technology and automated warehouses on the basis of mechanized warehousing. Nowadays, integrated automation warehousing is mainly based on integrated system, and the overall cooperation of the whole system is realized. The mainstream intelligent automation warehousing in the future is dominated by artificial intelligence, Internet technology is the core and a perfect intelligent warehouse operation system is composed of various advanced technologies.

### 1.3 Intelligent Storage

On the basis of the function of traditional warehousing, intelligent storage means the use of Internet of things, network communication, information system application and advanced management methods to realize the functions of automatic collection, automatic identification, automatic sorting and intelligent management of the storage, storage and transfer management, so as to reduce the cost of storage and arrange the space of storage[2].

## **2. The application and Development Strategy of Intelligent Storage Technology**

### **2.1 Status of storage logistics**

#### **2.1.1 The level of equipment mechanization and management informatization has been improved.**

From a mechanized perspective, the mechanized operation rate of warehousing companies nationwide is over 42%, and the degree of management informationization has reached more than 56%. From an informatization point of view, the informationization of China's warehousing industry is gradually being transformed into intelligent warehousing. However, there are still some problems in China's warehousing companies, such as high logistics costs and small enterprise scale.

① The cost of logistics is high. According to "Global Logistics Performance Index 2016 Ranking", China's score is 3.66 (5-point scale), and Germany ranks first with 4.23 points. So there is still a large gap between the logistics costs of the two countries [3].

② The phenomenon of enterprise scattered is obvious. From 2008 to 2017, the number of warehousing enterprises in China increased from 17,400 to 57,000, with a compound annual growth rate of 18.3%. The number of employed persons increased from 510,000 to 1,300,000, with a compound annual growth rate of 9.4%. So the number of enterprises and jobs are on the rise. However, some traditional warehousing enterprises do not provide additional logistics value-added services because of low technical level.

③ The infrastructure is backward and the technical level is low. WMS management system has not been used reasonably in the warehousing industry. The warehousing management model does not cover the entire warehousing system.

#### **2.1.2 Rapid development in the field of new warehousing.**

In order to adapt to the rapid transformation of the times and improve the service level of enterprises, warehousing enterprises are constantly innovating. On the one hand, they make rational allocation of their resources, and on the other hand, strengthen the introduction of technology and the application of equipment. Therefore, the field of intelligent storage has been developing rapidly.

#### **2.1.3 Initial progress has been made in the transformation and upgrading of the storage industry.**

In terms of management, warehousing enterprises constantly improve their management and improve their service level. At the same time, they introduce advanced equipment and technology to develop different types of storage centers. In the direction of development, enterprises are trying to improve the quality of service.

#### **2.2.4 Analysis of smart storage market.**

According to statistics, the number of warehousing companies reached 57,000 in 2016, and more than 3,000 automated three-dimensional warehouses have been built. From the perspective of industry funding, the fixed assets in the warehousing industry increased by more than 580 billion yuan in 2016. From the introduction of equipment, the scale of warehousing automation equipment increased from 2 billion 500 million yuan in 2007 to 45 billion 300 million yuan in 2015, with an annual average growth rate of about 43.64% [3]. From the perspective of market demand, the market of intelligent storage in 2016 exceeded 51 billion 940 million yuan, an increase of 15.3% over the same period last year. With the development of the logistics industry and the strengthening of the strategic position of the warehousing industry, it provides a huge market demand for the development of the warehousing industry, so there is a huge market demand in the future intelligent storage. It is estimated that the scale of the intelligent storage market will reach 95 billion 410 million yuan in 2020, see Figure 1.



Figure 1 Intelligent storage market scale analysis

## 2.2 Application of Intelligent Storage Technology

There are four main aspects of the application of intelligent storage, see Figure 2.

