Design of an engineering bionic flexible mechanical claw

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Abstract. The invention is improved on the basis of existing flexible robots and traditional robots, and for traditional robots, mostly rigid materials, when grasping fragile objects, the more fixed force is easy to cause damage to objects.

1. Introduction
In recent years, driven by the global mechanical automation, set off a new type of robot development boom, all kinds of robot products with various functions, began to appear frequently in our field of vision. Robotics is an indispensable part of high-tech artificial intelligence applications, of which robots are also an important component, and the properties of robots directly affect the versatility and practicality of robots. In this context, the concept of "flexible robot" began to be put forward gradually. Through the use of soft materials, driving innovation, people hope that robots can have better environmental adaptability, safety and human-machine interaction ability, so that in advanced manufacturing can play a greater value, so the need for further research on flexible robots. As for the application of flexible robots in the industrial field and flexible robots in the field of living and working, with the development of flexible robots in recent years, under the support of machine vision, machine perception and other technologies, its important role in industry and life will be more and more attention, the market demand will be increasing in the future.

2. Function analysis
The drive module is improved and the mechanical drive is used to make the robot grip process more controllable than today's flexible mechanical claws, enhancing its grip stability. Add flexible materials, grab softer than traditional robots, set flexible pressure feedback, achieve the function of controlling grip, in the process of flexible robot grip can achieve robot grip and control grip automation. The drive module is improved and the mechanical drive is used to make the robot grip process more controllable than today's flexible mechanical claws, enhancing its grip stability. Add flexible materials, grab softer than traditional robots, set flexible pressure feedback, achieve the function of controlling grip, in the process of flexible robot grip can achieve robot grip and control grip automation.
3. Design
After taking into account the current flexible robot application scenarios and functional needs, we will select the topic positioning in the will be able to achieve a significant increase in the grasping of items when the contact area, in the grasping process through the device's own fine-tuning, improve the stability of the crawled items, and can be different sizes and shapes of items to crawl. First of all, combined with the advantages and disadvantages of the existing flexible robot, taking into account the device in the grasping stage to complete some tasks, the preliminary design of the robot is divided into three parts, each part to complete its function, to achieve gradual fine-tuning, to achieve flexible function. Subsequently, we consider that due to the diversity of the shapes of the captured objects, we design infrared range devices and pressure feedback systems to sense the shape characteristics of different objects, change the working mode, and use pressure feedback to control the grip of objects to achieve flexible effects. Secondly, taking into account the change of the relative position between the fingers when the device changes the working mode, the center base track and the transverse orbit are designed to ensure the flexibility of the device's motion. Finally, the flexible robot appearance is designed to beautify the robot. During the design process, the strength check and stress analysis of key parts are carried out to improve the reliability of the design and facilitate the subsequent design.

3.1. Finger function module

3.1.1. Airbag module. Due to the different shapes of the objects captured, the center of gravity position is uncertain, and the hardness of the objects is different. The grasping process needs to maintain the smoothness of the object in the robot hand, the conventional robot uses the clamping force to create pressure on the finger, thus generating friction, friction and pressure to achieve the object's fixation, but easy to lead to the deformation of soft objects and damage to fragile objects, some objects have a devastating blow. The robot uses flexible airbags to achieve adsorption and preliminary fixation, which can play a good force performance on soft objects and protect vulnerable objects. The design of the airbag module avoids damage to the object and effectively meets the requirements for the use of flexible mechanical claws.
Figure 2. Airbags.

3.1.2. Flexible suction part. The fingertip part is a flexible fit part, which is expanded when the object is grabbed by the deformability of the flexible material, and the built-in mechanical skeleton is fixed, so that the flexible material fits the grasping object closely. Then the use of adsorption device, so that the flexible materials of the four claws work together, wrap the grasping object, by increasing the force area, reduce the pressure, so as to be able to grab the object and avoid greater stress on the object. For the crawled object, make the grasping action gentler, fully reflect the flexible characteristics of the flexible robot, fit the friction pad in the inner wall of the flexible robot, increase the friction with the grasping object, and improve the current flexible robot grasping the object unstable shortcomings. This part is retractable and changes the area to achieve adaptability to objects of different shapes.

When the projected area of the object is large and the height is small, the part can be straightened, the working mode is changed from grab to lift, and the rear mechanical bone bears the main lift force. Four surface-shaped claws work together to achieve a smooth lift and drop of the object.

When the weight of the object is large, the adsorption module will be sucked to the object, with flexible joint movement and force gain, the object can be fixed, when the weight of the object is small, the object will be sucked to the mechanical claws, so that the object and mechanical claws always keep in a state of fit, to ensure the smooth grasping process. The working principle is that the vacuum suction cup is first connected to the vacuum generator by taking over, and then in contact with the object to be crawled, the vacuum device is started to pump, so that the suction cup produces negative air pressure, so that the suction of the suction object can be lifted. When the grab is moved to the destination, it is smoothly inflated into the vacuum suction cup, which changes from negative pressure to zero or slightly positive air pressure, thus completing the task of grabbing.

