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Development of a Chain - driven Travelling Robot

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Abstract. In order to achieve efficient efficiency of food delivery in restaurant, a saving manpower travelling robot driven by chain mechanism is developed. Through the chain drive mechanism, the transmission agencies and the walking mechanism are integrated. The conveyor mechanism is consisted of two pairs of symmetrical chains to ensure a smooth vertical transport of the dishes. The flexible support plate on the chain has two levels of horizontal and vertical conditions due to its constraints. The running mechanism is composed of a motor drive module, a tracking module, an obstacle avoidance module and an imaging module, which can ensure the device to reach the target position. The automatic transmission meets the different set of dishes and saves labor requirements. Similarly, the device can also be applied to other areas where cargo transport is required.

1. Introduction

At present, some passing dishes robots are used in the restaurant, but their working efficiency is unsatisfied. To improve the efficiency of the food transmission, the chain-driven travelling robot is designed to increase the volume of dishes and provide convenience mechanism. To make customers more comfortable, the travelling track can be adjusted and the setting parts are closed, which ensure the hygiene and safety of dishes.

The chain - driven travelling robot can be used not only in the field of food and beverage, but also in logistics and other occasions which need cargo handling. At the same time, the main transmission mode of the device is driven by chain mechanism with simple structure, high reliability and low cost. In addition, the device has good automation performance, and the trajectory can be changed in any way to satisfy the demands of the customers.

2. Design Scheme

2.1. Walking Structure Design

2.1.1. Tracking Structure Design.

The most basic requirement is that the device can "walk" according to the desire of the customer instead of running in rampage. Two pairs of infrared transmitting and receiving tubes are installed at the bottom of the robot respectively by using the principle of less light reflected by the infrared

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absorption of the black material, and a dark track is put in the dining room to track the robot in order to make the device walk as required with considering the most.

2.1.2. Obstacle Avoidance Structure Design.

The robot has to be stopped when there exists an unavoidable blocking caused by customer. Based on this factor, the infrared obstacle avoidance method is used to solve the problem. Many pairs of infrared transmitting and receiving tubes are placed in front of the robot, of which the principle of the infrared transmitting and receiving tube is the same as that of the tracking part. The drive motor stops rotating until the obstacle disappears.

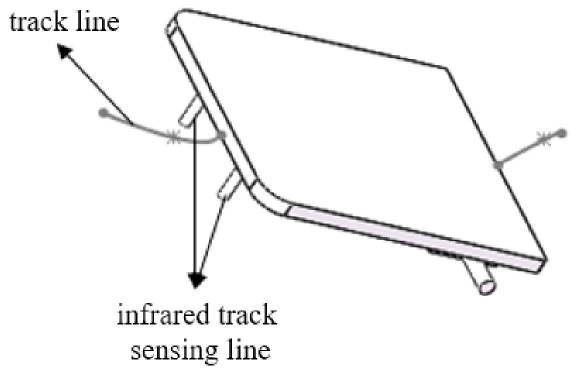

Figure 1. Part of Track line

2.1.3. Power Structure Design.

The output axis of the DC stepping motor with the reducer is connected to the two wheels respectively to provide enough power so that the dish can be carried to the target table by device. The passing speed can be adjusted by the program of the duty ratio of the input motor voltage. The speed regulation of the DC stepping motor and the turning of the robot are realized through the signal detected by sensors in the tracking part. Three wheels-the universal wheel, under the chassis of the device are installed to ensure the stability of the device.

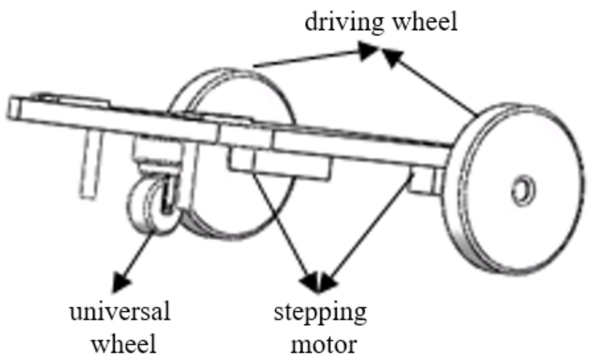

Figure 2. Chassis Structure

2.2. Transmission Structure Design

The transmission structure is the core of the device. In order to improve the efficiency of the dishes and deliver more dishes at a time, the device is divided into multiple layers and the number of bowls per layer can be determined according to the size of the bowl. In addition, the convenience and comfort of taking the vegetables can be ensured through designing the chain drive and the electronic

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control part combined with the electric control part, which makes the vegetable collector only needs to take the bowl from the fixed position---take the dish at the top of the device when the device arrives at the table.

