Design of Intelligent Robot Flexible Sorting Center

Wenxue Ran¹, Haixia Bai²,³* and Ruijin Ma¹

¹ School of Logistics, Yunnan University of Finance &Economics, Kunming 650221, China
² School of Business, Yunnan University of Finance & Economics, Kunming 650221, China
³ Tourism and Economic Management Department, Li jiang Teachers’ College, Lijiang 674199, China
Email: Bhx1982@126.com

Abstract. In order to make up for the shortcomings of traditional robot sorting flexibility and limited operation efficiency, the concept of intelligent robot flexible sorting center is proposed in this paper. We firstly conceive its characteristics, then construct its structure, which consists of a robot with changeable claws, a claw storage, an automatic setback stereoscopic warehousing system, an order goods conveying system, a visual recognition information system. Thus make the intelligent sorting intensive system with more functions enables the robot to adapt to a variety of picking methods, showing higher flexibility, higher order sorting quality, higher equipment utilization rate, relatively stable sorting capacity and great adaptability, its application scope can be continuously expanded to meet the needs of more diversified goods.

Keyword: Intelligent robot; Flexibility sorting; Intelligent robot flexible sorting center; Design

1. Introduction

Traditional robot sorting can only use special machines for automatic sorting of standardized packaged goods, which requires high product packaging and appearance. In traditional order production, due to the complexity of commodity items, except for some standardized packaging products that are automatically sorted by special machines and equipment, most products require manual auxiliary sorting, affected by the nature of manual operations, order sorting may have a higher error rate. The application of the intelligent robot flexible sorting center could reduce manual operations and fully guarantee the accuracy of order production.

This paper proposes a new equipment concept, Intelligent Robot Flexible Sorting Center (IRFSC), which is a new technology proposed to meet personalized needs in the intelligent era. It is a combination of some intelligent and flexible high-tech products, such as mechatronics technology, computer software and hardware technology, system control theory, information programming and cyber physical system (CPS) technology. Its biggest difference with the traditional robot is that the sorting center is equipped with a claw storage, which is equipped with a variety of claws suitable for different types of goods packaging, makes it have the ability to exchange claws automatically. It can be controlled by the robot automatic claw-changing mechanism and the picking claws can be selected and replaced, which greatly expands the integrated picking function of the robot. The core of intelligent robot flexible sorting center is the automatic claw-changing mechanism, which integrates multiple categories and functions such as clamping, sucking and holding on one robot body, and
constructs an intelligent sorting intensive system with complete functions, so that the robot can adapt to a variety of picking methods and show higher flexible characteristics [1].

The IRFSC can complete the centralized picking process of a variety of materials, so it can reduce the time of order transportation, positioning, combination, separation, inspection and calibration, simplify the sorting process of goods, promote the operation modernization of logistics distribution center, and reduce the construction cost of automation facilities. The IRFSC not only ensures the accuracy and speed of order sorting operation, but also reduces the cost of equipment configuration, saves the occupied space, and improves the competitiveness. It is an automatic and intelligent order sorting facility that can be popularized and applied in the logistics distribution center.

2. Characteristics of the IRFSC

(1) Intensive function, high accuracy and wide application range. The order goods are stored on the return table stereoscopic storage system. According to the needs of different picking operations, the intelligent robot can automatically select and replace the claws, complete the picking operations of multiple orders for a variety of goods in sequence. The goods packaging is not restricted, which further reduces the unrecognizable or error rate of automatic sorting. The setting of the gripper storage expands the application range of the robot by dozens of times, demonstrates the intensive function of the robot, and improves the utilization rate of the robot body.

(2) Simplify the sorting process. The IRFSC uses the function of automatically claw-changing to finish the picking process by the same robot station, which makes the arrangement of the sorting system equipment in the sorting workshop more concentrated, greatly reduces the floor space and the operation time of transportation, turnover, handling and storage of order goods, simplifies the sorting process, and thus shortens the operation cycle, speeds up the order delivery, which has obvious economic effect.

(3) Fully digital management and complete monitoring and tracing system. There are many kinds of order goods, the information of order goods is stored in the information system by the setback stereoscopic warehousing system, which realizes the complete digital management. The sorting center is equipped with feedback sensors and detection devices for various operation states, the sensors and detection devices are interconnected to form a complete monitoring and tracing system for the operation state of the sorting system.

