Structure Design of a Feeding Assistant Robot

Chenling Zheng [a], Liangchao Hou [b] and Jianyong Li [c]

Shandong University of Science and Technology, Qingdao 266590, China.

[a]2425614112@qq.com, [b]931936225@qq.com, [c]1690187499@qq.com

Abstract

With the continuous development of China's robotic automation technology, the application of robotics in China will be very extensive, involving industrial, medical, and other aspects of life.This paper analyzes the working principle of feeding assistant robots and designs a specially designed application to help patients with unmovable arms or frail elderly people to eat in order to improve the quality of life.The feeding assistant robot includes a base, a body rotation lifting mechanism, an arm structure, and a gripper structure.The main body rotation lifting mechanism is arranged above the base.The main body rotation lifting mechanism is used to drive the arm structure and the gripper structure to move up and down in a vertical direction, move back and forth, and swing left and right.The gripper structure can swing up and down relative to the arm structure. The gripper structure is a four-link mechanism that can control the opening and closing of the two half-spoons through the rotation of the screw.

Keywords

Dietary care; Feeding assistant robots; Structural design.

1. Introduction

With the continuous development of China's robotic automation technology, the application of robotics in China will be very extensive, involving industrial, medical, and other aspects of life.In recent years, patients with hand disability caused by sequelae of cerebral stroke, spinal cord injury, and natural and man-made disasters have been increasing year by year. The problem of dietary care for patients with hand disability needs to be solved.Robotics has developed rapidly over the past two decades. As a kind of rehabilitation robot, the development of feeding assistant robots has just started.However, as the world's aging population continues to intensify and the number of disabled people in the world continues to increase, their daily work and life problems need to be resolved, so feeding assistant robots have received more and more attention and research.The main service object of this robot is human. Our concern is whether it can provide convenience for people, not the products in the factory. Therefore, there is a higher requirement for the accuracy and safety of the robot.Through the analysis of the demand of the robot's service objects, according to the needs of different degrees of disability of the patient, an feeding assistant robot consisting of a gripper with a spoon is designed.

2. Structure Scheme of the Feeding Assistant Robot

2.1 Basic Requirements for Robot Transmissions

(1) Compact structure, that is, the smallest volume and lightest weight;

(2) The stiffness of the transmission is large, that is, the angle deformation is less when the torque is applied, so as to increase the inherent collar rate of the entire machine and reduce the low-frequency vibration of the entire machine;

(3) The return difference is small, that is, from the positive rotation to the reversed space-time travel is small, so as to obtain a higher position control accuracy;

(4) Long life and low price.

2.2 Robot Structure

2.2.1 Cartesian Coordinates Robot

The arm consists of three mutually orthogonal moving pairs. The wrist moves linearly in the direction of the three coordinate axes X, Y, and Z, respectively. The structure is simple and the movement position has high precision. However, it occupies more space and the scope of work is relatively small. As shown in Fig. 2.1.

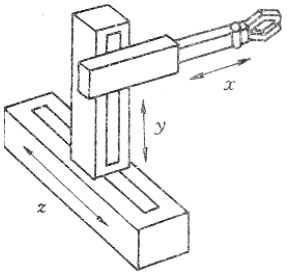


Fig 1. Cartesian coordinate's robot

2.2.2 Cylindrical Coordinate Robot

The arm consists of a rotating pair and two moving pairs. Relatively speaking, it occupies less space, has a larger scope of work and is more widely used. As shown in Fig. 2.2.

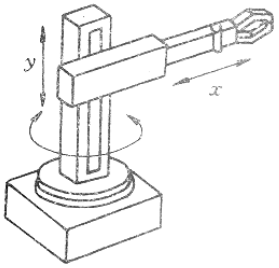


Fig 2. Cylindrical coordinate robot

2.2.3 Articulated Robot

It consists of rotating joints and front and lower arms. Articulated robots use relative angular displacements of adjacent parts of the arm as motion coordinates. With flexible operation, it occupies a small space and has a wide range of work. It can bypass various obstacles in a narrow space. As shown in Fig. 2.3.

