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Article

A Small Simulated Logistics Transfer Robot Car Structure Design

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Abstract: As a new product of the development of modern science and technology, the research and development of logistics robot has become the focus of social attention. Robot sorting and handling is the designated project of Jiangsu University Robot Competition. According to the requirements of the competition, this paper designs a kind of logistics robot trolley which can identify and grab materials according to a given path and transport them to a predetermined location. The mechanical structure design, driving motor selection and mechanical checking calculation of the car are mainly completed. According to the later experiments, the results show that the desired results can be achieved.

Keywords: Handling robot; structural design; mechanical checking calculation

1 Introduction

With the rapid development of the logistics industry in recent years, the research and design of logistics handling robots are becoming more and more diversified and their functions are becoming more and more powerful. By consulting and studying relevant literature at home and abroad in recent years, it is found that logistics handling robots are developing towards intelligence, high efficiency and large-scale development [1–4]. In order to better adapt to social development, Jiangsu Province has set up a sorting and handling robot competition in the annual robot competition for college students to simulate industrial automation places. This paper studies and designs from task demand analysis, mechanical structure design, fabrication and assembly.

2 Analysis of Competition Task Demand

According to the requirements of Jiangsu Robot Competition, a logistics robot trolley which can identify and grab materials according to the given path and transport to the predetermined location is designed in the simulated industrial automation place. According to the product demand analysis, the following design requirements are proposed:

A. The robot car can follow the black line in the set site to the set place.

B. Carry objects of different colors and the same shape to the area with corresponding specified colors. The competition venue for sorting and carrying robots is shown in Fig. 1.

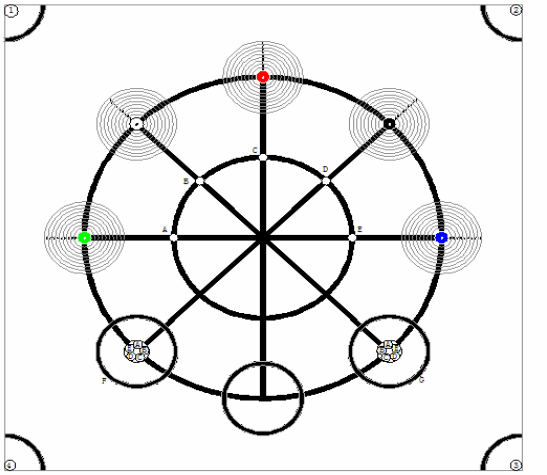

Figure 1: Schematic diagram of the sorting and carrying robot competition site

3 Mechanical Structure Design, Manufacture and Assembly

According to the demand analysis of products, it is necessary to complete the design of moving mechanism, hook and grab mechanism, body overall structure and so on.

3.1 Walking Mechanism Design

By referring to relevant literature and considering many factors such as turning situations in the field, this paper mainly considers that the walking mechanism of the car is a three-wheel structure. The usual three-wheel structure is shown in Fig. 2 below.

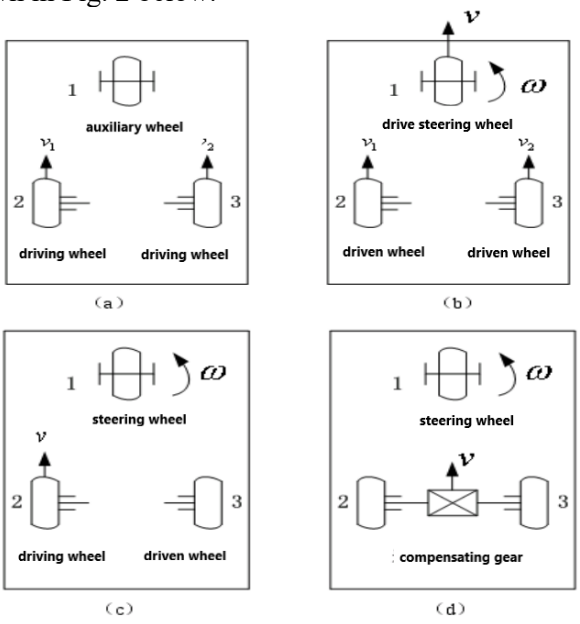

Figure 2: A schematic diagram of four three-wheel movement configuration modes

The main speed and the steering of the trolley in the process of walking. Therefore, according to the positions of the driving wheel and the driven wheel, there are different distribution schemes, as shown in Fig. 2. The disadvantages of the four configurations are shown in Tab. 2. Considering the complexity of the mechanism, steering performance, energy loss and other factors, scheme (a) is selected according to the comparison results.

