Design of Automatic Claw Changing Robot for Intelligent Sorting System

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Abstract. In recent years, China's express business volume has steadily increased, which has greatly increased the operation volume and complexity of sorting operations. However, the current logistics sorting process is still in manual or semi-automatic sorting, and the technology in the process of express sorting cannot match the surging order volume in the express industry. And with the rapid development of e-commerce and the increasing personalized demand, customer orders gradually tend to be multi-variety, small batch, multi-frequency, and then put forward higher requirements for the flexibility of the sorting system. In this paper, aiming at the low sorting efficiency caused by the inconsistent standards of goods in the sorting process, based on the idea of automatic tool changing in machining center, a hand changing grasping robot is designed, which includes the structure of cluster, "claw library" and robot automatic claw changing structure. The design can realize the multi-purpose of one machine and improve the flexibility of the sorting system.

Keywords: Robot; Robot "changing claws"; Flexible sorting system

1. Introduction
China's express sorting work is still in the stage of manual sorting or automatic sorting, which has the problems of high sorting error rate, high cost, heavy workload and low sorting efficiency. At present, there are only a few large-scale express companies in China, such as China Post and SF express, which have advanced modern sorting technology and equipment. Most of the other express companies are mainly manual operation. In addition, with the new retail mode of "Online + offline", many large supermarkets sell online, and are sorted and distributed by stores or warehouses. Due to the nonstandard specifications, shapes and weights of daily necessities, robots of different types of claws are needed to pick, which not only costs a lot, but also requires more venues. In order to solve the above problems and improve the satisfaction of consumers to the logistics express industry, it is urgent to design and optimize the logistics sorting robot, realize the flexibility and automation of express sorting, and improve the logistics sorting ability.

2. Literature Review
Some scholars have studied the improvement of the actuator at the end of the robot. For example, in the mid-1970s, the electronic laboratory in Japan developed a 3-finger 11 joint terminal hand that can perform complex operations such as screwing [1]. The follow-up research summarized the robot end Grab: claw type, sucker type, grab type [2-4]. Endo and Otomo applied Bernoulli's principle and multi finger grab to pick up noodles and appetizers. Bloss, R. applied electric gripper and vacuum sucker gripper in prepackaging robot, which can effectively meet the requirements of picking up articles [5].
The combined robot can play a greater flexibility in the sorting system to meet the current demand of multi variety, multi batch and small batch sorting line.

3. Robot Claw Replacement Designing

3.1. Robot Automatic Claw Changing Structure

The robot claw connection is generally realized through the robot claw connection sleeve. Therefore, in this section, the robot claw connection sleeve is introduced and designed first, and then the robot automatic claw replacement structure is designed.

3.1.1. Robot Claw’s Clamping Sleeve. With the advantages of high intelligence level, high security and significant economic benefits, robots are widely used in various specific operation links of industry, agriculture, commerce and other services. However, the robot itself is just a multi-degree of freedom business processing platform, and the specific operation links are completed by robot hands.

Traditionally, a robot is used with only one gripper to perform one or one type of function. General robot manufacturers will focus on the research and development of the robot itself, but do not provide the specific structure of the grips. It is redeveloped and designed by the robot application developers according to the actual needs, in order to achieve flexible use of the robot. The connection between the robot and the paw of the robot is usually realized through the end-execution structure connecting sleeve equipped with the robot, as shown in figure 1. This connecting sleeve is the basis of the automatic claw changing structure design of the robot.

Also have the robot is not set sleeve, in view of this situation we have to fix the robot automatic claw structure to find a way to change the actuator at the end of the fitting robot, in addition to design unicom gas (oil) road, high voltage (elv) system components, such as the robot flexible sorting center, the integrated function of robot flexible sorting system.

3.1.2. Robot Automatic Claw Changing Structure. Robot automatic claw replacement structure is one of the key components of flexible sorting center of robot, and it is also the connecting piece of robot extended function execution device. Its function is to support and drive the movement of the hand, to bear the load of the picked goods, and to complete the movement of the picking operation.

The robot automatic claw changing structure is installed on the flange of the hand claw of the terminal actuator of the robot. Because the speed of the robot picking operation is fast, the switching
frequency of the action is high, and the manual can not intervene in the operation process, so the positioning accuracy, structural stiffness, reliability and other characteristics of the robot itself are required to be higher. For the robot flexible sorting center with automatic claw changing, it is also necessary to realize the automatic loading and unloading and clamping of the claws on the robot automatic claw changing structure.

![Figure 2. Robot automatic claw change structure.](image)

As shown in figure 2, robot automatic claw structure change by hand shank positioning flange, denham claw, block pad, folding spring group, the pressure pad, lock nut, hydraulic piston, hydraulic cylinder head, tighten a detection sensor, loosen the position detection sensor, hydraulic cylinder, automatic gripper bars change, connect the main shaft, gas (oil) road, high voltage (elv) connecting device and other parts.