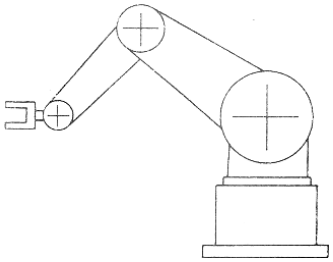


Fig 3. Articulated robot

2.2.4 Polar Coordinates Robot

The arm consists of two rotating pairs and one moving pair. It generates a linear motion along the arm axis X, a rotation around the base axis Y and a swing around the joint axis Z. The arm can make a pitch motion around the Z axis and can grab objects on the ground. As shown in Fig. 2.4.

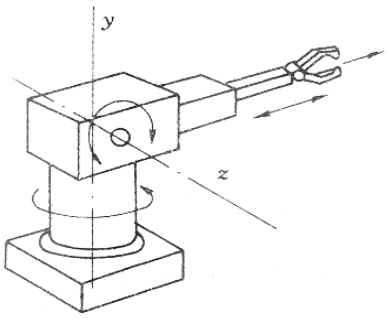


Fig 4. Polar coordinates robot

According to the requirements of this design, the robot needs to have high flexibility, accuracy and safety, imitating the feeding process of the human arm.In order to enable the robot to work properly, the three degrees of freedom of the arm need to be accurately positioned. the food caught is very light so the robot belongs to light load.The robot adopts a combination of cylindrical coordinates and articulation to make the mechanism more stable and deliver food to people's mouth more precisely. The mechanism and joints can be rotated through the power system, so that the arm swings back and forth and swings up and down, so that the gripper reaches a designated position and completes the desired trajectory.

3. Structural design of the Feeding Assistant Robot

The feeding assistant robot in the present invention includes a gripper, a robot arm, and a rotarye lifting mechanism for driving the gripper and the robot arm as a whole to perform lift movement, forward and backward movement, and left and right swings,as shown in Fig. 3.1. The gripper includes a gripper shell and a spoon for gripping food at a front end of the gripper shell. The gripper shell is hinged with the front end of the robot arm and can swing up and down relative to the robot arm.The spoon includes a first half spoon and a second half spoon, and a gripper driving mechanism for driving the first and second half scoops to separate and move closer to each other is disposed in the gripper shell.