### 2.2.1 The application of information technology

Nowadays, information technology has been widely applied to warehouse working systems, and integrated systems have also been applied. The integrated system can make the warehousing work resilience to get qualitative improvement. Integrated warehouse technology as a computer integrated manufacturing system (CIMS), including people, equipment and automatic control system [4]. The information of the goods can be accepted by the computer system at the first time. Then record the time of warehousing and calculate the inventory of goods. Therefore, planners can make effective supply decisions, and managers can accurately grasp the demand for goods. With the development of information technology, computer integrated system and equipment automation put forward higher requirements for storage system. The flow of goods in factories and warehouses must be accompanied by parallel information flows. Therefore, the development of information technology will promote the development of automated warehouse technology to intelligent automation.

### 2.2.2 Application of Internet of Things

At present, the Internet of Things is mainly supported by RFID technology and WSN technology. RFID technology is an extension of sensor technology. It is a non-contact automatic identification technology. It has the characteristics of large capacity, quick response, high tolerance, and anti-interference. Its automatic recognition function can improve the recognition ability of logistics intelligent storage system, and also improve the efficiency of logistics intelligent storage system [5]. WSN technology is the core of Internet of things technology, and it has strong information data sensing function after it is applied to logistics intelligent storage system. WSN needs to be able to transmit information quickly under the joint operation of ZigBee, infrared, Bluetooth and Wi Fi technology. herefore, the Internet of things improves the stability and security of logistics intelligent storage system, and expands the timeliness of wireless sensor technology.

### 2.2.3 The application of artificial intelligence

As far as the logistics industry is concerned, the application of artificial intelligence is mainly changed in the fields of data processing, rational planning, recognition mode, computer vision inspection and intelligent robot. Artificial intelligence can replace human computation, so that the problem of warehouse location can be optimized to the maximum extent. Artificial intelligence can fully modify and optimize the problem according to the constraints of the analysis of the realistic environment, so as to give a location model near the optimal solution[6]. Artificial intelligence can reduce the intervention of human factors, improve the utilization of storage space, make the location more accurate, so as to reduce the cost of storage more effectively and improve the profit of the enterprise. Artificial intelligence is also embodied in the workflow of warehousing. The introduction of a large number of intelligent robots greatly reduces the cost of time and space.

### 2.2.4 Application of cloud storage

The concept of cloud comes from cloud computing, and the rapid development of Internet makes a large number of industries covered by cloud concept. Cloud storage is the establishment of a large information management system at the company headquarters and setting up a division in a branch center.[4]The information system links the sorting centers of the whole country to form a huge information network. The information system serves as a server to analyze data for other sub

warehouses to achieve rapid reaction between distribution networks. From the initial data storage to the current data platform computing and analysis, cloud storage fits this aspect admirably. With the emergence of cloud storage, the entire storage sector will face new shocks and reforms. Traditional warehousing and logistics only provide customers with low-level logistics services such as storing goods. Under the cover of cloud storage, the warehouse management system will grasp the goods and financial information of all the customers, and then analyze the law of the sales of the customer's goods and the laws of the import and export of the goods, and even calculate the market change of the national storage industry and the law of the rise and fall of the industry, and so on. The final cloud storage will achieve the ultimate goal of zero inventory.

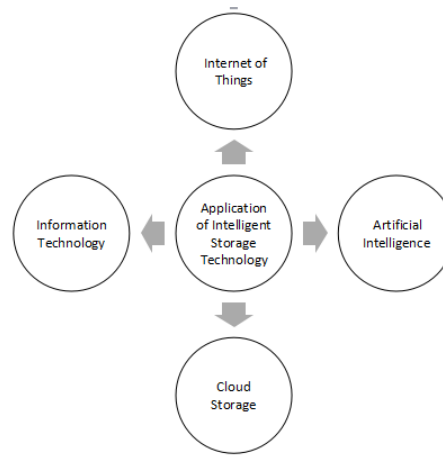


Figure 2 Application of Intelligent Storage Technology

## 2.3 Strategy for Realizing Intelligent Storage

### 2.3.1 Improve the logistics Management Mechanism and Improve the Standardization of logistics Information.

Logistics enterprises should set up a special intelligent logistics department to coordinate the logistics resources of various departments and ensure the circulation and sharing of logistics information. In addition, they should establish a unified standard of logistics informatization and improve enterprise information standardization. It is not only conducive to the improvement of the enterprise's own information construction, but also can break the barriers of information exchange between different enterprises. On the other hand, if the standard degree of goods in the warehouse is low, it will affect the use of related intelligent equipment. Therefore, enterprises attach importance to information standardization, which is the premise of improving automation and intelligent operation level, improving warehouse efficiency and management quality.

