Analysis of Structure and Process of a Robot with Obstacles

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Abstract

Aiming at the motion requirements of mobile robots in complex environments, a new six-legged compound robot is proposed. Based on the structure design of the robot with front and rear wheel retracting functions, the characteristics of the model and the movement process of obstacles in different environments. At the same time, the obstacle obstacle height of the step obstacle is analyzed and the maximum obstacle height is given. A detailed description is provided to provide a theoretical basis and basis for further research on the six-legged compound robot.

Keywords

Six-wheel-legged robot, obstacle height, step obstacle.

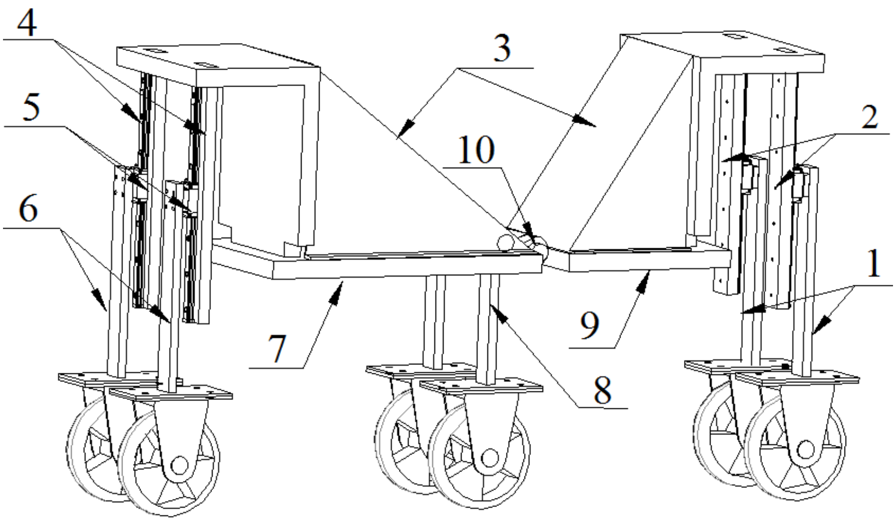
1. Introduction

With the development of society and the advancement of science and technology, the emergence and application of robots have brought great changes to the world. With the wider application of robots, people have higher flexibility and adaptability to robots for non-structural environments. , can successfully and quickly complete the specified tasks. Mobile obstacle-obstacle robot is a comprehensive system integrating environment perception, dynamic decision-making and planning, behavior control and execution.

According to the characteristics of the robot's motion mechanism, common mobile robots can be divided into three types: wheel, leg and track. Wheeled, legged, and crawler styles all have their own unique advantages, and there are obvious deficiencies. The composite moving mechanism not only retains the advantages of a single structure, but also eliminates the disadvantage of a single structure to the greatest extent. The characteristics of the wheel-leg composite moving obstacle-obstacle mechanism not only have the superiority of the leg-type mechanism crossing obstacles on different roads and strong terrain adaptability, but also have the advantages of wheeled high speed, high efficiency, flexibility and easy control, and good mobility .

2. Robot Structure Design

The structural design is a fusion of the quadrilateral mechanism and the telescopic leg structure, so that the wheel-leg composite robot has a waist rotation and a leg telescopic function, mainly by the front wheel leg, the front car body, the rear car body, and the rear wheel. The legs, the middle wheel legs, etc., as shown in Figure 1.



1. Front wheel movable leg 2. Front wheel fixed leg 3. Protective cover
4. Rear wheel fixed leg 5. Slider guide 6. Rear wheel movable leg 7. Rear body
8. Intermediate wheel leg 9. Front body 10. Car body rotating drive shaft
Figure 1. Wheel-leg composite robot structure

The characteristics of the wheel-leg composite robot are as follows:

1) The front and rear body are designed as a Z-shaped structure, which greatly improves the overall obstacle resistance of the robot.

2) The corresponding wheel legs are not in contact with obstacles during the obstacle crossing process, which reduces the impact of the obstacles on the robot during the obstacle crossing process and improves the obstacle stability of the robot.

3) The front and rear wheel legs adopt the linear motion of the slider guide rail to make it have the telescopic function, which greatly increases the obstacle-obstacle ability of the robot, which not only ensures high positioning accuracy and good stability during the telescopic process of the wheel leg. The characteristics, but also able to withstand the up and down load caused by a certain body.