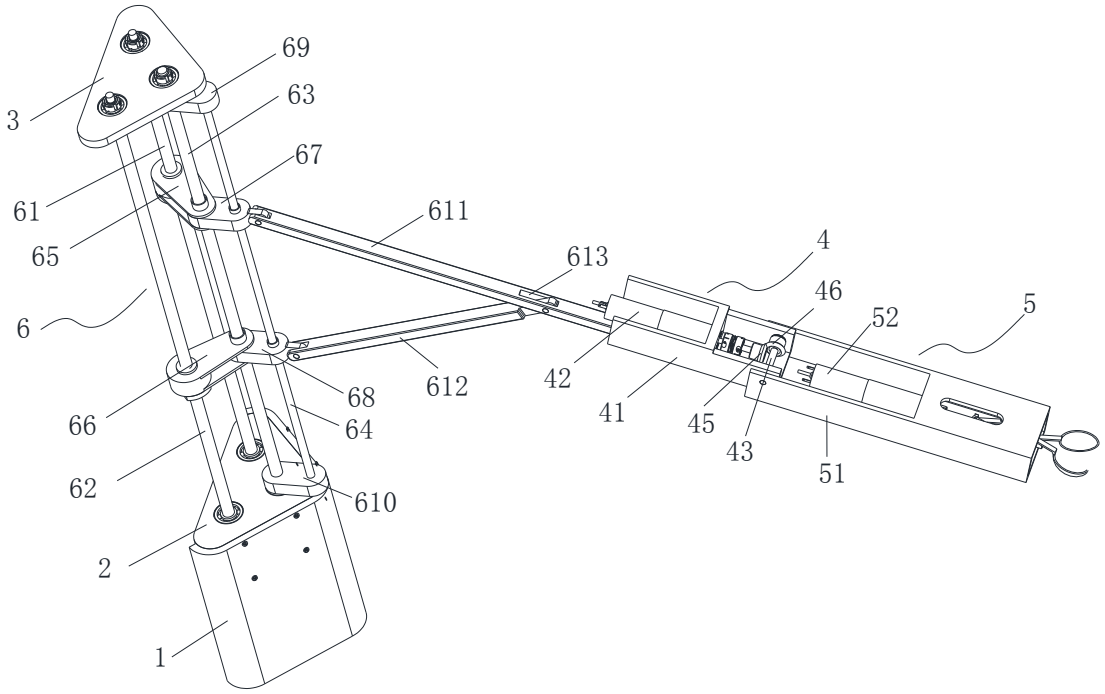


Fig 5. The overall structure of the feeding assistant robot

3.1 Structure Design of the Gripper Driving Mechanism

The gripper driving mechanism in the feeding assistant robot includes a first half spoon, a second half spoon, a first spoon handle, a second spoon handle and a rotating shaft. The first spoon handle and the second spoon handle are arranged crosswise and the middle portions of the two are hinged with each other.The first half scoop is disposed at the front end of the first scoop handle, and the second half scoop is disposed at the front end of the second scoop handle. The end of the first half spoon is hinged with the front end of the first spoon handle, and the end of the second half spoon is hinged with the front end of the second spoon handle. The end of the first scoop handle and the end of the second scoop handle are collectively placed on the rotating shaft and synchronously rotate around the rotating shaft. The first half scoop, the second half scoop, the first scoop handle and the second scoop handle cooperate to form a parallelogram mechanism; The gripper driving mechanism also includes a linear driving mechanism for driving the rotating shaft to perform reciprocating rectilinear motion. As shown in Fig. 3.2.

The linear drive mechanism in the gripper driving mechanism includes a first motor and a first ball screw set driven by the first motor. The first motor is mounted on the gripper shell. The first ball screw pair includes a first ball screw and a first ball bearing matched with the first ball screw. The first screw is driven by the first motor, and the rotating shaft is arranged on the first ball bearing. The first motor controls the opening and closing of the first half spoon and the second half spoon through cooperation of the first ball screw pair and the parallelogram mechanism.

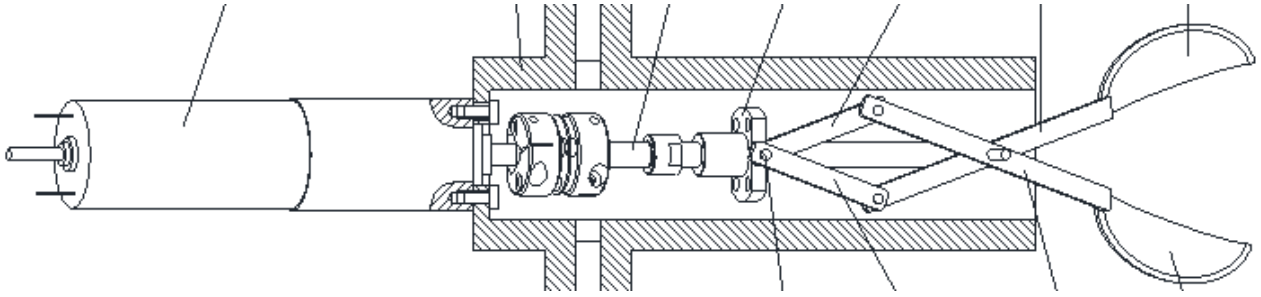


Fig 6. The structure of the gripper driving mechanism

3.2 Structure Design of the Robot Arm

In the feeding assistant robot, the robot arm includes an arm frame and a first transmission shaft disposed at the front end of the arm frame.The gripper shell is provided with a shaft hole adapted to the first transmission shaft, and the arm frame is provided with a rotary drive mechanism for driving the first transmission shaft to rotate.The rotary drive mechanism drives the gripper shell to swing up and down relative to the front end of the arm support by driving the first transmission shaft to rotate.

