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THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN LOGISTICS MANAGEMENT OPTIMIZATION RESEARCH

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Abstract. In order to solve the problem of low efficiency and low accuracy in manual data collection in traditional logistics management systems and traditional warehouse management, the author proposes the application of artificial intelligence in logistics management optimization research. The author designed an RFID based warehouse management system that includes management layer, intermediate layer, and physical layer, focusing on the warehousing and warehousing operations in the production and manufacturing workshop. This system can optimize the traditional warehousing process, dynamically and intelligently perceive management objects, and achieve effective management and monitoring of warehousing management. Establish a simulation model using Flexsim software to simulate the inbound process and simulate the model entity in a relatively short period of time. The experimental results show that the total utilization rate of AGV in the simulation model reaches 72%. This method effectively solves the problems of slow data collection and low accuracy in traditional logistics warehousing processes.

Key words: Smart warehousing, Manufacturing workshop, Digital carrier, RFID, Inbound operations, Warehouse management system

1. Introduction. With the advent of the Internet era, e-commerce has an increasingly significant impact on people, greatly promoting the development of the logistics industry [1]. At present, the development level and scale of e-commerce have been in a leading position. With the in-depth implementation of the national "Internet plus" action plan, the scale of e-commerce market has continued to expand, e-commerce service products have been widely popularized, and higher requirements have been put forward for the logistics industry [2]. Therefore, enterprises need to give full play to the advantages of artificial intelligence technology and use Internet, big data, cloud computing and other technologies to provide new ideas for logistics management [3,4]. The use of artificial intelligence technology by enterprises in the traditional logistics industry can effectively improve logistics management efficiency while providing consumers with higher quality and efficient services and products.

Artificial intelligence technology can promote the informatization and logistics of enterprises in a sense, and has great significance in improving the economic and social benefits of enterprises [5]. Taking the world's express logistics as an example, due to various constraints, there are still some problems in the combination of world logistics and artificial intelligence technology, such as long delivery cycles, slow delivery speeds, and low delivery rates of express delivery [6]. In order to address these issues, express delivery companies have begun to utilize artificial intelligence technology. For example, an automated warehousing and logistics system based on AI technology has been established, making the entire process of operations more intelligent and efficient [7]. Artificial intelligence can be applied in multiple aspects of logistics management, from warehouse management to supply chain management, from logistics distribution systems to logistics planning systems, all of which can be optimized through artificial intelligence [8]. In practical applications, artificial intelligence can be effectively integrated with logistics technology to improve logistics management through advanced technologies such as machine learning. At present, the logistics industry is in a critical period of transformation and development, which requires the improvement of logistics management level through intelligent technology. Artificial intelligence is a high-tech means, and its advanced algorithms can effectively solve various problems that arise in the logistics management process, thereby improving the overall development level of the logistics industry [9,10].

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2. Literature Review. With the development of artificial intelligence, logistics services need to be constantly updated and iterated to meet the service needs of enterprises at different stages and industries [11]. Based on artificial intelligence technology, logistics enterprises can integrate warehousing and distribution processes, effectively control each link in the transportation process, and thereby improve the transportation efficiency of goods [12]. Taking the express delivery industry as an example, it has now achieved automatic pickup function and is continuously promoting the development of unmanned vehicle delivery mode, which also puts higher requirements on delivery services. In this mode, the intelligent delivery robot achieves real-time positioning and navigation of goods through an onboard system; Avoiding the risk of obstacles during vehicle operation through autonomous path planning; At the same time, it will also engage in voice communication with users to understand their needs [13-14]. Today, with the rapid development of artificial intelligence, many industries have undergone tremendous changes. The introduction of artificial intelligence technology into the modern logistics industry has promoted the digital transformation of the logistics industry. As a major component of modern logistics industry, energy logistics has a broad operating scale and huge market capacity. Therefore, in the process of national development, energy logistics will inevitably be highly valued by people. Zhang, J. et al. proposed the Internet of Things intelligent logistics network. The integration of various applications in logistics systems into many systems is costly and in some cases not used, making it difficult to justify their purchase. IoE is important in information and communication technology because it can generate large amounts of data and use various mathematical techniques to evaluate the complex connections between the transactions represented by this data [15]. Yang, X. et al. proposed an optimization algorithm for logistics transportation costs of prefabricated building components suitable for project management. We constructed a project management oriented prefabricated building component management system, analyzed the logistics and transportation process of prefabricated building components, and scheduled logistics vehicles for prefabricated components within a time window [16]. Zhao, H. and others combined the characteristics of logistics distribution to mathematically design the distribution vehicle routing problem. Introduce the mountain climbing process with strong local search ability into the particle swarm optimization (PSO) process to improve the provided method [17].