The flexible robot sets up a flexible pressure sensor in the flexible adsorption device. This sensor is used to control the flexible material inflation controller. Through the data feedback of the pressure sensor, to determine whether the flexible robot grasps the item, and makes the flexible robot grasp the item to reach the set pressure to send a signal to the controller, the controller after receiving the signal to control the inflator to stop inflating, and then carry out the following operations.

Figure 3. Flexible suction and modules.
3.1.3. **Infrared range fest module.** In the center of the base and the center of the three fingers are equipped with infrared rangefinders, which work together to accurately measure the surface area and height of objects and calculate whether or not to deform the operating mode.

3.2. **Finger Movement Module**
The module is driven by a motor and works with the card slot through the track on the center base to achieve the adjustment of different finger positions and open amplitude.

![Figure 4. Finger adjustment.](image)

3.3. **Rotating open-close mechanism**
The rotating opening and opening mechanism uses the cooperation of the lever and the card slot to connect with the finger, and realizes the extension and recovery of the lever through the rotation of the center turntable, realizes the rotation opening and close, changes the opening amplitude of the finger, and realizes the adaptability of objects of different sizes. At the same time, the modules can move individually, changing the operating mode of the unit.

![Figure 5. Rotate open and close.](image)
3.4. Working mode analysis
The device is equipped with a deformation mechanism, which can drive a series of mechanical transformations and change operating modes according to the feedback information of the infrared rangefinder fixed to the claws and on the connecting block. The robot is divided into three modes, namely clamping type, claw grip type and lift type.

3.4.1. Clamping mode. Clamping mode is a combination of mechanical claws, forming a clip similar shape, to achieve the grasping of simple objects, so that for simple objects, mechanical claws do not have to complete too complex deformation, reduce power, while increasing the life of precision parts. This mode allows you to complete the grab of cylinders, boxes, spheres, etc., or objects of one-way length.

![Figure 6. Hold mode.](image)

3.4.2. Grab mode. Grab mode can be moved by four fingers to achieve the function of grasping, holding, pinching. In addition, the two joints of a single finger can be changed according to the shape of the object to be grabbed, so that the mechanical claws better fit the object to be grabbed, and thus complete the grasping of various special shape objects.

![Figure 7. Grab mode.](image)
3.4.3. Forklift lift mode. Adsorption mode is to make the fingertip part of the basic tile, similar to the shape of the basket, airbag direct contact with objects to achieve adsorption grab. This mode is mainly designed to grab flat-shaped objects. Traditional robots in the grasping of flat-shaped objects will usually appear to grasp up, grasp deformation problems, and the robot through the forklift lift mode can grasp such objects, the suction module on the side to the object to complete adsorption fixation, leaving a gap at the lower end, so that it can complete the grasping of such objects.

![Figure 8. Lift mode.](image)

3.5. Stress analysis
Because the mechanical finger is forced during the grip of the robot, the stress requirements of the mechanical finger must meet the stress criteria during the operation. For the foot through solidworks analysis module, we did the following analysis:

| Model reference | Property | Parts |
|-----------------|----------|-------|
| Name:            | Alloy steel (SS). Linear elastic esoxuality | Little Fingerty.iam |
| The model type:  | Maximum von Mises stress | |
| The default failure criterion: | 6.20422e-08 N/m-2 | |
| Yield strength:  | 7.23826e-08 N/m^2 | |
| The intensity of the stress: | 2.1e-11 N/m2 | |
| Elastic modulus: | 0.28 | |
| Poissonby:       | 7,700 kg/m^3 | |
| Mass density:    | 7.9e-10 N/m2 | |
| Anti-shear mould:| 1.3e-05 /Kelvin | |
| Thermal expansion coefficient: | | |
| Curve data: N/A | | |

Depending on the size of model 1:1, apply the weight of the unit removing the rest of the base module to the face and apply a fixed constraint on the sole face of the foot. Stress analysis results are as follows:
4. Conclusion
In the existing flexible robot and traditional robot on the basis of improvement, for the traditional robot is mostly rigid materials, when grasping fragile items, more fixed force easy to cause damage to the object; The use of multi-stage adjustment, so that flexible materials more closely fit the grasping object, more prominent flexible material in the flexible mechanical hand, improve the current flexible robot grasping object instability shortcomings. And according to the shape characteristics of the grasping object to change the working mode. It can be seen that this flexible robot can play a more practical role, the significance is more important, a wide range of applications.

References
[1] Wang Zuojun, Mo, Guowei, Yufan, Cohan, Jie. n and analysis. Electrical and Mechanical Engineering, 2019, 48 (09): 135-137.
[2] Liu Xiaomin, Xu, Zhao Yunwei, Dexu, Jiang, s and crawl experiment. Machine tools and hydraulics, 2019, 47 (15): 24-28.
[3] Zhou Qi, Sun Yi, Zhang Liang, Xu Weigu. Optimization design of manipulator connector based on SolidWorks [J]. Forging equipment and manufacturing technology, 2020, 55 (05): 63-66.