4) For the convenience of control, the middle wheel leg is selected as the auxiliary wheel, and the front and rear four wheel legs are separately driven and controlled, and the universal wheel is used for convenient steering. The front and rear bodies are driven by the drive motor to complete the robot, and obstacles such as stepped vertical obstacles are completed.

5) The six-wheel mobile system has strong adaptability and obstacle-tolerance.

6) The sliding steering mode of the front and rear wheels is adopted as a whole.

7) When the road condition is good and the ground is flat, the front and rear universal wheels and the auxiliary wheels are in contact with the ground at the same time. When the obstacles need to be crossed, the cooperation of the six wheel legs is completed, and the driving and steering modes of the mobile robot determine the robot. Stability, flexibility and other performance.

3. Description of the Movement Process

Mobile robots move through complex terrain and encounter a wide variety of obstacles. Generally, these obstacles can be abstractly divided into five types: slopes, steps, bosses, trenches, and stairs. Among them, the stepped obstacle, that is, the vertical obstacle, is the most typical. Many documents regard the maximum height of the vertical obstacle as an important indicator of the obstacle crossing characteristics of the robot.

The height h of the vertical obstacle is different, and the obstacle-traveling method adopted by the wheel-legged robot is also different. The height of the obstacle $h < H1$ (H1 indicates the maximum height that the robot can smoothly cross without assistance), the robot can pass smoothly without any assisting action, and this will not be repeated here.

When H1 < h < H2, the obstacle crossing process of the robot can be divided into three stages, that is, the front wheel is over obstacle, the middle wheel and the rear wheel are obstacle-obstructed, as shown in FIG. 2 . When the current wheel approaches the obstacle (Fig. 2(a)), the front wheel slider drives the movable part to contract to the upper part of the obstacle, the rear wheel and the middle wheel drive the robot to advance (Fig. 2(b)); 2 the middle wheel approaches the obstacle, The rear and front wheels are extended until the middle wheel exceeds the obstacle. The front and rear wheel drive robots advance (Fig. 2(c)); 3 when the rear wheel approaches the obstacle, the rear wheel contracts, the middle wheel and the front wheel drive (Fig. 2(d)) until the entire robot completely crosses the obstacle (Fig. 2(d)) Figure 2(e)).

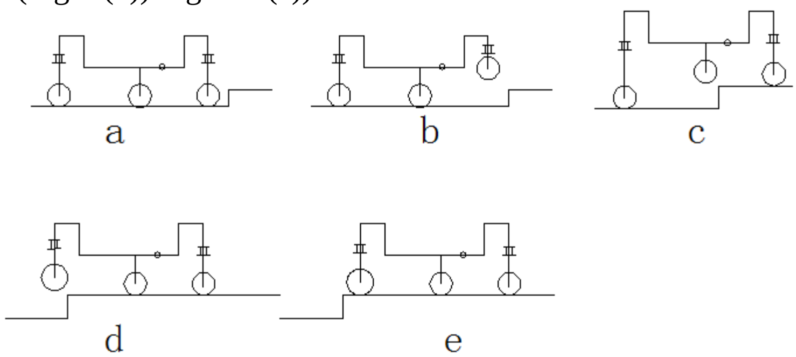


Figure 2. Stepped obstacle1

When H2 < h < Hmax, the robot's obstacle crossing process can be divided into three stages, that is, the front wheel obstacle crossing, the middle wheel and the rear wheel obstacle, as shown in FIG. 3 . 1 When the current wheel approaches the obstacle (Fig. 3(a)), the front body is deflected, and the front wheel slider drives the movable part to contract, ensuring that the front wheel is completely placed above the obstacle, and the rear wheel and the middle wheel drive the robot to advance (Fig. 3(b), Fig. 3(c)); 2 the middle wheel is close to the obstacle (Fig. 3(d)), the rear wheel and the front wheel are extended, and the front and rear wheel drive robots are advanced (Fig. 3(e)); After the middle wheel contacts the ground, the three sets of wheels simultaneously drive the robot forward (Fig. 3(f)). When the rear wheel approaches the obstacle, the rear wheel contracts, and the front body always keeps rotating, ensuring that it always touches the ground. The middle and front wheels are driven (Fig. 3(g)) until the entire robot completely crosses the obstacle (Fig. 3(h)).