The author introduces digital carrier technology and designs a warehouse management platform based on Radio Frequency Identification (RFID), which solves the problem of difficult and error prone data collection in traditional manufacturing workshop management processes. According to the principles of material identity, similarity, complementarity, and first in, first out, intelligent analysis of storage capacity is carried out to ensure that suitable goods are stored in appropriate locations and monitored. In addition, the author used Flexsim software to establish a production and manufacturing warehouse workshop model, analyzed simulation output results, identified bottlenecks in system design, improved warehouse operation efficiency, and saved operating costs.

3. Method.

3.1. Smart warehousing. Smart warehousing logistics is a crucial part of smart manufacturing, which combines the scattered personnel and cluttered information in traditional warehousing workshops to enable enterprises to operate smoothly and efficiently [18]. Smart warehousing logistics replaces rigid and high maintenance cost elevated warehouses with more flexible and lower maintenance cost building storage methods, replaces manned forklifts with more flexible and intelligent mobile robots, replaces traditional equipment that is prone to single point failures with more reliable equipment, and replaces complex and highly specialized traditional equipment with simpler structure, intelligent control, and easy maintenance intelligent equipment [19]. Traditional warehousing logistics mainly records and stores information manually, which is not only inefficient, but also has problems of large errors and high costs in the process of information statistics [20]. The introduction of digital carrier technology can improve the recognition rate of goods in the process of entry and exit, facilitate the visual management of goods in the warehouse, and also increase the transparency of the entire workflow in manufacturing logistics, improve the level of warehouse automation and operational efficiency of warehouse management, which is of great significance for further improving the level of enterprise logistics and warehouse management.

3.2. RFID based warehouse management system. RFID technology is a non-contact information transmission technology that identifies radio frequency signals through spatial coupling. It has long recognition

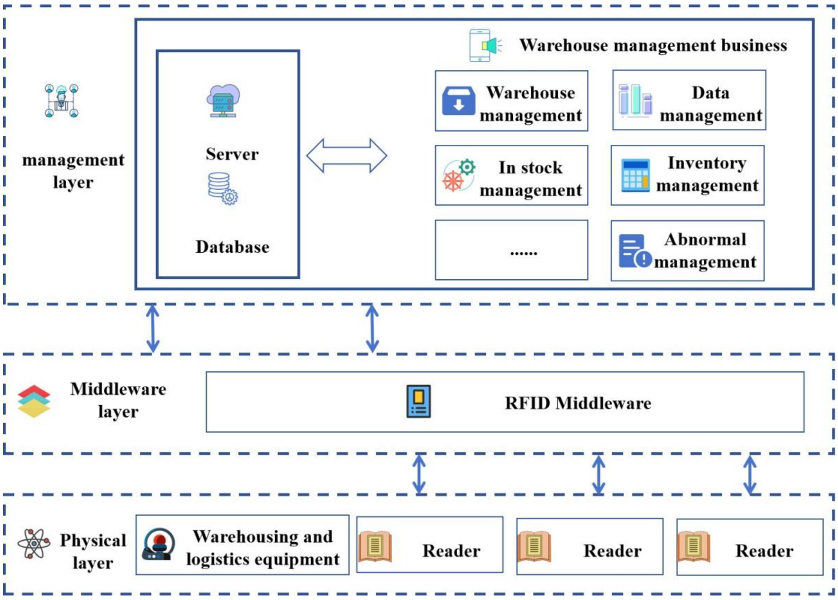

Fig. 3.1: RFID based warehouse management system

distance, small size, large data storage capacity, and can be reused. In the RFID system, the reader sends the signal from the tag through the transmitting antenna, and the carrier signal is demodulated and decoded before being sent to the receiving antenna. The data management system in the computer application software determines the validity of the tag through logical operations, and then processes and controls it according to different settings, issuing command signals.

