Intelligent integrated multifunctional vegetable cutter system

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Abstract. With the continuous development of the Internet of Things technology, people's requirements for quality of life are gradually improving. However, cutting vegetables is still a manual work with low efficiency. Food processing has many shapes, high requirements, time-consuming and labor-consuming, and there is a certain risk factor. Therefore, a new type of vegetable cutter is designed. After the objects are loaded in the feeding box, they are conveyed and fixed, so that the device can automatically press, cut and drive vegetables, and make artificially desired slices, filaments, blocks, peels and the like according to different requirements of dishes, which is small in size, low in noise, safe and convenient.

1. Introduction

Through on-the-spot investigation, we found that with the aging of the population, more and more elderly people living alone have many difficulties and risk factors when cooking, such as inability to cut vegetables and poor cutting effect; Hand shaking, fatigue, cutting, easy to hurt the hand; Standing for a long time is prone to fainting. The purpose of this project is to develop a home intelligent integrated multifunctional vegetable cutter for the above-mentioned existing devices are not suitable for families and the elderly.

2. Overall design scheme

The intelligent vegetable cutter can be divided into human-computer interaction interface, automatic tool changing module, feeding and discharging module, bearing rotating mechanism and other parts to work together. According to the cutting methods required by different dishes, the dishes are placed in the feeding box, and the vegetable cutter automatically advances to prepare for cutting. At the same time, different working modes, such as shredding, slicing and dicing, are selected in the cutting mode on the LCD touch screen, and the knives required by the dish shape are provided through the automatic knife changing module, and the touch screen is clicked to start. After fixing and cutting, people can click the touch screen to stop cutting the dish according to the required degree. Finally, the cut vegetables fall to the bottom discharge box, and the discharge box slides out of the device through the guide rail, and is taken manually to cut the vegetables. The intelligent vegetable cutter is an intelligent and high-precision device, which is easy to operate, small in size, convenient to place, good in safety and suitable for
household use. Users can place the vegetable cutter by themselves according to the family space, making it more convenient for the elderly to cut vegetables.

![Overall appearance model of vegetable cutter.](image1)

**Figure 1.** Overall appearance model of vegetable cutter.

![Perspective view of internal structure of vegetable cutter.](image2)

**Figure 2.** Perspective view of internal structure of vegetable cutter.

The overall process is shown in the following figure:

![Overall work flow chart of vegetable cutter.](image3)

**Figure 3.** Overall work flow chart of vegetable cutter.
3. Design of each module

3.1. Feeding module
When using this vegetable cutter, the power is turned on and the small DC motor turns the trigger switch. At first, people only need to put the dishes in the feeding box, and then, the baffle is set in the feeding box, which pushes the dishes inside for the next process. The feeding box is closely matched with the side structure, and no looseness occurs. At the same time, the electric screw rod is connected with the baffle plate, so that the baffle plate can push the dish tightly when pushing the dish into the next link, which is convenient for fixing when cutting the dish. At the same time, pushing forward continuously speeds up the completion of the vegetable cutting operation, and also enables the dishes to accurately fall into the discharge box. With the action of the electric screw rod installed on the transverse fence of the feeding mechanism, the cutting food is always pressed, which ensures the safety and reliability of the cutting process. At the same time, combined with the baffle installed with the compression spring, the automatic feeding of the cut food can be realized without manual operation, thus saving manpower.

![Feeding module](image)

**Figure 4.** Feeding module.

3.2. Smart touch screen
The intelligent touch screen is a man-machine interaction interface between the vegetable cutter and people. The touch screen can realize all processes only by clicking. These include selecting function, starting, and stopping. When selecting the function, that is, selecting the required blade according to the shape of the dish to be cut, and then clicking Start, the vegetable cutter can operate. For example, when mashed garlic reaches the required level, you can click to stop the process of cutting vegetables.

![Smart touch screen](image)

**Figure 5.** Smart touch screen.
3.3. Automatic tool changing module

First of all, according to the commonly used blades, we choose four most common ones: cutter, kopis, peeling knife and toothed knife. They are respectively installed on a disc, which is convenient to rotate and select the required blades. When a blade is selected, the blade disc rotates to a certain angle, so that the designated blade protrusion passes through the groove and is finally used for cutting vegetables. At the same time, the height of protrusion between the blade and the disc can be adjusted to control the cutting height and realize the adjustment of cutting thickness.

![Figure 6. Blade disc.](image)

When the required blade is clicked according to the dish shape cut in the LCD touch screen, the motor starts to drive the middle bearing to rotate. Rotation of the cam makes the front locking lever rotate in the sliding groove to select the designated blade. The blade disc rotates to a certain angle to reach the clamping groove position of the fixed disc seed, and the cam drives the locking rod to push the fixed blade forward into the clamping groove seed and fix it in the notch of the fixed disc for operation.