(4) High cost performance of technical solutions. Compared with traditional robots, the application scope and function of robot flexible sorting center have been expanded dozens of times, that is, one robot is equivalent to dozens of robots, which not only reduces the equipment cost of robot used in the sorting operation of logistics distribution center, but also improves the utility of robot, showing a good cost performance ratio, which is suitable for the sorting of small and medium-sized batches in logistics distribution center with complex order structure and a wide variety of goods.

3. The IRFSC Structure

The structure of the IRFSC includes a robot with changeable claws, a claw warehouse, an automatic setback stereoscopic warehousing system, an order goods conveying system, a visual recognition information system. The mechanical arm is equipped with an automatic claw-changing structure to realize the robot’s automatic claw exchange function; multi-functional claws are designed and integrated into a claw storage for robot to change claws according to the needs of sorting operation, the structure of the claw storage can be flexibly adjusted to meet the number and type of claws. The center is also equipped with a setback stereoscopic warehousing system for temporarily storing the goods to be sorted, under the control of electronic control system and computer system, it can quickly and accurately complete the picking order of various kinds of goods; the robot then places the sorted goods on the automatic conveyer, thus the goods are transported to the order processing main line for subsequent operation.
3.1. Claw-changing Robot and Claw Storage System

![Diagram of claw-changing robot and claw storage system]

The intelligent robot automatic claw-changing structure consists of the claw handle positioning flange, Denham claw, cushion block, disc spring group, pressure pad, lock nut, hydraulic piston, hydraulic cylinder head, tension position detection sensor, loose position detection sensor, hydraulic cylinder block, automatic hand-changing claw rod, connecting spindle, air circuit (oil circuit), strong current (weak current) link device and other components.

Working principle of robot automatic claw-changing structure is shown in figure 1. The robot can intelligently perceives the needs of changing claws in different situations. The connecting spindle mechanism is a hollow cylinder part [2], with the front end equipped with a claw handle positioning flange, matching the claw handle adopts a 1:10 taper fit. The automatic tightening and loosening mechanism of the claw handle is installed in the inner hole of the robot automatic claw-changing mechanism, the automatic tightening and releasing action of the handle is realized by the combination of the pull rod and the Denham claw, the spring set, the hydraulic piston, the tension position detection sensor and the release position detection sensor. When tightening, oil is fed into the left side of the piston cavity of the hydraulic cylinder, and the right side of the hydraulic piston has no oil pressure, the tension of the folded spring set tightens the pull rod and the Denham claw into the tension detection position, then the steel ball enters into the annular groove of the pull pin at the tail of the claw handle, and the claw handle is tightened. When the handle needs to be released, the oil is fed into the right side of the piston cavity, the hydraulic piston moves to the left, compresses the spring set, generates pressure, pushes the pull rod and the Denham claw to the left, the Denham claw opens, and the steel ball is separated from the annular groove, the handle is released to facilitate the claw quickly pull-out, then, the hydraulic piston is in the loose detection position. Next, when the other gripper is selected, the mechanism repeatedly moves to the right automatically to return to the tension position, so as to fix the gripper on the end of the robot again. And so back and forth.

As shown in figure 2, the IRFSC is equipped with a claw storage which can place 14 claws and a setback stereoscopic warehousing system which has 60 channels for goods temporarily. That is to say, the center designed in this scheme can select 60 categories of goods those to be sorted in each channel, according to their appearance, weight, packaging characteristics etc., the functions of clamping, holding and sucking are designed as 14 corresponding claws to meet the needs of goods picking. The claws are stored in the claw storage, under the command of the control system, the robot can automatically select the appropriate claws to complete the picking operation.
3.2. Setback Stereoscopic Warehousing System

The structure of the setback stereoscopic warehousing system is shown in figure 3, which is composed of the support column, guardrail, withdrawal limit fixing mechanism, automatic ball chain conveyor, withdrawal limit mechanism, roller conveyor pickup platform, limit stop, the automatic ball chain conveyor drive motor, the roller conveyor pickup platform drive motor, constituting a number of commodity cache channels in the plane, which are vertically superimposed, and then let out of the work platform, then constitutes a setback stereoscopic warehousing system.