The author designed an RFID based warehouse management system that includes management layer, middleware layer, and physical layer. The overall structural framework of the system is shown in Figure 3.1.

The management mainly controls the entire system process, is responsible for information management and equipment scheduling of the intelligent warehousing and warehousing management system, and completes functions such as querying, statistics, and scheduling of inbound operations.

The middleware layer is the integration of RFID data collection system and warehouse management system, responsible for storing the data collected by the physical layer in the database. The middleware layer transfers system information, receives scheduling instructions from the management layer, completes tasks based on the sent content, and timely transmits information to the physical layer, possessing strong implementation capabilities and processing efficiency.

The physical layer is responsible for deploying RFID devices and other logistics devices in inbound operations, mainly for data collection and rapid identification of cargo label information. It can receive instructions from the management and quickly transmit information from the work site.

3.3. Optimization of Intelligent Warehousing Warehousing. The warehousing process mainly involves taking inventory of the goods entering the warehouse, confirming specific data such as quantity and type of goods. The author takes the warehousing process of intelligent warehousing in the production and manufacturing workshop as an example to introduce the warehousing process.

3.3.1. Traditional warehousing process. Traditional warehousing and logistics management records goods at designated locations through manual recording. In this management mode, the space utilization of the warehouse cannot be planned in advance, and the accuracy and completeness of product information cannot be guaranteed through traditional records or barcodes. The time cost is too high, and the error rate in the process of recording information is high. The traditional warehousing process is shown in Figure 3.2.

Traditional warehousing methods can easily lead to location conflicts, increase material quantity errors,