Table 1: Configuration characteristics of each type of three-wheel movement

No.	Configuration characteristics of each type of three-wheel movement
a	Dual wheel drive mobile robot [5]. Front wheel 1 is a universal wheel that can roll in any direction [6]. The universal wheel is used to stabilize the car body. The rear wheel 2 and the rear wheel 3 are independent driving wheels. This combination is characterized by simple mechanism and good steering.
b	The steering mechanism and driving mechanism are concentrated on the front wheel 1, while the two rear wheels only play the role of supporting driven [5]. Compared with Fig. 2(a), the mechanism can also rotate around the midpoint of the connecting line of the two rear wheels, but its front-wheel drive is concentrated and its structure is relatively complex.
c	Front wheel 1 steering wheel, rear wheels 2 and 3 of one for the drive wheel, the other for the slave wheel. This kind of wheel mechanism is characterized by simple structure and easy composition, but the drive of unilateral drive is poor, stability is not good, cannot rotate.
d	The single wheel drive in Fig. 2(c) was changed to a dual rear wheel differential drive to improve the drive performance, but a differential gear device was added to make the structure more complex, which also increased the manufacturing difficulty and weight.

3.2 Overall Structural Design Scheme

On the basis of the selection of 3.1 walking mechanism, the overall structural design scheme of the carrying robot car is shown in Fig. 3. The driving wheel is arranged in the front part of the chassis, and the universal wheel is arranged in the rear part of the chassis. The grasping mechanism is arranged in the front end of the chassis, and the hook is arranged in the front middle.

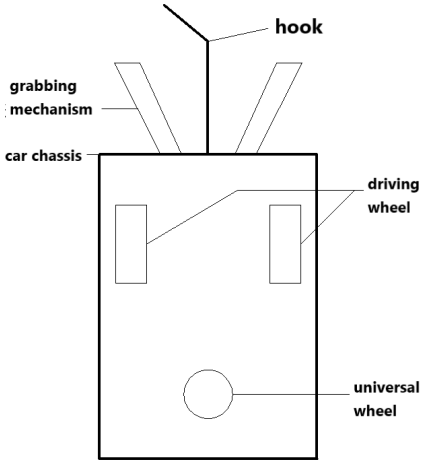

Figure 3: General structure diagram of the handling trolley

3.3 Design of Grab and Hook Mechanism

According to the rules of the competition, the physical shape and size of materials to be transported are shown in Fig. 3 below. The outer contour of the cylinder is packed in different colors, with a height of 38 mm and a diameter of 40 mm. According to the material size and design requirements, consider the actual grasp fit, drive mechanism driving principle and the state of material placement. The grasping mechanism of the transport robot car is designed as a claw structure. The shape of the internal structure of the claw should be fitted with the external diameter of the material and set as a semi-circular arc with a radius of 20 mm. The initial part of the claw is designed as a circular structure consistent with the positioning hole of the steering gear. In the design of hook structure, the distance between the material and

the parking location of the robot and the diameter and height of the material should be taken into account, and the configuration structure is designed as shown in Fig. 5.

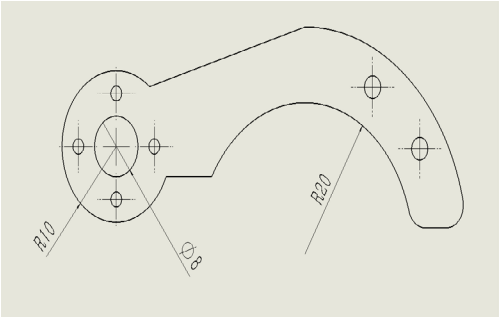

Figure 4: Capture mechanism design drawing

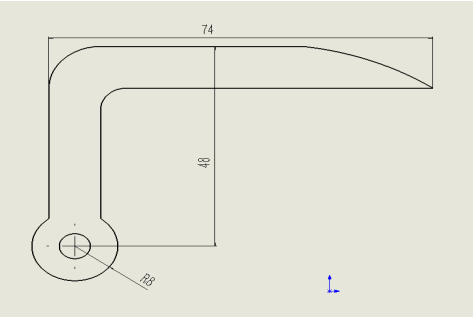

Figure 5: Design drawing of hook mechanism

3.4 Drive Motor Selection and Performance Check

The precision of the action and the complexity of the control should be considered in the forward, backward, grab and hook actions of the handling trolley. Through the understanding of the working principle of the steering gear and its mechanical checking, this paper finally considers the steering gear as the driving motor of each action.

