Research and Design of Household Intelligent Mechanical Claw

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Abstract. In order to design a kind of intelligent mechanical claw for home and office scene. Based on the investigation, analysis and arrangement of the features of items in the family and the functional demands of the family on the mechanical claw, a design scheme of intelligent mechanical claw which can switch functions and grasping modes according to the different grasping objects is proposed. Mechanical structure design, including mechanism motion design, part structure design, and use Autodesk Inventor software for mechanical parts, component design and simulation assembly; The stress analysis module in Autodesk Inventor was used to simulate the key components. Finally, the design scheme of mechanical structure and control system for the mechanical claw are proposed.

Keywords: Family scene; mechanical claw; function switching; Autodesk Inventor.

1. Introduction
With the continuous development of human society, the economic level of the society and the level of science and technology have been greatly improved. In the development of science and technology, all kinds of mechanical arms have entered people's field of vision. Because of its high degree of automation and precision, robotic arms are widely used in industrial production, which greatly improves industrial production efficiency. However, due to the high connection between the functions of the robotic arm and its working environment and the high economic cost, its application fields are currently limited. However, the characteristics of the robotic arm guarantee that it will have broad development prospects in other scenarios. In a complete mechanical arm, the end mechanical claw determines the overall function and application range. At present, in the field of robotics, the method of solving the end mechanical claw clamping has problems such as high cost and complicated operation. The research and development cost of the mechanical claw accounts for about 40% of the entire robot cost. It can be seen that the current mechanical claw is in urgent need of development. At the same time, in home or other office scenes, items with different shapes and specifications need to be transported, sorted, and stored, and different types of items will lead to changes in the grasping method and strength of the grasper. At the same time, with the gradual deepening of the concept of intelligent life, intelligent robots represented by sweeping robots have gradually entered people's homes, and intelligent machines that can further serve people and liberate limbs in homes, offices and other areas are also deeply concerned by people. Based on the above-mentioned status, using
Autodesk Inventor and other 3D design software, we have designed an intelligent mechanical claw suitable for home and office scenes. Another section of your paper

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2. Project significance
In view of many problems in homes and offices, the home intelligent mechanical claws designed by us have the advantages of fast sorting speed, high grasping accuracy, and compatibility with multiple grasping methods.

The household intelligent mechanical claw is a special household and office service mechanical claw, which is an automatic mechanical device used in home and office scenarios. Its particularity lies in:

1) There are two different claw heads, which can respectively realize flexible grasping of objects and grasping with a small contact area with objects, and can switch between the two types of claw heads through an electric push rod and a claw head switching mechanism. To satisfy the grasping of different objects.

2) Through the combination of multiple sets of ball hinges and more sensitive micro pneumatic springs, the mechanical structure can be used to achieve flexible grasping of objects.

3) The claw body of the mechanical claw has a claw body turning mechanism composed of gear transmission and multiple sets of connecting rods, which can realize the conversion of the mechanical claw grasping in three directions in space and grasping in two directions on the plane, which can overcome grasping Restrictions on the volume of the object, whether it contains liquid, etc., adapt to a variety of scenarios.

4) The mechanical claw can adapt to a variety of loading platforms, such as robots, robotic arms, etc., and can be selected according to the actual needs of the user and the work scene.

3. Design ideas and feasibility analysis

3.1. Design ideas
After investigating the home and office scenes, we found that people now encounter many problems in the home and office: when it is necessary to organize and move objects, lack of manpower or large object mass causes a lot of effort and efficiency. Low; extreme care is required when handling liquid containers, resulting in extremely slow speed; when transferring fragile objects, the object is often damaged due to insufficient concentration or external interference.

After comprehensive consideration, it is preliminarily determined that the mechanical claw needs to realize the functions, including the ability to achieve flexible grasping, accurate grasping and transfer of special items such as fragile objects and liquid containers. The mechanical claw should be affected by different grasping objects. Adapt to the characteristics of a variety of grabbing objects and work scenarios. After determining the function of the mechanical claw, we began to design.

Firstly, according to the functions and advantages and disadvantages of the existing mechanical claws, a mechanism that can realize the grasping of fragile objects and the liquid container is found, and the claw head of the mechanical claw and its operating mechanism are designed after synthesis. On this basis, the claw body and its mechanism with the claw head are designed. In the design process, strength check and stress analysis of key parts are carried out to improve the reliability of the design and facilitate subsequent design.
3.2. Feasibility analysis

3.2.1. Feasibility analysis of mechanical claw grabbing mechanism. The grabbing mechanism of the mechanical claw consists of a linkage mechanism and an electric push rod. The movement of the mechanism is relatively simple. The extension and contraction of the electric push rod can directly control the closing and opening of the claw.

![Figure 1. Mechanical claw grabbing mechanism diagram](image1)

3.2.2. Feasibility analysis of claw body turning mechanism. The power of the claw body turning mechanism is provided by a stepping motor. Through gear transmission and multiple sets of linkage mechanisms, the movement of the linkages on both sides can be controlled. The movement of the linkages drives the hinges in the vertical direction to turn, thereby realizing space folding of the upper claw body. The one-way self-locking property of the worm gear mechanism ensures the one-way nature of the turning control of the motor rotation control claw body, and avoids the confusion of the position of the connecting rod gear.