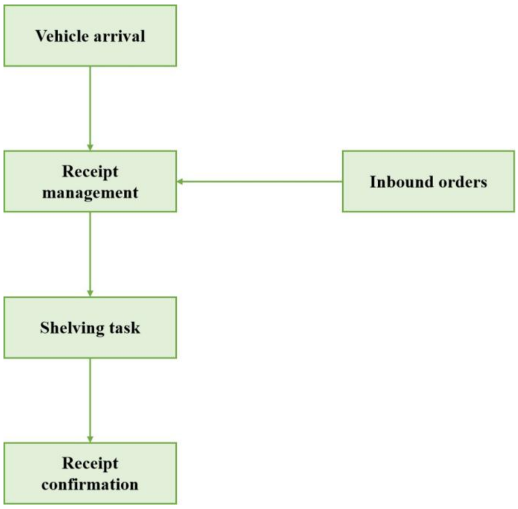

Fig. 3.2: Traditional Warehousing Process Diagram

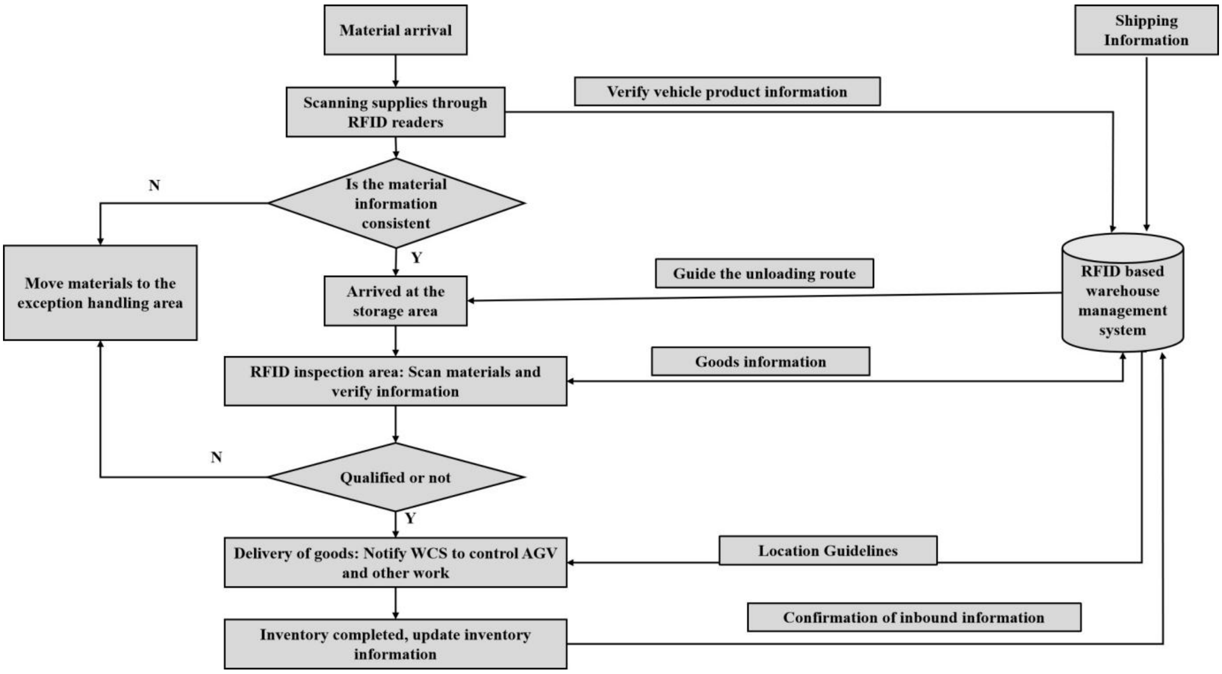

Fig. 3.3: Inbound process diagram based on RFID warehouse management system

generate classification errors, and thus affect the operational efficiency of the entire warehousing management system.

3.3.2. Inbound process of RFID based warehouse management system. In response to the problems existing in the traditional warehousing process, the author has introduced digital carrier technology in logistics warehousing management to improve the warehousing process. The specific warehousing process is shown in Figure 3.3.

Enter vehicle information, cargo list, specific information, etc. into the computer system at the original warehouse of the goods, and generate relevant RFID tag information through computer software. Then, embed the tags into the packaging of each type of product. When the goods arrive at the storage area, they are scanned through an RFID reader, and the RFID warehouse management system synchronizes the information after receiving it. At the same time, WMS plans and allocates the storage area in the system. After the information of the goods is confirmed to be correct, they arrive at the storage area. The RFID warehouse management system scans the RFID tags on the items and generates target shelves based on the location allocation in the WMS system. After the goods arrive at the acceptance area, the reader at the entrance of the warehouse area scans and identifies the information of the incoming goods. The system will verify the data read with the cloud data, if the information is consistent with the database, send the relevant instructions to the WCS system. At this time, the destacking robot and AGV car move the goods to the designated location according to the system's path planning, and generate the inventory information in the WMS system.

If there is an abnormal reading of RFID information, the abnormal goods will be moved to the RFID exception processing area for processing. At the same time, the WMS terminal system in the exception processing area will provide the relevant information of the abnormal goods, including the warehouse receipt, to the exception handling personnel. The exception handling personnel handle the situation based on the abnormal information. After the exception handling is completed, the exception handling personnel can initiate a warehouse entry command on the WMS terminal system, and then the WMS system allocates a transfer robot to transport the goods into the warehouse.

3.4. Algorithm selection. The commonly used algorithms for logistics information data mining include neural network algorithms, genetic algorithms, fuzzy set algorithms, Bayesian algorithms, decision tree algorithms, and nearest neighbor algorithms. Below is a brief introduction and analysis of the Bayesian algorithm used in this article.

Bayesian algorithm is a general term for a class of classification algorithms based on Bayesian theorem, usually divided into naive, tree enhanced, and traditional Bayesian algorithms. Among them, Naive Bayes algorithm is the most common and easiest to implement among the three, and the author adopts this algorithm as the data mining algorithm for designing logistics information monitoring systems. The definition of this mining algorithm is as follows:

1. Assuming $A = \{a_1, a_2, \cdots, a_m\}$ is a raw dataset with m different feature attributes; $C = \{c_1, c_2, \cdots, c_n\}$ is a set of n different categories.
2. Use the set D of known classifications as the training sample set. Make category c and feature attribute a, and then calculate the conditional probability values of feature attribute a under category c.
3. Assuming that each feature attribute in A is conditionally independent, according to Bayesian theorem, it can be inferred that:

$$P(c_i|A) = \frac{P(A|c_i)P(c_i)}{P(A)} \tag{3.1}$$

Among them, molecules can be equivalent to:

$$P(A|c_i)P(c_i) = P(c_i)\prod_{j=1}^{m} P(a_j|c_i) \tag{3.2}$$

4. Calculate $P(c_1|A), P(c_2|A), \cdots, P(c_n|A)$ according to equation 3.1.
5. Find $P(c_k|A) = max\{P(c_1|A), P(c_2|A), \cdots, P(c_n|A)$, then $A \in c_k$.