3.4.1 Working Principle of Steering Gear

The inside of the steering gear is generally a DC motor, because the speed of the motor is relatively fast, so the output shaft of the motor is connected with the gear set, so as to achieve the role of deceleration. As can be seen from Fig. 6, when the speed decreases, the torque will also increase, that is, there will be greater pretension when clamping the object. Therefore, the appropriate reduction ratio will be conducive to the manipulator to grab the object.

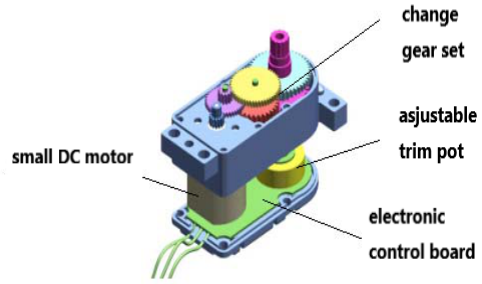

Figure 6: Internal structure diagram of steering gear

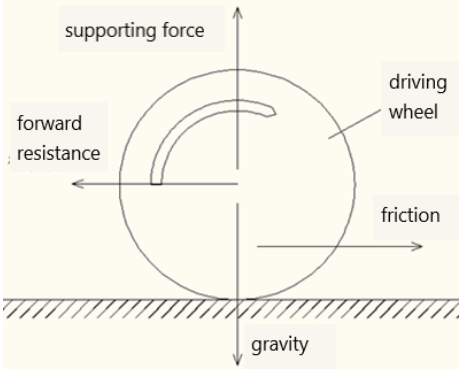

Figure 7: Stress analysis diagram of wheels

3.4.2 Check the Mechanics of Steering Gear

In the handling trolley mechanism, the weight of the robot structure is about 2 kg, and the load borne by the trolley does not exceed 2 kg when handling the goods, so the weight of the whole trolley will not exceed 4 kg. The weight carried by the robot is borne by the wheel of the car, and the force exerted on the driving wheel of the car is shown in Fig. 7. The friction force F1 between the driving wheel and the ground in the figure; Travel resistance F2; And only if F1 > F2, does the drive wheel not skid or idle. It is assumed that the gravity borne by the two driving wheels of the car is 80% of the bearing gravity, and the universal wheel carries the remaining 20% of gravity. According to the table, the friction coefficient = 0.45 between the driving wheel and the field (PVC material), the diameter of the driving wheel D = 8 cm, and the diameter of the supporting wheel D2 = 4 cm.

Positive pressure on a single drive wheel:

$$N_1 = 0.5 \times 80\% \times 4 \times 9.8 = 15.68(N) \quad (1)$$

Positive pressure on a single support wheel:

$$N_2 = 0.5 \times 20\% \times 4 \times 9.8 = 3.92(N) \quad (2)$$

Friction overcome by a single drive wheel:

$$F_1 = f \times N_1 = 0.45 \times 15.68 = 7.056(N) \quad (3)$$

The friction of a single support wheel:

$$F_2 = f \times N_2 = 0.45 \times 3.92 = 1.764\ （N) \quad (4)$$

In normal driving conditions, driving wheel drive driven wheel movement, is the main driving wheel to overcome friction, when the robot turn, due to the design of the car is implemented by using differential turning, so at this time is equivalent to two driven pulley, a driving wheel drive these two driven wheel movement, when the car has to overcome the friction of the largest. At this point, the resistance of the robot is as follows:

$$F = F_1 + 2F_2 = 7.056 + 2 \times 1.764 = 8.82(N) \quad (5)$$

The power of the motor required to drive the robot:

$$P = FV/n = 8.82 \times 0.14/0.8 = 1.5435(W) \quad (6)$$

The steering gear selected this time is SM-S4303R, its operating voltage is 4.8–6.0 V, operating torque is 3.3–5.1 n.m, rated speed N = 32 r/min, and the torque required for calculation is 0.46 n.m, which completely meets the requirements.