The mechanical part of the device utilizes 4 chains, two square chains, and two Yizi chains. The motor is driven by the rotation of the spindle, thus the rotation of sprocket is driven by its axis. The constraint of a part of the flexible support plate (Figure 4) of the dish is connected over a Yizi chain through a screw component (Figure 5), and the other part is connected to a square chain through a screw assembly. When the support plate is on the top of the plate, the support plate is in the horizontal state of the device. When the motor drives the sprocket, the supporting plate in the horizontal state is vertically and steadily upward. The design of this part enables the horizontal supporting plate to move into a vertical state under the action of its restraint after the dish is took away by the customer, which makes the height meet the demand, make the customer comfortable and high efficiency. The supporting plate is changed from the horizontal state of the dish to the vertical state after the vegetable is finished, thus ensuring the utilization ratio of the space. At the same time, the retaining plate has a stopper for restricting the sliding of the vegetable bowl to prevent the sliding of the vegetable bowl.

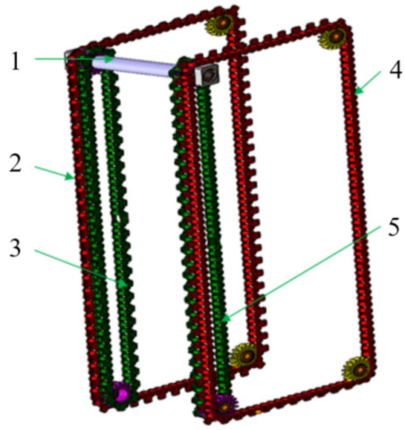
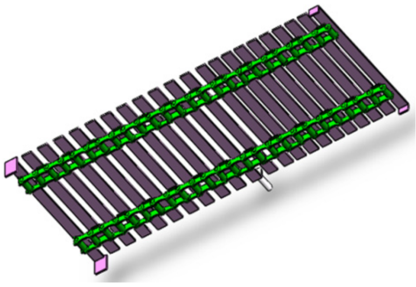


Figure 3. Chain Structure



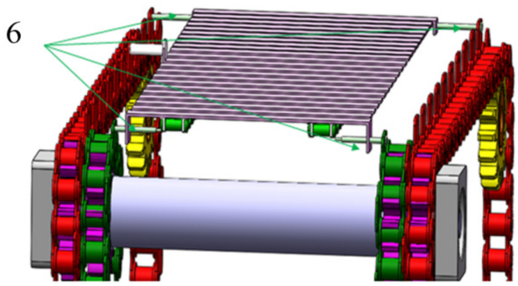


Figure 4. Flexible Support Plate Structure Figure 5.Connection Structure of Support plate

(1- Spindle; 2- Square Chain 1; 3- Yizi chain 1; 4- Square Chain 2; 5- Yizi chain 2; 6- Screw Assembly)

In order to keep the dish bowl on the support plate in the right position of the dish, on the support, a metal close switch is installed (Figure 6) to determine whether the support board reaches the correct location of the dish. The signal of the supporting plate is supposed to be detected at the metal proximity switch when the supporting plate is in a horizontal state and at the top. Two limit switches are installed on the support frame to check whether the supporting plate reaches the limit position. The support plate 3 is horizontal, while the support plate 2 and 1 are vertical, and the metal close to the switch just detects the signal of the support plate 3, and the lower limit edge of the support plate 1 contacts with the second limit switch in this state; the support plate 1, 2 and 3 are in horizontal, and