The above process can be mainly divided into four stages: mining preparation, classifier training, classifier evaluation, and practical application. The main role of the mining preparation stage is to determine the feature attributes of the object to be mined and divide it manually, which has a significant impact on the processing effect of subsequent data; The training stage of the classifier is to use known training sample data to calculate the conditional probabilities of various feature attributes under different categories; The classifier evaluation stage calculates the category corresponding to the set A with the highest value for each category attribute, and obtains the corresponding classifier model; The practical application is to analyze the newly transmitted data based on the obtained model.

Table 3.1: Main Equipment Configuration Parameters

Name	Quantity	Main performance indicators
Storage area	2 storage ports	
Connecting device	2 connecting machines	Connect 8 boxes and 4 stacks at once
AGV	12	running speed $0.5m \cdot s^{-1}$
conveyor	Chain conveyor 2 locations	Conveying speed $1m \cdot s^{-1}$
Stacking robot	2	Complete the grabbing action in 4 seconds
Unstacking cache station	12	6 per warehouse entrance
Area of storage area	$1840m^2$	40m×46m

3.5. Simulation experiments. The author takes the logistics warehousing and storage area of the workshop as the design prototype, and uses the Flexsim simulation platform to fit and construct the data associated with each entity in the system in the order of the warehousing area, inspection area, and temporary storage area, based on the logistics distribution operation process sequence. A simulation model of the warehousing process is built. The main equipment configuration parameters of the model are shown in Table 3.1.

The design concept of the simulation model for the storage area is to divide the warehouse into three parts: upper, middle, and lower: The upper part includes two storage ports, two connecting devices, two cargo buffer areas, and an RFID exception handling area. The central area includes the temporary storage area for goods and the temporary storage area for empty shelves; The lower part includes two shelf storage areas. The AGV car spreads throughout the entire area according to the set position.

4. Results and Discussion. The workflow of the simulation system designed by the author based on RFID warehouse logistics management system is as follows: when raw materials arrive at the warehouse, the truck transports the goods to the entrance, and a double row chain conveyor is set up at the entrance to transport the goods. The dual track mobile connection device can connect 8 boxes and 4 stacks at once. The mobile connection device adjusts the height through photoelectric tubes and then connects with the chain machine of the material transport vehicle. The goods are placed on the conveyor and transported to the warehouse area. When the destacking robot is destacking, it grabs the goods and reads the RFID information at the end of the chain conveyor RFID reader. At the same time, the read information is transmitted to the RFID warehouse management system for vehicle and cargo information verification. After reading, the destacking robot places the goods on the destacking buffer station. When the system initiates the inbound command, the destacking robot grabs the goods from the cache station, reads RFID information, and binds it with the corresponding shelf barcode, transmitting the information to the inbound management system. The warehouse management system allocates storage locations and dispatches transfer robots to carry out material handling, achieving full automation in the process. If an RFID exception occurs during the process, the transfer robot will transport the box of goods to the RFID exception handling area.

Assuming that one unit of simulation time in the system is equivalent to the actual 1 second. In order to simulate the actual warehouse operation for 24 hours, set the simulation time to 86400 units. After setting the time, reset and run the model. After 24 hours of running, perform statistical analysis on the state data in the model. The simulation results are shown in Figures 4.1 to 4.3.

According to the simulation results, it can be seen that at the end of a simulation cycle, the storage volume at storage 1 and storage 2 is 2876 boxes and 2880 boxes, respectively. The work efficiency of the destacking robots at the storage port is 58.84% and 60.11%, respectively. The two destacking robots operate uniformly during storage operations and have a high utilization rate. From Figures 5 and 6, it can be seen that the total utilization rate of AGV in the simulation model is 72%, while the utilization rates of AGV11 and AGV12 are 36.70% and 18.64%, respectively, with utilization rates of less than 50%. This is because there are too many devices, resulting in low utilization of some devices. It can be inferred that idle equipment can easily lead to resource waste.