![Figure 7. Automatic tool change module.](image)

3.4. Motor part

First of all, low-power DC motor is selected as the motor, which has low power and less noise. And is suitable for household use. At the same time, the encoder inside the DC motor can identify the angle that the cam needs to rotate, etc., and can drive the bearing to rotate 90°, 180°, 270°, etc. for accurate positioning to work, and stop working after the encoder detects that the position is accurate.
3.5. Bearing rotating module

When the initialization of motor, bearing and cam is completed, the small DC motor will drive the middle bearing to rotate, thus driving the cylindrical cam to rotate. When the encoder of the DC motor detects that the cam reaches the jacking position required by the slicing knife, the DC motor will stop rotating. At this time, the convex surface of the blade is just aligned with the notch and the groove surface is parallel.

The cam bearing and the linear bearing cooperate with each other. Under the constraint of the linear bearing, the cam bearing lifts the blade disc, and the blade enters the notch of the fixed disc and protrudes outward, thus realizing full-automatic tool change.

Finally, due to the upward and downward cutting of the raised blade and the automatic feeding and fixing of the feeding module, the automatic vegetable cutting process can be safely and reliably carried out.
3.6. Discharge module
In the process of fixing and intelligently cutting vegetables, the user can judge according to the required cutting degree, such as the required particle size of garlic paste. If the requirements are met, the user can click on the touch screen to close and stop cutting vegetables. Finally, due to gravity, the cut dishes will fall into the lower discharging box, and the discharging box will slide out through the side guide rail to obtain the cut dishes, which has high efficiency, low energy consumption, automation and intelligence in the whole process, and achieves the effect of man-machine exchange interface.

![Discharge box](image)

**Figure 11.** Discharge module.

4. Feasibility analysis
1) Technically, the design of each module of this project is relatively reasonable, which not only completes intelligent vegetable cutting, but also meets the higher and more complex requirements in the process of vegetable cutting;
2) In terms of materials, the materials needed for this project are easily available, the processing is relatively simple, and the physical objects are easy to obtain;
3) Economically, this project is suitable for different food materials in different places, which can improve the efficiency and safety factor of cutting vegetables, reduce the use of a large number of manpower, and has wide application range and remarkable economic benefits.

The device is suitable for kitchen placement.
Specific dimensions of the device are as follows:

![Assumed size of device](image)

**Figure 12.** Assumed size of device.

5. Result analysis
In case of using a small motor, to prevent the motor from being overloaded for a long time. When using high-power motors, it is necessary to avoid the waste of electric energy caused by low power factor and
efficiency. Therefore, after calculation and comparison, the most suitable motor should be selected to provide vegetable cutting.

A transformer is installed in the motor part to convert the domestic voltage from 220V to 24V for DC motor.

The equipment will take JGB37-520 DC deceleration motor as an example, in which the operating voltage is 24V, the locked-rotor current is 0.6A, the maximum power is 14W, and the maximum load is 25KG.

Assume that the rated frequency of the motor is \( f = 50 \text{ Hz} \)

The number of poles \( r = 8 \) (the number of poles is 16)

Rotating speed: \( n = \frac{60 \times f \times r}{r} = \frac{60 \times 50}{8} = 375 \text{ (rpm)} \)

Torque: \( T = \frac{P \times 9550}{n} = \frac{14 \times 9550}{375} = 356.53 \text{ (N·m)} \)

With this given torque, all kinds of cutting can be carried out in the vegetable cutter. The whole vegetable cutter can be started and operated by using this small DC motor, and the whole vegetable cutter can be operated by using a common motor.

At the same time, the movable range of the device is limited, and the moving speed of the device is properly regulated, so as to meet the stability of the device in motion.

The motion parameters are shown in the following table:

| Content                        | Adjustable range |
|-------------------------------|------------------|
| Movement speed of guide rail  | 0.8-10mm/s       |
| Transmission range            | 0.8-10mm         |
| Acceptable weight             | \( \leq 25\text{kg} \) |

Force analysis of cutting plane is as follows:

Under the condition that the cutting plane is subjected to its own gravity, downward pressure, tension and pressure of external force and pre-tightening force of a plurality of pins, the device can still ensure effective feeding and cutting within a reasonable stress range.
6. Conclusions
Through research and design, the intelligent integrated multifunctional vegetable cutter based on control and structural innovation has reached the predetermined goal. By designing the integrated vegetable cutting system, it can meet people's high requirements for the shape of vegetable cutting, improve the overall quality of the vegetable cutter, and improve the efficiency and effect of vegetable cutting, thus realizing the diversification of the shape of food materials. It brings full convenience to people's lives. It is expected that the intelligent, open, networked and informationized kitchen supplies intelligent management system will gradually develop towards the direction of high efficiency, high precision and high reliability after being put into the market, and will gradually be loved by people.

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