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the metal close to the switch detects a signal of the support plate 1, and the lower surface of the horizontal support plate 3 is in contact with the first limit switch. In order to know whether the food on the support board is taken away or not, a pair of infrared gratings is fixed to the top of the support, which the existence of the stuff on the table can be judged by the change of the level. In order to enable the device to identify targets, a camera sensor module on this device is installed to monitor the target location in real time. In order to keep the dish bowl on the support plate in the right position of the dish, on the support, a metal close switch is installed to determine whether the support board reaches the correct location of the dish. The signal of the supporting plate is supposed to be detected at the metal proximity switch when the supporting plate is in a horizontal state and at the top. Two limit switches are installed on the support frame to check whether the supporting plate reaches the limit position. The support plate 3 is horizontal, while the support plate 2 and 1 are vertical, and the metal close to the switch just detects the signal of the support plate 3, and the lower limit edge of the support plate 1 contacts with the second limit switch in this state; The support plate 1, 2 and 3 are in horizontal, and the metal close to the switch detects a signal of the support plate 1, and the lower surface of the horizontal support plate 3 is in contact with the first limit switch.

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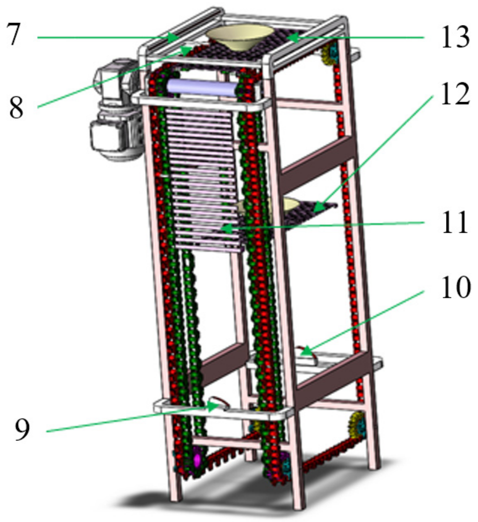

Figure 6. Transfer Part Structure
(7- Infrared Grating; 8- Metal Proximity Switch; 9- Second Limit Switch; 10- First Limit Switch; 11- Support Plate 1;12- Support Plate 3; 13- Support Plate 2)

3. Working Principle

The size of the object on each support plate of this chain transmission device is limited to 350x400mm, the height is not more than 250mm, and the height is about 1150mm, which the height is in accordance with the ergonomics.

Firstly, the operator presses the "reset" button in the kitchen, the infrared grating detects whether there is an object occlusion, if it does exist, then the spindle motor reverses (the reversal can turn the support plates into a vertical state) until the obstacle disappears. The spindle motor stops rotating when the metal proximity switch detects the upper end support plate signal. However, if there are no objects on the support board (the infrared grating does not detect the signal), the spindle motor continues to reverse, until the second limit switch detects the signal of the support plate 1. Under such circumstance, the supporting plate 3 is in horizontal, while the supporting plate 1 and the supporting plate 2 are in upright position, which is the initial position before placing vegetables.

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The operator writes the table number corresponding to the dish bowl to the buffer zone of the single chip system through key input after pressing the "place" button to placing the dish in the upper limit block of the support plate. Then press the "continue" button, the spindle motor is turning (this positive rotation can make the supporting plate become a horizontal trend). The supporting plate of the dish placed can keep the horizontal state moving down smoothly owing to that the square chain moves as fast as the Yizi chain. When the metal close to the switch detects the signal of the next supporting plate, the spindle motor stops turning, and the operation method of placing the first dish bowl above can be placed on the second and the first support plate. The supporting plates should be in horizontal after the bowl was placed, and the metal switch just detects the signal of the first supporting plate at the same time. Such operation of placing kitchen dishes in the supporting plate is considered as a kitchen dish placing process.

Then the dishes are delivered to the designated table by pressing the "transfer" button. The infrared tracking sensor moves along the trace line laid on the ground previously, which makes the device move back to the preset trace line through the tracking sensor and controlling the speed of driving wheel by PWM adjustment. There is an obstacle and the driving wheel stops if the infrared barrier sensor induces the signal, it appears contrary if there is no signal from the infrared barrier sensor while the device is working. The motor of the driving wheel stops according to the information of the top dishes and the preset table position captured by the camera module. The device returns to the kitchen along the tracking line, and then carries out the next cycle after all the dishes are removed.