In practical system design applications, the number of AGVs running in the warehouse area can be set based on the order quantity of goods, reducing the idle running time of equipment, thereby improving the efficiency of the warehouse storage process, reducing energy consumption during idle running, and saving production costs.

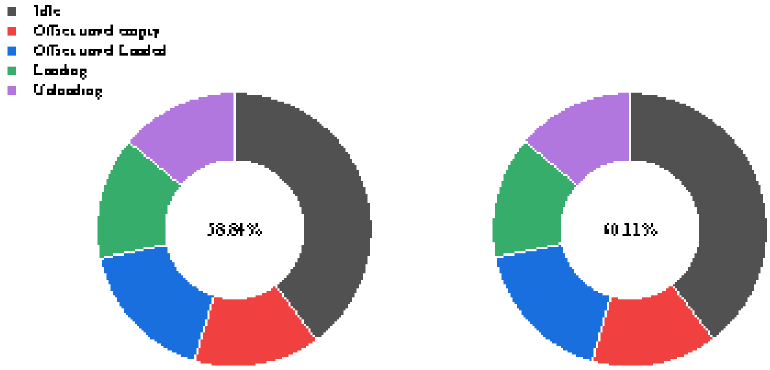

Fig. 4.1: Dynamic pie chart of utilization rate of inbound and destacking robots

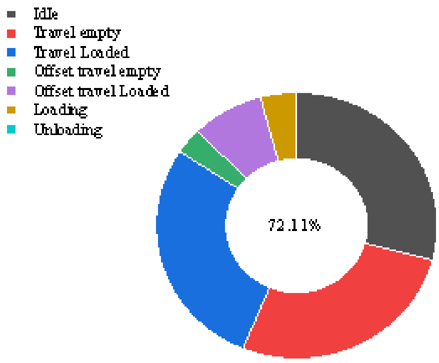

Fig. 4.2: Dynamic pie chart of total utilization rate of AGV in storage

The author used Flexsim's logistics operation simulation to virtually reproduce the actual process of inbound operations, which can optimize the model entity in a relatively short period of time. This result provides theoretical support for the operation and improvement of actual warehouses.

5. Conclusion. The author proposes the application of artificial intelligence in logistics management optimization research, focusing on the warehousing operations in production and manufacturing workshops, and applying RFID technology to warehousing management. The author constructs an RFID based warehouse management system architecture based on the design of management layer, middle layer, and physical layer, and applies it to the warehousing process of warehouse management, solving the problems of slow data collection and low accuracy in traditional logistics warehousing processes. The author used Flexsim software to establish a simulation model for warehousing, and through the establishment of various modules for warehousing, they intuitively understood the operation of the system, which has substantive guiding significance for the operation of a real warehousing and warehousing system.

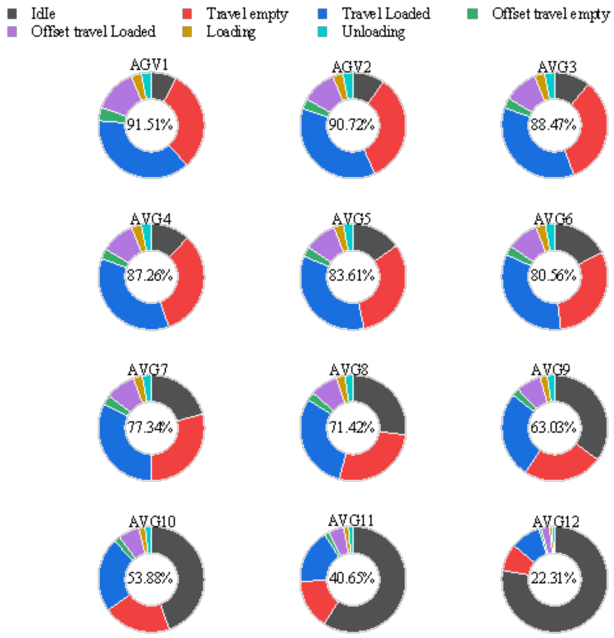

Fig. 4.3: Dynamic pie chart of utilization rates of various AGVs in storage

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