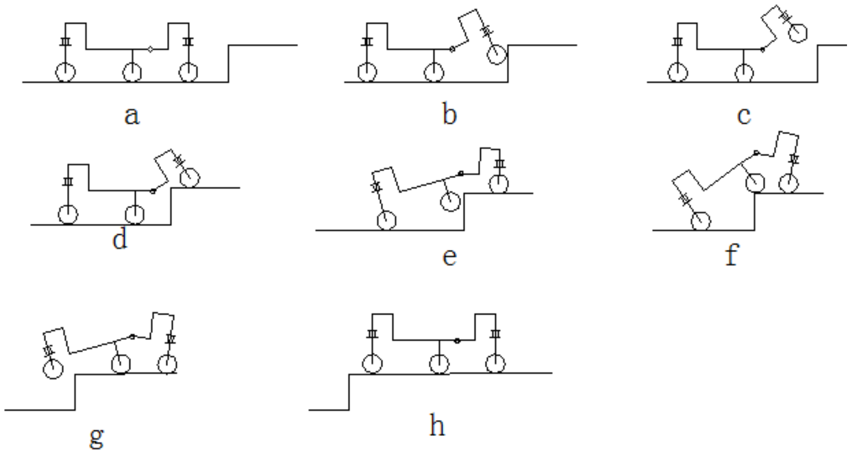


Figure 3. Stepped obstacle2

The process principle of the robot over the sulcus is the same as the H1<h<H2 process principle of the stepped obstacle, and will not be described again, as shown in Fig. 4.

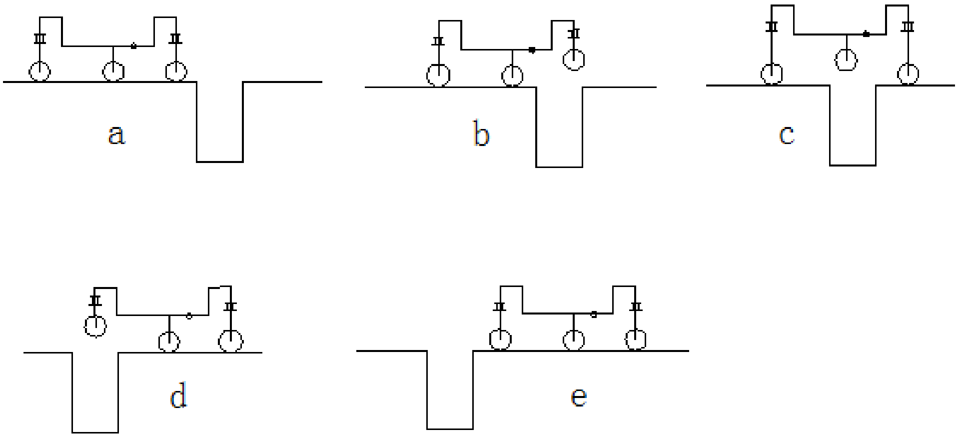


Figure 4. Sulcus obstacle

The process of the robot passing the slope is also relatively simple, mainly relying on the common driving of the three sets of wheels, and at the same time relying on the constant rotation of the front body to ensure that the three sets of wheels simultaneously play the driving role, as shown in Fig. 5 .

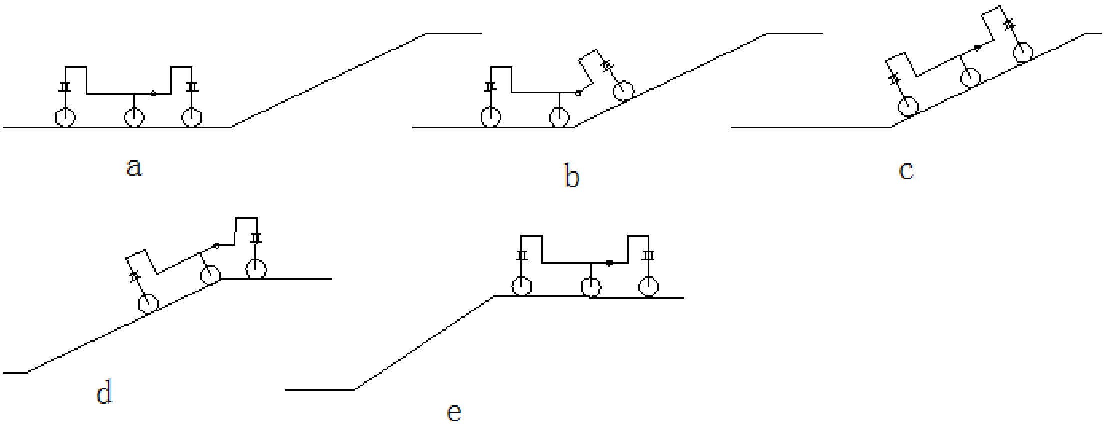


Figure 5. Slope obstacle

4. Obstacle Height Analysis

The geometric relationship of the attitude of the obstacle crossing robot when the front wheel is over obstacle is shown in Figure 6:

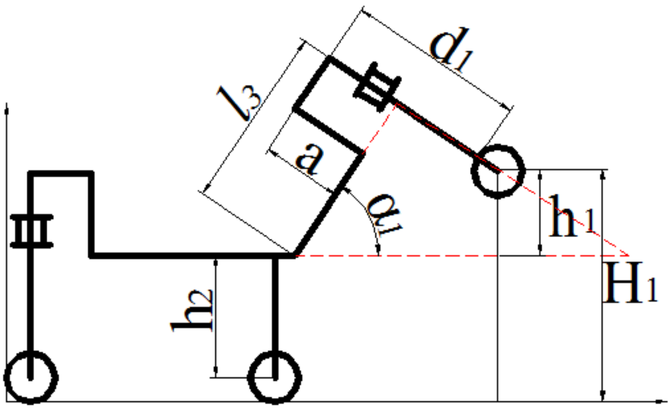


Figure 6. Front wheel obstacle height

As can be seen from the above figure, the height that the front wheels can pass is H_1:

$$H_1 = l_2 + h_1 \tag{1}$$

$$h_1 = [l_1 \tan\alpha_1 - (d_1 - a - r)]\cos\alpha_1 \tag{2}$$

Where $l_1$is the length of the front body, l_2 is the length of the middle leg, α_1 is the angle of rotation of the front body relative to the rear body, and r is the radius of the wheel. Since the front wheel of the robot is a telescopic leg, Therefore, the length of the front wheel leg is the dynamic value d_1.

According to the above, the maximum height that the front wheels can pass is:

$$H_{1max} = l_2 + h_{1max} \tag{3}$$

H_{1max} appears when α_1 is its maximum value and the front wheel legs are in the minimum contraction state, when d_1 takes the minimum value.

The geometric relationship of the attitude of the obstacle-obstacle robot in the middle of the obstacle is shown in Figure 7:

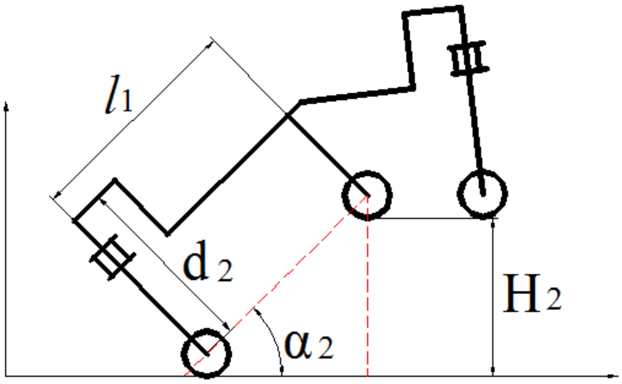


Figure 7. Middle wheel obstacle height

As can be seen from the above figure, the height that the front wheels can pass is H_2:

$$H_2 \approx (l_1 + r)\cos\alpha_2 \tag{4}$$

In the formula, l_1 is the length of the rear body, and α_2 is the rotation angle of the rear body relative to the ground.

According to the above, the maximum height that the middle wheel can pass is:

$$H_{2max} \approx (l_1 + r)\cos\alpha_{2max} \tag{5}$$

Since the size of α_2 is affected by dd_2, α_2 is a dynamic value, that is, the maximum height that the middle wheel can pass only when d_{2max} is in the maximum extended state d_2 max and α_2 is in the maximum state.

As the obstacle of the middle wheel is completed, the center of gravity is completely placed on the upper part of the step and moves forward. The front wheel starts to drive the whole drive, and the rear body lifts the rear wheel leg until the rear wheel completes the obstacle, the obstacle of the whole robot It is also completed, so there is no maximum obstacle height requirement for the rear wheel.

5. Conclusion

A six-legged composite mobile robot that can adapt to complex environments is studied. Through the structural design and process control flow of the obstacle-obstacle robot, the calculation formula of the maximum obstacle height is given, and then the wheel-leg composite obstacle is established. A detailed description is provided to provide a theoretical basis and basis for further research on the six-legged compound robot.

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