Figure 3. Setback stereoscopic warehousing system.

1-support column; 2-guardrail; 3-setback limit fixing mechanism; 4-automatic ball chain conveyor; 5-setback limit mechanism; 6-roller conveyor picking up platform; 7-limit stop.

Among them, the column is the support structure of the setback stereoscopic warehousing system, which carries the system channel superimposed in space, and a limit stop is placed at the front of each channel to block the goods conveyed to the foremost end. When the setback limit mechanism and the setback limit fixing mechanism function, the automatic ball chain conveyor forms a zero-pressure conveying to continuously send the subsequent goods to the pickup position, which automatically picked up by the robot; meanwhile, a guardrail is set up in each aisle to prevent the goods from
deviating from the channel during transportation. The robot sorting speed should be greater than the transmission speed of automatic ball chain conveyor, so as to avoid system congestion and ensure the normal operation of automatic operation [3].

3.3. Order Goods Conveying System
Order goods conveying system is composed of a variety of transportation devices and order processing equipment, such as order conveying main conveyor belt, order cache, automatic boxing equipment, etc., which can complete the transmission and processing of order goods and grippers. It is the main part of robot flexible sorting system.

The order cache structure is set to collect the same order goods picked by different sorting robots at the same time. That is, when the sorting robots receive the order instruction information, each flexible sorting center carries out the sorting operation, and places the goods on the main transmission line. When one order task finished, the conveyor belt quickly transports the goods to the order cache area until all the goods of the same order are assembled, the whole order package is transferred to the next station [4]. The setting of order package cache structure can not only take advantage of the sorting characteristics of the IRFSC and realize the collection of order goods, but also alleviate the capacity limitation of subsequent operations, save time for emergency handling when the system fails.

3.4. Visual Recognition Information System
Visual recognition information system refers to the collection, processing and feedback of all kinds of information required in the order sorting process, and upload or issue control instructions to the robot or other sorting equipment through the computer system to form a hierarchical control system. The robot needs a dynamic vision system with fast and powerful target recognition capabilities to quickly select the specified goods from the randomly goods places and put them to a designated position [5]. Therefore, this paper uses machine vision technology to realize the information recognition of sorting robot, builds a set of "eye in hand" robot recognition system, which automatically chooses the corresponding gripper and adjusts the grasping speed for different specifications of goods, and adjusts the direction of the end axis of the robot according to the position and posture information of the target object, so as to carry out the sorting operation quickly and accurately.

4. Conclusion
The intelligent robotic flexible sorting system is a kind of system with complex technology and high automation, which has high economic utility. The system can select suitable claws, robot or robot flexible sorting center, material storage and transportation system according to the sorting operation needs. It is centralized controlled by computer information system, and the required sorting orders can be arranged in time to meet the needs of consumers at the fastest speed. Since the advantages of the IRFSC, such as high equipment utilization rate, relatively stable sorting capacity, high order sorting quality, flexible operation and great adaptability, its application scope can be continuously expanded to meet the needs of the construction of logistics distribution centers for consumer goods, cigarettes, cosmetics, etc.

Acknowledgement
This paper was supported by Yunnan Philosophy and Social Science Planning Project(QN2019008).

Reference
[1] Xiong Zh W and Zhang H 2019 Design and application of automatic control system of a multi-function intelligent sorting machine based on PLCMachinery &Electronics (5):11-14.
[2] Ji Q J, Lu W, et al. 2020 Design of an intelligent soft gripper for on-line measurement of fruit size.Jiangsu Journal of Agriculture 36(2): 455-462.
[3] Briant O, Cambazard H, CaTtaruzza D, et al. 2020 An efficient and general approach for the joint order batching and picker routing problem European Journal of Operational Research 285(2): 497-512.

[4] Bozer Y A and Aldarondo F J 2018 A simulation-based comparison of two goods-to-person order picking systems in an online retail setting International Journal of Production Research 56(11-12): 1-21.

[5] Xu Q Q 2019 Design of intelligent sorting system for industrial robot based on machine vision Instrument Technique and Sensor (8):92-95.