### 2.3.2 Developing large Data Technology for Logistics

Large data is the basis for building an intelligent storage system. The storage system platform based on large data has a certain development difficulty, and it needs to analyze and process a large amount of data to form the expected logistics service ability. The storage enterprise needs to continue to invest in the growth stage and gradually transition from artificial intelligence to artificial intelligence. The application of large data technology can be divided into four levels. The first level is the collection of warehousing logistics data. The second level is to use the large logistics business to carry on the effective evaluation. The third level is also the core of large data application is the prediction of material reserves or material flow, the fourth level is to use large data to help the leaders to make intelligent decision.

### 2.3.3 Use Technology to Optimize and Balance the Manual Work of Warehousing.

Although intelligent technology can replace manual work, artificial judgement, management and labor are still essential.[1]Therefore, the effective prediction, measurement, evaluation and management of different artificial work and the establishment of a scientific working mechanism can ensure the stability, flexibility and efficient.

### 2.3.4 Operation of the whole storage system.

Building a multi-functional integrated background management system is the key to building intelligent warehousing. For a successful intelligent repositories, the advanced hardware facilities are only a part, and the software system is the key to the integration of the equipment and links in the storage and the integration of functions such as monitoring, computing, control, analysis and management. The system interconnects the hardware and equipment in the intelligent warehouse through the network, carries on the large data collection and analysis, the intelligent calculation, the instruction sending, and the timely report and correction of the abnormal problem, so as to keep its overall efficient and accurate operation.

### 2.3.5 Training Intelligent logistics Talents.

Although artificial intelligence has lost some artificial jobs, it has also created new requirements for advanced talents in intelligent logistics [2]. At present, students from colleges and universities can not take part in the work of intelligent logistics. The workers in the logistics industry are also studying and groping. Therefore, in the field of logistics personnel training, on the one hand, enterprises should train the existing employees with intelligent logistics technology. On the other hand, colleges and universities should keep pace with the times, adjust the training program rationally and modify the training objectives, so that students can meet the needs of intelligent logistics talents after graduation.

## 3. Case Analysis

The intelligent warehouse of Jingdong is mainly represented by the unmanned logistics center. All logistics processes are operated by intelligent robots. Intelligent robots take the place of people to complete the complex work and liberate people from them. At the same time, the intelligent robot saves a lot of labor force for the Jingdong mall and saves the cost of artificial logistics. At present, the unmanned warehouse of Jingdong (see Figure 3) is the first unmanned warehouse company in the whole world. Unmanned warehouse in the whole process can realize the unmanned and intelligent goods from the links of warehousing, sorting, storage and outgoing. The operation of unmanned warehouse mainly includes storage, order, picking and packing. The automation equipment involved mainly include logistics robot, manipulator, and automatic shuttle and so on.



Figure 3 Shanghai Jingdong unmanned warehouse

### 3.1 Automatic warehousing system

#### 3.1.1 Automatic transportation system.

Automated conveying system is connected with automated stereoscopic storehouse in the warehousing process, which can realize efficient warehousing of goods. In the unmanned warehouse system, the automated transportation system and the robot system need effective coordination to automate the unmanned storage system[7]. At present, the automatic transportation system of Jingdong is capable of automatic unloading, automatic feeding and automatic separation. In the automatic unloading system, the cage box transportation can deliver the express parcel to the unmanned sorting center. In the automatic supply system, the goods can be transported directly from the dumping equipment to the single part and in the automatic separation system, the system can separate the goods into different cargo areas.