The working principle of the robot automatic claw changing structure is as follows: the connecting spindle mechanism is a hollow cylindrical part, the front end is installed with the claw handle positioning flange, and the matching part of the claw handle adopts a 1:10 taper match. The automatic tensioning and releasing mechanism of the gripper handle is installed in the inner hole of the robot automatic claw changer mechanism. The automatic tensioning and releasing action of the gripper handle is realized by the combined action of the pull rod, Denham puller, double spring group, hydraulic piston, tensioning position detection sensor and releasing position detection sensor. When the tension, the left end of the hydraulic cylinder piston cavity into the oil, the right end of the hydraulic piston without oil pressure, the tension tension rod and the Denham pull claw of the spring group, in the tension detection position, the steel ball into the ring groove of the handle tail pull nail, the handle tension. When need to loosen the hand grip, piston chamber right end feed, hydraulic piston moving to the left, compression fold spring group, stress, tension taut rod and mobile denham pulling claw to left, DE rana jaw open, steel ball from hand claw the ring groove rivet tail handle out, gripper to loosen the handle, convenient to handle quickly pulled up, the hydraulic piston with loosen a position at the moment. When the next claw is re-selected, the mechanism automatically moves to the right repeatedly to restore the tensioning position, so as to fix the claw at the end of the robot again.

### 3.2. Robot Claws

The robot "claw", namely the robot end-effector, is an additional device installed on the wrist of the robot that has the functions of gripping, transporting and placing, and can directly act on the working object. Robot claw is the final link and execution part of the interaction between the robot and the working object. It can reflect the key component of the robot's ease of use and flexibility. According to the needs of grasping materials, this research designed a variety of end-effectors of the robot, namely, a variety of types of grippers, including adsorption type, clamping type, bionic finger clamping type.

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3.2.1. Adsorption Gripper. Adsorptive material taking hand uses the negative pressure in the suction cup to generate suction and move the object, not easy to damage the packaging of goods. Easy to use and reliable, there are mainly gas adsorption and magnetic adsorption of two kinds of suckers, but the general requirements of the adsorption object is smooth and smooth, no hole no groove, tight material, no air permeability gap.

The air adsorption chuck has the advantages of simple structure, light weight, uniform adsorption force distribution, and easy to absorb thin sheet objects. It is suitable for large and thin metal or flat plate, paper, smooth arc shell and other workpieces with poor rigidity.

Magnetic adsorption and material taking hand uses the magnetic effect of electromagnet to absorb objects, there are two kinds of electromagnetic chuck and permanent magnet chuck.

The exchangeable adsorption gripper structure designed in this project is shown in figure 3. The exchangeable gripper handle is designed with a taper of 1:10 (the taper design of other types of gripper handles is the same).

![Figure 3. Adsorptive gripper structure.](image)

The exchangeable adsorption gripper structure designed in this project is shown in figure 3. The exchangeable gripper handle is designed with a taper of 1:10 (the taper design of other types of gripper handles is the same).

The structure of the adsorption gripper includes an exchangeable gripper handle, a negative pressure adsorption device, a gas (oil) strong current (weak current) connection device, etc.

According to the adsorbable area and weight of the selected products, an adsorbable claw family is designed, as shown in figure 4. In the actual production, the computer system issues corresponding automatic replacement instructions to the robot according to the information of the selected materials, so as to quickly adapt to the changes of different materials.
Clamp gripper is widely used, the shape of the gripper is also varied, different forms, can be a claw, clip or splint form, depending on the appearance characteristics of the packaging of goods.

Clamping manipulator has the characteristics of compact structure, uniform force, long clamping duration and high load-bearing. It is suitable for large bearing area and uniform gravity distribution of rigid and irregular objects. With the progress of social production, vegetable picking and other industries upgrade the robot clamping mechanism. Using hyperelastic materials and compressed air software driving technology, pneumatic soft plastic clamping mechanism is developed, which can be easier to grasp the hard to grasp, soft and fragile goods, and improve the flexibility and reliability of clamping operation.

The exchangeable clasp structure designed in this project is shown in figure 5.

The structure of the gripper includes a handle that can be changed, a clamping device, a gas (oil) strong electricity (weak electricity) Unicom device, etc.

3.2.2. Bionic Finger Claw. The initial form of bionic finger claw is mostly double-fingered claw, which can clamp objects by driving the opening and closing movements of fingers. Double-fingered claw has the advantages of simple structure, flexible operation and fast response. Different sizes can adapt to different kinds of cargo forms, so there is great room for progress in improving the operation ability of robot hand claw. The clamping manipulator has the characteristics of compact structure, uniform force, long clamping duration and high load-bearing capacity, which is suitable for rigid irregular objects with large force area and uniform gravity distribution.