$$T = 9550P/n = 1.5435 \times 9.55/32 = 0.46(N.M) \quad (7)$$

3.5 Overall Structural Design

According to the external dimension and installation position of the grab mechanism and the hook actuator, as well as the actual dimension and overall balance of the drive actuator and mechanical checking, the mechanical structure can be determined to meet the basic requirements of this design. The robot can be assembled according to the mechanical part of the design, so as to complete the mechanical part of the design. However, considering the need for hardware installation, enough space should be set aside on the trolley support plate for the installation of the trolley hardware. According to the determined mechanical structure and the location of pre-install hardware, the general outline of the designed product can be determined. Then, the overall design structure of the designed handling trolley is shown in Fig. 8, and the assembly drawing of the THREE-DIMENSIONAL entity is shown in Fig. 9.

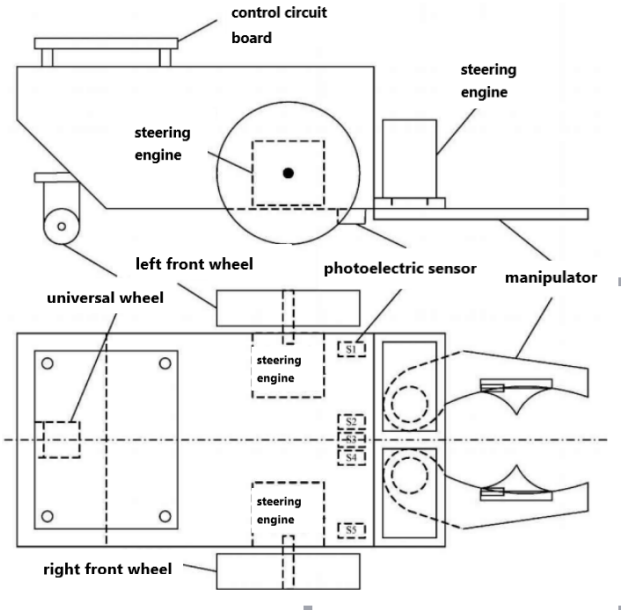

Figure 8: Overall structure of the handling trolley

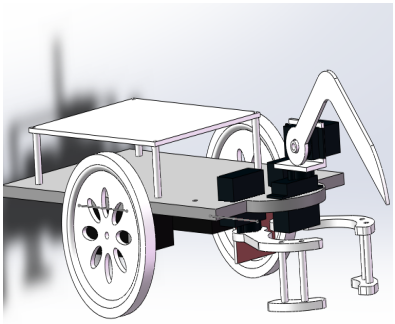

Figure 9: Assembly drawing of the three-dimensional entity of the handling trolley

According to the size requirements of the design drawings, the parts for processing, production. For the part of grasping mechanism, the traditional processing means are more troublesome. In the later stage, the design and production are completed by 3D printing technology, with good results. Combined with other students in the project group, the hardware circuit was designed and made, and finally the whole assembly was carried out. The physical picture is shown in Fig. 10.

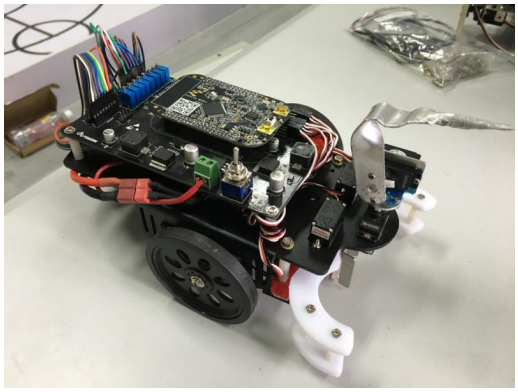

Figure 10: Physical drawing of carrying trolley

4 Conclusion

In this paper, the robot competition task, simulation automation industrial site design requirements. This paper focuses on the structural design of the transport trolley, namely, the design and assembly of the walking mechanism, grasping mechanism, hook mechanism, body structure and the overall THREE-DIMENSIONAL solid body, and carries out the selection and mechanical checking and verification calculation of the driving motor. At last, the whole assembly is carried out, and the experiment in the later stage shows that the handling trolley works well. At present, this achievement has been applied to participate in national and provincial robot competitions for college students and achieved excellent results [7].

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Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

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