### 3.1.2 Six axis robot.

In the packing box, Jingdong adopts the six axis robot called 6-AXIS and It is suitable for picking up large pieces of goods. The six axis robot is about two meters high, the maximum arm is about 2.7 meters, and the weight is about 1.7 tons. The weight of the transportable goods is within 165 kilograms, the handling efficiency is high, and the movement of the single movement is 8 to 12 seconds. Compared with manual operation, the efficiency can be increased by about 30%.

### 3.2 Automatic Storage System

In the automated warehouse of Jingdong, there are 8 sets of shuttle storage system, consisting of automatic warehouse and multi-layer shuttle vehicle. The system can store 60 thousand boxes of goods at the same time. The speed of the shuttle car can reach up to 6m/s, and the throughput is up to 1600 boxes / hour. This saves the use of human resources, while improving the utilization of warehouse space, when taking goods, we can realize the change from "man to goods" to "goods to people", see Figure 4.



Figure 4 Goods to people

### 3.3 Automatic Picking System

#### 3.3.1 Intelligent handling robot.

In Jingdong's unmanned warehouse, 3 types of intelligent robots are mainly used to carry out warehouse management tasks. They are the SHUTTLE robots that can run on the shelves, the AGV handling machine and the ELTA robot with sorting function, see Figure 5. The SHUTTLE can walk on the shelves at high speed and access the goods between the shelves. When the shuttle is running, the speed can reach 6m/s, and it has the function of automatic adaptation according to the size of the goods. The characteristics of the AGV robots are flexible and compact, and have the function of low automatic charge, so it can release more space for the storage shelf of the Jingdong. In addition, the anti-collision sensor and wireless communication module are embedded in the AGV body. Therefore, AGV can work freely in the complex condition of Jingdong warehouse. The DELTA sorting robot is the sorting equipment in Jingdong unmanned warehouse. It is suitable for the sorting of small items. In order to identify the new goods, Jingdong also has the image recognition equipment for the DELTA robot[8].



Figure 5 Sorting robot

### 3.3.2 The application of RFID technology.

In Jingdong warehouse management, RFID technology plays an important role, which is a non-contact automatic identification technology, which can identify the delivery order and ensure the accuracy of the delivery. RFID tag technology can store relevant data labels. It reads data from tags through RFID read-write device, and can also write data. Compared with barcode information, the RFID tag technology is far away from reading, and it is not affected by obstacles. Located in the Jingdong warehouse in Shanghai, the machine vision recognition model is used to realize the active interaction between the machine and the environment by 2.5D visual technology, which is composed of many visual recognition technologies. Let the machine maximize the use of visual technology to process work, see Figure 6.



Figure 6 Visual Inspection

Thus, Jingdong of automated warehouse mainly rely on a large number of intelligent robot and management system full coverage. In the whole operation process, all kinds of robots cooperate with different functions and features, realizing automatic avoidance, line optimization and other functions. At the same time, RFID technology and automatic identification technology in the Internet of things also play a key role. With the development of the times, the unmanned storage system will become an inevitable trend. In the unmanned storage, automation technology will gradually be widely applied. The future warehouse is not only the automatic operation dominated by robots, but the intelligence of the warehouse will be more and higher. Automation and intelligent equipment will replace most of the storage equipment, and intelligent robots will gradually optimize the workflow of storage and improve the timeliness of storage work.

## 4. Conclusion

In the era of intelligent logistics, the development of warehousing and logistics must rely on advanced technology and move towards the direction of intelligence. Information technology provides a guarantee for the establishment of storage management system. Large data technology has laid the foundation for the storage management system. The application of the Internet of things has solved a large number of logistics problems, and the arrival of artificial intelligence greatly reduced the use of human resources. The rational use of these technologies is a necessary stage for warehousing to move towards intelligence. Intelligent warehousing will become the mainstream of warehousing enterprises in the future, and also the core part of building intelligent logistics, and will promote the advent of intelligent logistics era.

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