The exchangeable bionic finger double-fingered gripper structure designed in this project is shown in figure 6.
Bionic finger double finger type claw structure also includes exchangeable hand handle, bionic finger type hand claw device, gas (oil) strong current (weak current) communication device, etc.

According to the size and packaging form of the selected goods, a bionic finger and claw family is designed, as shown in figure 7. In actual production, the robot will automatically replace and use the selected materials according to the needs of the material.

Aiming at multi-variety, small batch and multi-frequency order sorting, this paper designs a multi-function robot end-effector to meet the diversified needs. This topic for the design of machine hand claw is based on modular design idea, will grab objects according to the size, weight and other factors, such as packaging material classification system by computer programming, to variant design of all kinds of robot end actuators, consider the operability and practicability of the scraping scheme, from the pick object whether the outer packing can adsorption, to determine whether to choose simple adsorption gripper. According to the size of the adsorption area, it is preliminarily divided into different types of end suckers, and then the size and load of suckers are further considered. Similarly, the selection of other grips should also consider the size, weight, packaging form and other factors of the goods, and select the appropriate robot grips for different picking objects, so as to realize the multi-purpose of one machine, so that it can meet the diverse picking tasks and improve the efficiency of automatic sorting.

3.3. "Claw Library" Structure

3.3.1. Structure Design of Gripper of "Claw Library". The claw library of the robot uses a chain mechanism, because the chain mechanism can be wound into a variety of shapes, can be placed horizontally or vertically, with high flexibility. Claw the clamping device of machine hand claw in the
repository as shown in figure 8, on the other side of the machine hand claw clamping claw library organization links on the chain institutions, according to the requirements of the job is composed of a number of different hand claw gripper library, each robot is equipped with the corresponding "claw library", the position of the robot in claw are set in the system in advance according to the robot's operational areas.

![Figure 8. Clamping mechanism of robot claw in claw library.](image)

According to the needs of the operation, the robot needs to change the paw, then the robot needs to directly complete the "paw taking" and "paw changing" process.

When the robot takes the claw, the chain mechanism, driven by the servo motor, rotates an idle gripping mechanism to the position where the robot replaces the claw. The robot body has multiple degrees of freedom, which can meet the needs of different movements of claw replacement. The robot first completes the related actions required by the claw in the claw changing mechanism, and then clamps the trapezoidal groove of the claw handle into the clamping mechanism of the claw claw in the claw library. Through the action of the oil cylinder at the tail of the robot claw changing mechanism, the robot claw changing mechanism is released to complete the automatic claw taking process of the robot.

When the robot changes claws, the chain mechanism, driven by the servo motor, rotates the claws needed to grab specific materials to the position where the robot changes claws. The robot uses its multiple degrees of freedom to complete the claw changing action. The robot inserts the paw to be changed into the claw changing mechanism. The oil cylinder at the tail of the robot claw changing mechanism acts as a function to tighten the claw changing mechanism of the robot, and then the robot steps back horizontally to a safe distance of the claw from the claw holding mechanism to complete the automatic claw changing process of the robot, and then the robot enters the automatic picking operation.

3.3.2. "Claw Library" Designed in this Project. According to the characteristics of the comprehensive comparison the several forms, combined with the project of flexible robot edcs and sorting object characteristics, design of disc type decorate robot paw library (as shown in figure 9) and the expansion of disc type is decorated robot paw library (as shown in figure 10) in two forms, its structure is simple, scalable high flexible, and more degrees of freedom robot can realize direct exchange for PAWS, High speed, high precision and high operating efficiency.
Figure 9. Disc robot claw library. Figure 10. Extended disc robot claw library.

Disc type is decorated robot paw library and the expansion of disc type is decorated robot claw library just difference in suitable size, but the driving principle is the same, is driven by servo motor worm and worm wheel mechanism, drive gearbox, gearbox drive sprocket, chain wheel swings have hands claw chain movement of clamping structure, to offer machine to automatically change claw.

4. Conclusion
In this paper, the idea of robot automatic claw changing is introduced by the automatic tool changing system of machining center, and the robot claw "family" including adsorption claw, clamping claw and bionic finger claw which can be exchanged according to the size and packaging form of the product is designed, as well as the structure of "claw library" clamping claw, claw library and robot automatic claw changing. This paper studies the flexible sorting system from a new perspective, aiming to provide a new idea for the logistics distribution center to reduce costs and increase efficiency. Robot claw changing can not only avoid the defects of traditional manual sorting and semi-automatic sorting, reduce the error rate and greatly improve the efficiency of the system, but also select different grippers according to the difference of cargo types, keep the robot body unchanged, realize one machine multi-purpose, improve the utilization rate of robot body, and realize the intensification of equipment, which has low requirements for the site, It has a wide range of applications.

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