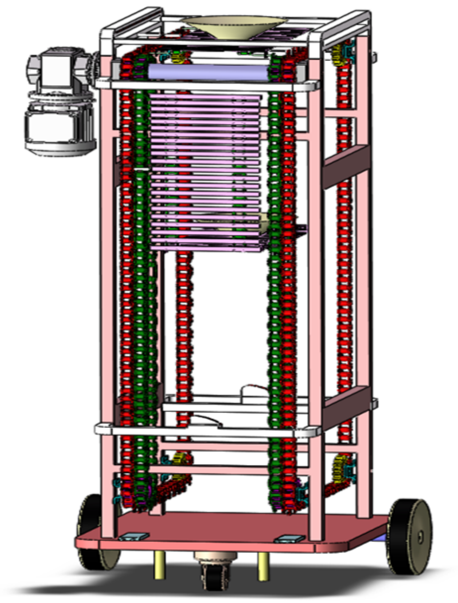

Figure 7. Overall structure of the robot

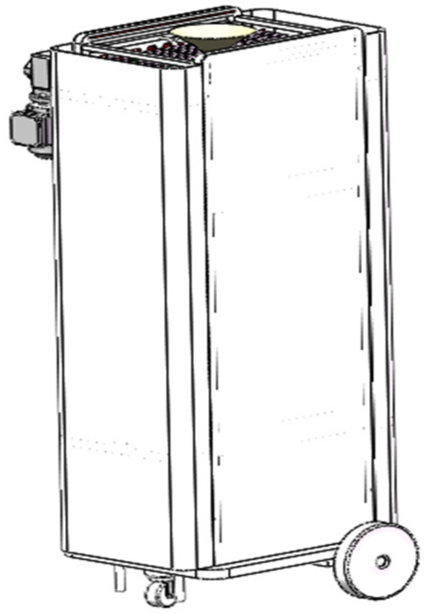

Figure 8. Overall appearance of the robot

4. Chain Drive Calculation

The relevant parameters of the robot are showed in the following table:

Table 1. Parameters of the robot

Name	Number of Two chain tooth	Power	Chain Type	Node Distance	Center Distance	Chain Number	Maximum Center Distance	Chain Speed
Data	21,21	2.4kw	16A-1	25.4mm	900mm	92	901.7mm	0.4m/s

5. Force Analysis and Strength Checking

The core component in this device is the main shaft. The strength of the spindle is checked by Auto Inventor, of which the main shaft parts are Q235, the power of the motor given in 3 is 2KW, the speed of the chain line is 0.4m/s, and the motor torque is 20Nmm calculated from the following parameters: v= WR (V-m/s; R-M; w-rad/s); w=2 PI n. N-r/min); T=9549*P/n (P-Kw; n-r/min; T-Nm), and there is T=T1+T2 while the spindle rotates in a uniform speed; The check diagram is as follows:

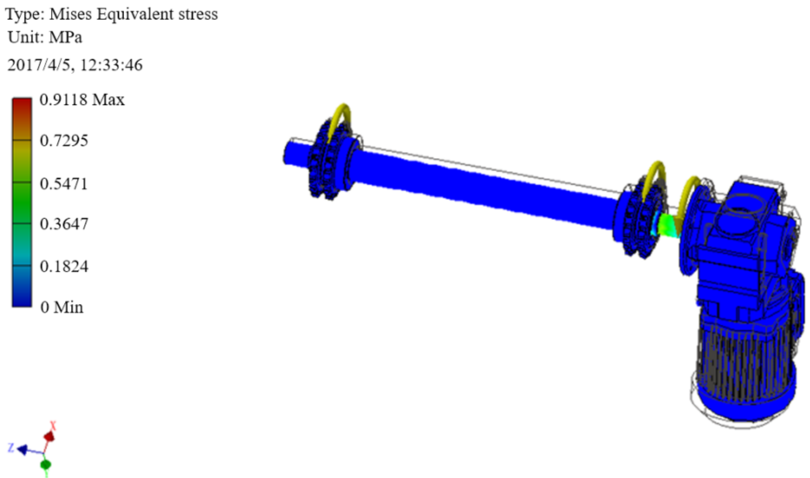

Figure 9. Equivalent Stress

According to the graph, the maximum stress on the shaft is 0.9118MPa, which is smaller than the allowable stress value of the steel and is located in the red mark of the drawing.

6. Conclusion

The designed robot is highly automated, combined with mechanical structure and control part, which achieves efficient transmission of dishes with high automation performance. At the same time, there are few related products in the market which serve as a highlight for restaurant to attract customers and makes a new dining enjoyment for the customer. It also provides a way to integrate more service robots closely into people's daily life.

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