In the robot arm, the above-mentioned rotary drive mechanism includes a second motor, a second transmission shaft, a first bevel gear, and a second bevel gear.The second transmission shaft is driven by the second motor, and the axis of the second transmission shaft is perpendicular to the axis of the first transmission shaft.The second bevel gear is mounted on the second transmission shaft, the first bevel gear is mounted on the first transmission shaft, and the first bevel gear meshes with the second bevel gear.Then the gripper shell is driven to swing up and down relative to the arm frame.As shown in Fig. 3.3.

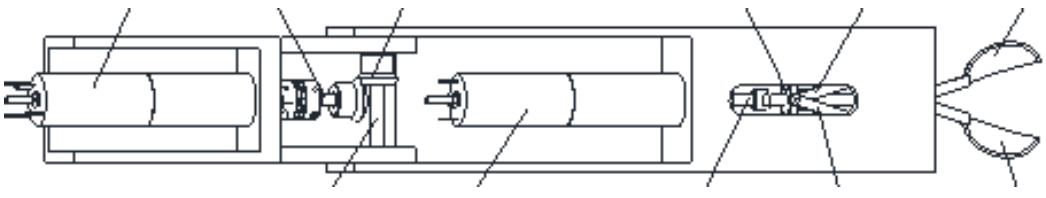


Fig 7. The structure of the robot arm

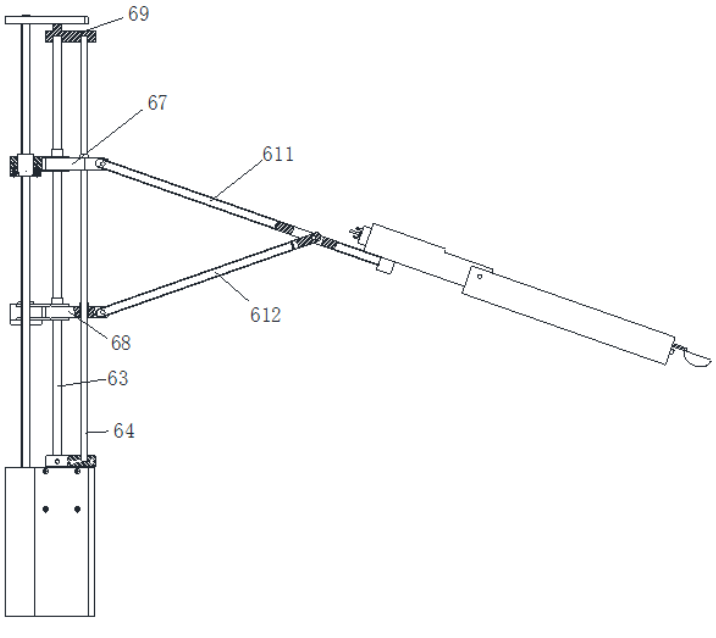
3.3 Structure Design of the Rotary Lifting Mechanism

The rotary lifting mechanism in the feeding assistant robot includes a first link and a second link, one end of the first link is connected to the rear end of the mechanical arm, and one end of the second link is hinged to the first link. The length of the first link is greater than the length of the second link;The rotary lifting drive mechanism also includes a lifting drive mechanism for changing the angle between the first link and the second link.

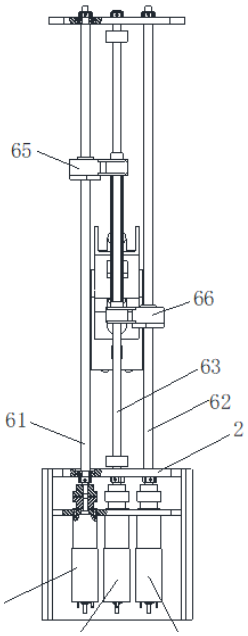
The lifting drive mechanism includes a first lifting drive mechanism for carrying out a lifting movement of one end of the first link that not connected with the robot arm; and a second lifting and lowering drive mechanism for lifting and lowering an end of the second link not connected with the first link. When the first link and the second link move up and down synchronously, the angle between the first link and the second link does not change. The robot arm and the gripper perform lifting movements under the effect of the first and second links. When the first link and the second link move up and down asynchronously, the angle between the first link and the second link changes. The robot arm and the gripper move back and forth under the action of the first and second links.

