Design of Household Items Delivery Robot

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Abstract. The household items delivery robot is a multi-functional robot mainly facing the delivery and handling of household goods. It can handle a variety of items while delivering them, such as cup cleaning and fruit cutting. It achieves the grabbing and delivery of various items through multi-degree of freedom robotic arms and claw-changing devices. Its versatile internal structure enables clean cups, cut fruit and transport items. The multi-functional robot as mainly household goods delivery service will make people living feeling standards having a greater improvement and bring great convenience to home living.

1. Introduction
With the continuous improvement of people's living, people's quality of life requirements is also increasing day to day. The home living service robot has been investigations[1-3]. In recent years, countries have introduced a number of home robots, such as Fujitsu's service robot Enon, Mitsubishi’s home robot Wakamaru and RiSH robot[4-6]. A variety of home robots with entertainment and cleaning functions are pouring into people's lives[7-9]. Most of the robots used in the home are moving towards entertainment and sanitation, but there is little helps in the delivery of items. A service robot for the household items delivery is designed in this paper. It could realize the intelligent handling of items in the delivery process at the same time and support a good help for people's home living. Moreover, the quality of life of some elderly people and special people with limited mobility could be improved with the help.

2. Overall design
The robot is mainly composed of item grab delivery system and cleaning cutting system. With the purposes of the household item delivery, the robot can move to anywhere at home to complete the grabbing and delivery of items, such as fruit cutting and cleaning of water cups. The system flowchart is shown in figure 1. When it starts working, the owner or user sends instructions to the robot through the smart information terminal. The robot captures the positioning through the camera and automatically plans the path to the item to be captured. The grab of items of different shapes and sizes is then achieved by selecting different mechanical claws. After the successful grasp, the robot’s top spring power door opens. Then the lifting mechanism will be the clamping mechanism to the appropriate position, and then the robot arm puts the item into the clamping mechanism fixed in the robot. Finally, the machine delivers the item to the specified location for users. The overall appearance is shown in figure 2. The overall length of the household items delivery robot is 597 mm, the total width is 317 mm, the maximum height is 1120 mm. And the front face of the robot is designed with a special face picture.
3. Part design

3.1. Items grab delivery system

The item grab delivery system is mainly composed of seven-axis robotic arm, mechanical claw, claw-changing mechanism. The robot arm's compact structure, freedom, flexible and diverse work, can solve the user's residence in place of goods complex environment. It is capable of taking specified items in much interference. Its overall appearance and freedom display as shown in figure 3.

With seven degrees of freedom, the robotic arm is flexible and versatile and can handle the complex environments in an ordinary family home. Since the size of the joints of the robot arm is close, the number of joints can be increased to increase their degrees of freedom, so that the robot arm can clip objects farther away. The transmission of each joint of the robot arm is completed by the harmonic gear reduction device. Compared to the decelerator of the same transmission ratio, the numbers of parts of the harmonic drive reducer are reduced by $1/2$ and the volume and weight is also reduced by about $1/3$. It can improve the carrying capacity, transmission stability and motion accuracy.

In the process of picking up items from cylindrical, spherical and irregular objects, the robot selects different mechanical claws to achieve accurate picking of items of different sizes and shapes. There are two mechanical claws in the design. As shown in figure 4, the mechanical claw 1 can be used to grab spherical items and the mechanical claw 2 can be used to grab column and long striped items. The drive shaft rotates to move the cross along the drive shaft, thereby drives the link 1 motion, link 1 drives the link 2 connecting claws. It can achieve the closing and opening of the claws. Due to the feature of the two link 2 connected to the claws, the claws are moving strictly horizontally during the actions.
3.2. Cleaning cutting system
The cleaning cutting system is mainly completed by cleaning the water cups and cutting the fruit. The system is mainly composed of cup sleeve, rail, telescopic mechanism, cleaning mechanism, cutting mechanism and water tank. The overall structure is shown in figure 5.

When it starts working, the system first places the cup cover through the item grab delivery system, and the water pipe in the water tank fills the cup with water. After that, the cup sleeve is transferred to the upper part of the cleaning mechanism by the guide rail, and the cleaning of the water cup is completed by the cleaning mechanism. Finally, the sewage is poured into the waste water tank through the guide rail.

The process of cleaning the cup involve shaking the cup, mimicking the process of cleaning the cup manually. The motion of the agency is made up of a combination of reciprocating straight and rotating motion, consisting mainly of large gears, pinions, discs, and cross-slide sliders, as shown in figure 6. The large gear engages with the centre gear to drive the cross slider to do reciprocating linear motion, and the pinion drives the disc to drive the cross slider to do the rotation altogether.

![Figure 5. Cleaning cutting system.](image)
![Figure 6. Sine mechanism with parts.](image)

3.3. Cleaning cutting system
There is cleaning cutting system designed for the clean and cutting helps. The clip mechanism with parts is shown in figure 7. The cutting system with parts is shown in figure 8.

![Figure 7. Clip mechanism with parts.](image)
![Figure 8. Cutting mechanism with parts.](image)
The clip mechanism can clip a column or spherical object within a range of graspable. It consists mainly of motors, rotors, rods and clips. The pinion on the motor and the large gear in the lower part of the rotor engaged, the motor provides the power to rotate the rotor, then the rotor drives 6 levers to make 6 clips moving towards the centre. The clip action is realized, and the motor is reversed to carry out the opening action.

The cutting mechanism is mainly designed for the fruit cutting, which is convenient for users to eat fruits. As shown with its structure diagram in figure 8, it is mainly composed of column cams, tools and connecting rods. It is mounted on the rails for horizontal movement and precise positioning of the cutting position. The motor control worm gear driving the cylindrical cam to rotate, and the cylindrical cam has a guiding groove for the movement of the link. The connecting rod of the tool is converted into a linear motion according to the rotation angle of the cylindrical cam according to the corresponding specification. The user can adjust the cutting speed and cutting force by adjusting the speed controller.

4. Conclusion
The household item delivery robot is one type of the home living service robot. The design in this paper uses a multi degree of freedom robot and a replaceable mechanical claw to facilitate quickly and reliable operation. It can deliver most items in an ordinary household at home. It can be achieved cutting fruit and cleaning the water cups. The robot structure is small, compact with high practical actions which can bring enough convenience to the family livings. Through the investigation, the household items delivery robot has big market demand with considerable economic and social benefits. Moreover, it can be used not only in household at home, but also in companies, gyms, nursing homes and so on.

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