![Figure 2. Claw turning mechanism diagram](image2)

3.2.3. Feasibility analysis of spherical hinge part. The combination of multiple sets of ball hinges and micro pneumatic springs constitutes the flexible gripping part of the mechanical claw. The spherical hinge can realize 180° rotation in space, and the pneumatic spring can realize accurate and sensitive quick reset. After the two are combined, the plane of one end of the spherical hinge can be tangent to any object in the space above, thereby achieving flexibility with the object fit.
3.2.4. Feasibility analysis of claw head switching mechanism. The claw head switching mechanism adds a set of parallel slides and slide rails ② to the double slide mechanism to ensure that the slide rails ① and ② are parallel, the motor in the sliding block on the slide rail ② can provide power for the movement of the slide rail ②, which balances the freedom of the mechanism. Not only increases the movable distance of slide rail ①, but also increases the slide rail ①. The distance between the ③ hinges. The electric push rod is connected with the slide rail ① through a sliding block, which pushes the connecting rod to rotate around the hinge, and the other end of the connecting rod is connected with the track in the claw head to drive the claw head to fold and realize the switching of the claw head.

4. Mechanism design and principle description
The overall structure of the device is shown in Figure 5:
4.1. Design of mechanical grabbing module
The mechanical claw grasping module is composed of an electric push rod, a claw body connector, and a claw head connector, which are connected by a hinge. There are three groups of the modules, which are evenly distributed on the mechanical claws and fixed on the mechanical claws by a combination of tenon and screws. Since each part contains two hinges, and the original length of the electric push rod is basically fixed, the size of the claw body connector is affected by the claw body, and the range of change is not large, so the rotation range of the mechanism is mainly determined by the size of the claw head connector constraint.

4.2. Ball hinge part design
The ball hinge part is composed of multiple sets of ball hinges and pneumatic springs, and is connected with the claw head through a mortise joint. In order to realize the flexible grasping of the
object by the mechanical claw, it is necessary to make the part of the surface of the spherical hinge fit the body. A 3×10 ball hinge group is now designed to fit irregular objects. As shown in Figure 8 when fitting.

4.3. Claw turning module design
The claw body turning module is composed of a gear drive and a linkage mechanism. The stepping motor rotates, and the worm is driven by the pulley to rotate. The worm wheel is connected to the gear set. The rotation of the gear set drives the rotation of the connecting rod. The connecting rod pushes the block with the claw head to rotate to realize the folding of the claw body and realize the mechanical claw in space three The conversion between single-azimuth grasping and planar grasping can overcome the constraints of the volume of the grasped object, whether it contains liquid, etc., and adapt to multiple scenarios.
4.4. Claw head switching module design

The function of the claw head switching module is realized by the claw head switching mechanism, and the power is provided by an electric push rod. This module can quickly and accurately switch the mechanical claw between the flexible gripping state and the small area gripping state.

In the flexible grasping state, the ball hinge part is located inside the claw head of the mechanical claw (effective working position). At this time, the mechanical claw mainly relies on the ball hinge part to realize the flexible grasp of the object. But at the same time, the ball hinge module located on the inner side occupies part of the space inside the mechanical claw, which limits the volume of the object grasped by the mechanical claw.

In the small-area grasping state, the ball hinge part is located outside the claw head of the mechanical claw. At this time, the mechanical claw relies on the small protruding part of the claw head to realize the grasping of the object. Although in this state, the mechanical claw cannot be flexibly grasped, the turned-out claw not only enlarges the effective space inside the mechanical claw, but also increases the length of the mechanical claw head, so that the volume of objects that the mechanical claw can grasp is large increase.

Figure 9. Claw turning module
Figure 10. Flexible gripping state (left) and Small area grab state (right)

5. Conclusions

Compared with the existing products, this mechanical claw can not only realize the grasping work, but also adapt to different work scenarios and grasping objects through the switching of the claw head and the change of the grasping position, which makes up for the work of the existing domestic mechanical claws. The object is single and cannot deal with the defects of different working conditions. The mechanical claw can accurately and steadily grasp the target object for home and office use, can effectively improve the efficiency of placement, solve the problem of manual service, and has a broad market prospect.

At the same time, the mechanical claw has strong compatibility, can be installed on different loading platforms according to the needs of users, and is suitable for grasping and moving more kinds of objects.

References

[1] Li Yingcheng, Yu Zeyu, Zhang Longhan, Guo Zhaoyang, Ma Xinling. Structural design of multifunctional modular home finishing robot [J]. Light Industry Machinery, 2020, 38(06):86-91.

[2] Qiu Wenxing, Li Chao. Online and offline home intelligent robot market survey [J]. Journal of Hubei University of Science and Technology, 2020, 40(02): 34-38.

[3] Qiu Wenxing, Li Chao, Fan Guoxing. Analysis of the market of home intelligent robots [J]. Journal of Mudanjiang Teachers College (Natural Science Edition), 2020(01):11-15.

[4] Wang Yong, Zhang Xinjing, Shi Yinggang. A three-degree-of-freedom picking mechanical claw design [J]. Rural Science and Technology, 2019 (25): 123-124.

[5] Peng Wensheng, et al. Mechanical Design. 2nd Edition. Wuhan: Huazhong University of Science and Technology, 2000.