The first lifting drive mechanism includes the fourth motor, the second ball screw pair, the first upper guide joint and the second upper guide joint. The second ball screw pair includes the second screw driven to rotate by the fourth motor and the second ball bearing adapted to the second screw. The rotation of the second screw drives the second ball bearing to move up and down along the second screw, the second ball bearing is connected with the first upper guide joint, and the first upper guide joint is also connected with the second upper guide joint. The end of the first link that is not connected to the robot arm is hinged to the second upper guide joint. The second lifting drive mechanism includes the fifth motor, the third ball screw pair, the first lower guide joint and the second lower guide joint. The third ball screw pair includes the third screw driven to rotate by the fifth motor and the third ball bearing adapted to the third screw. The rotation of the third screw drives the third ball bearing to move up and down along the third screw. The third ball bearing is connected with the first lower guiding joint, and the first lower guiding joint is also connected with the second lower guiding joint. The end of the second link not connected to the first link is hinged to the second lower guide joint.

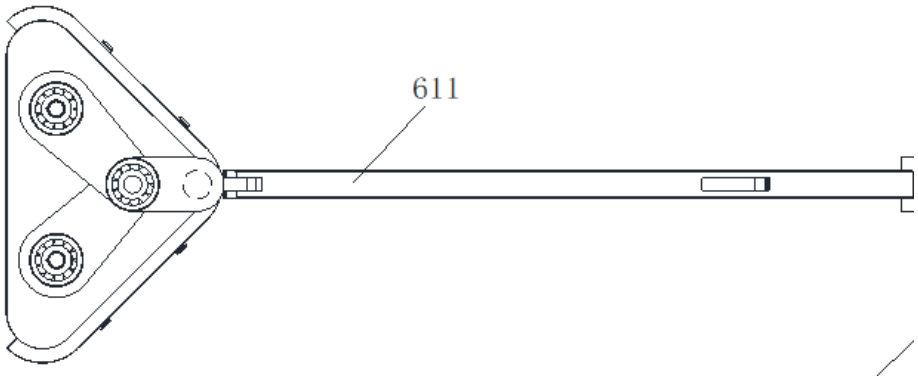
The rotary lifting device in the feeding assistant robot further includes a swinging drive mechanism for driving the first link, the second link, the robot arm, and the gripper to swing left and right. The swinging drive mechanism includes the sixth motor, the driving shaft, the driven shaft and the transmission components. The driving shaft is rotated by the sixth motor, and the driving shaft rotates the driven shaft through the transmission components. The transmission components includes the upper linkage block that is placed on the upper part of the drive shaft and rotates synchronously with the drive shaft, and the lower linkage block that is placed on the lower part of the drive shaft and synchronously rotates with the drive shaft. The top end of the driven shaft is connected with the upper linkage block, and the bottom end is connected with the lower linkage block. One end of the second upper guide joint is placed on the drive shaft and the other end is placed on the output shaft. One end of the second lower guide joint is placed on the driving shaft and the other end is placed on the drive shaft. When the driven shaft rotates, the second upper and lower guide joints are rotated around the driving shaft to drive the first link, the second link, the robot arm and the gripper to swing around as a whole.



(a) The front view



(b) The left view



(c) The top view

Fig 8. The structure of the rotary lifting mechanism

4. Conclusion

Compared with the prior art, the feeding assistant robot has the advantages of simple overall structure, compact and reasonable layout, large motion space, good coordination of movement between various moving parts, and flexible manipulation. Especially in the course of its operation, each action performs with high precision, high sensitivity and good consistency. The robot solves the problems of insufficient accuracy, poor flexibility, and large occupied area of the existing food-assisted robot, and is practical, intelligent, safe, and simple and flexible in operation and capable of realizing the feeding operation.

Acknowledgements

The authors are grateful to the support of the National Natural Science Foundation of China.

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