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Design of A Climbing Wheelchair-Using Mecanum Wheels

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Abstract

According to the sixth national census, the total population in China, and the second national sample survey of persons with disabilities, the total number of persons with disabilities in China is about 85.02 million, of which 24.72 million are physically disabled. First of all, due to the narrow staircase space in the old building, it is not easy for conventional climbing wheelchairs to turn, so the Mecanum wheel was selected first to achieve zero-radius turning and save running space. This article intends to use a step-by-step climbing method to perform stable climbing. Secondly, a separate control system design is adopted to realize the independent transmission of Mecanum wheels and transmission shafts. Finally, the operation of the climbing wheelchair was tested. The results show that the climbing wheelchair can safely and effectively help people with reduced mobility and meet the needs of moving upstairs and moving at high speeds peacefully.

Keywords

Electric wheelchair; mecanum wheels; step-by-step climbing; wheelbase adjustment; four-bar mechanism.

1. Introduction

As a mobility tool for the disabled and the disabled, the wheelchair can assist the physically disabled and the disabled to exercise and participate in social activities. It has been widely used. However, the ordinary wheelchairs currently in use can only travel on flat ground, which cannot meet the needs of the elderly and people with disabilities of the lower limbs to go up freely and down the stairs, limiting the user's range of activities [2]. There are currently four types of wheelchairs for climbing stairs on the mainstream market, tracked, stepped, self-driving, and planetary. Comparing them, we get the following table [3].

	Safety performance	Abrasion resistance	Stair slope requirements	Weight	Working noise	Comfort
Planetary wheel	Medium	Medium	No requirement	Weight	Medium	Low
Tracked	Low	Weak	Less than 45 degrees	Weight	High	High
Stepped	High	Strong	No requirement	Light	Low	Medium
Self-driving	Low	Weak	Less than 45 degrees	Weigh	Medium	High

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By comparison, we can find that the advantages of step-supported wheelchairs for climbing stairs are apparent, so we chose the climbing method as step-type. We use the step-by-step climbing method. This method always keeps four mechanisms in contact with the ground, which dramatically improves the stability and safety of the wheelchair. Through investigation, this article finds that Mecanum wheels can move forward and backward like traditional wheels, and can also run horizontally, obliquely, rotating and their combined movements, with high flexibility. When the working environment is very narrow, a variety of solutions can be provided to achieve transportation work [4]. The context for wheelchair climbing work is mostly old buildings, and the staircase space is generally relatively narrow, so I decided to use Mecanum wheels as the wheels for climbing the building. We use Mecanum Wheel Climbing Wheelchairs to turn flexibly in a narrow staircase space to save space. At the same time, if sensors are added in front of the wheelchair to detect obstacles, and the characteristics of mecanum wheels turning at zero angles can be used, climbing wheelchairs can effectively avoid obstacles autonomously to improve their obstacle avoidance capabilities. And because the specifications of the stairs in the old community without elevators are different, it is difficult for wheelchairs to adapt to these stairs. Therefore, a structure that can adjust the front and rear wheelbase is specially designed to accommodate most stairs.

This article presents a design idea for a climbing wheelchair-using Mecanum wheels, and systematically explains the mechanical structure and control system of the expected climbing wheelchair.

2. Mechanical Design

2.1. Mechanical Structure

The mechanical structure of the entire climbing wheelchair is roughly divided into four parts: wheels, climbing mechanism; wheelbase adjustment mechanism.

The first is the wheel. The wheelchair uses Mecanum wheels as wheels. Each Mecanum wheel is controlled by a motor. Each wheel can be controlled individually. Through various combinations, wheelchair flexibility is greatly improved. The flat section allows for flexible movements without adding additional aids.

The second is the climbing mechanism. The mechanical principle of this mechanism is a parallelogram four-bar mechanism. A virtual constraint is added to the four-bar mechanism to eliminate the uncertainty of the instantaneous motion of the overlapping collinear position of the parallelogram four-bar mechanism. The calculation analysis of the building process has further designed the climbing method, and the main parameters of the existing climbing mechanism are obtained. To break through the restriction that the original crank cannot be larger than the outer profile of the wheat wheel, on the one hand, the wheel diameter is further reduced to make it more suitable for different stair lengths. Completed the climbing movement, and can adapt to various stair heights without being limited by wheel diameter. The climbing frame is installed on both sides of the wheelchair frame to support the ground when the wheelchair is climbing to achieve the climbing movement. As shown in the figure, it is a schematic diagram of a climbing mechanism.

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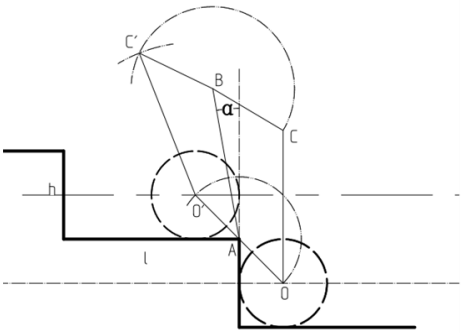

Figure 1. Schematic diagram of the climbing mechanism

Parameters of simulated stairs: h = 1500mm; l = 3000mm; diameter of wheat wheel Φ = 150mm. Points O and O 'are the positions where the wheel center starts to move and stops when the wheelchair is climbing the building. α = 0 ° ~ 15 °, the range of the climbing angle of the support structure to be temporarily proposed.

Point A is the limit case of the supporting structure, which is simplified to a point on the edge of the stairs. Point B is the fixed hinge for this part of the movement. C is the moving hinge. The two arcs in the figure are the paths that O and C traverse, respectively. The two horizontal centerlines are the positions where the wheel center needs to be lifted.

Select the extreme position: the wheel is close to the vertical wall as the starting position, and by drawing, it is generally determined that LAO = LAO '= L crank = 106.07mm. Assume that the main body of the wheelchair is perpendicular to the staircase before climbing. In this process, the bracket AB can be regarded as a frame (fixed end), and a four-bar mechanism can be drawn to support the climbing movement.

At the same time, the wheelchair divides the climbing mechanism into three types: manual mode, climbing mode, and flat mode. When switching to flat style, the climbing mechanism is stowed. Manual mode can be controlled by the operator in flat ground, freely adjusting the direction of movement. In the climbing mode, the crank is lowered in preparation for climbing.

Then the wheelbase adjustment mechanism designed to adapt to most stairs uses the way of changing the angle between the front and rear supports and the ground to change the front and rear wheelbase. To change the included angle, the front and back supports of the wheelchair are hinged with the intermediate coupling, and this has been achieved by adjusting the length of the hydraulic rod.

2.2. Transmission Structure

Finally, the transmission mechanism is powered by a battery. The power source of a Mecanum wheel is provided by a motor, so a total of four motors are required. We divided the four motors into two parts, two engines were installed on the front wheel frame and the rear wheel frame, and two motors were added in the middle of the two-wheel structures as the power source of the climbing mechanism. The movement of the wheels and the progress of the climbing mechanism are differential transmission, so the coaxial sleeve design is adopted. The climbing mechanism takes a parallelogram design. The transmission uses a sprocket to control the synchronous communication of the upper and lower shafts to ensure the stable movement of the parallelogram mechanism. The connection between the worm and the gear is used to output the torque of the motor.

The design of the control system

The movement program for climbing the stairs is written in the controller so that the wheelchair for climbing stairs can realize the climbing movement at the specified place. We install sensors in front of the wheelchair, which can be identified by the control system when

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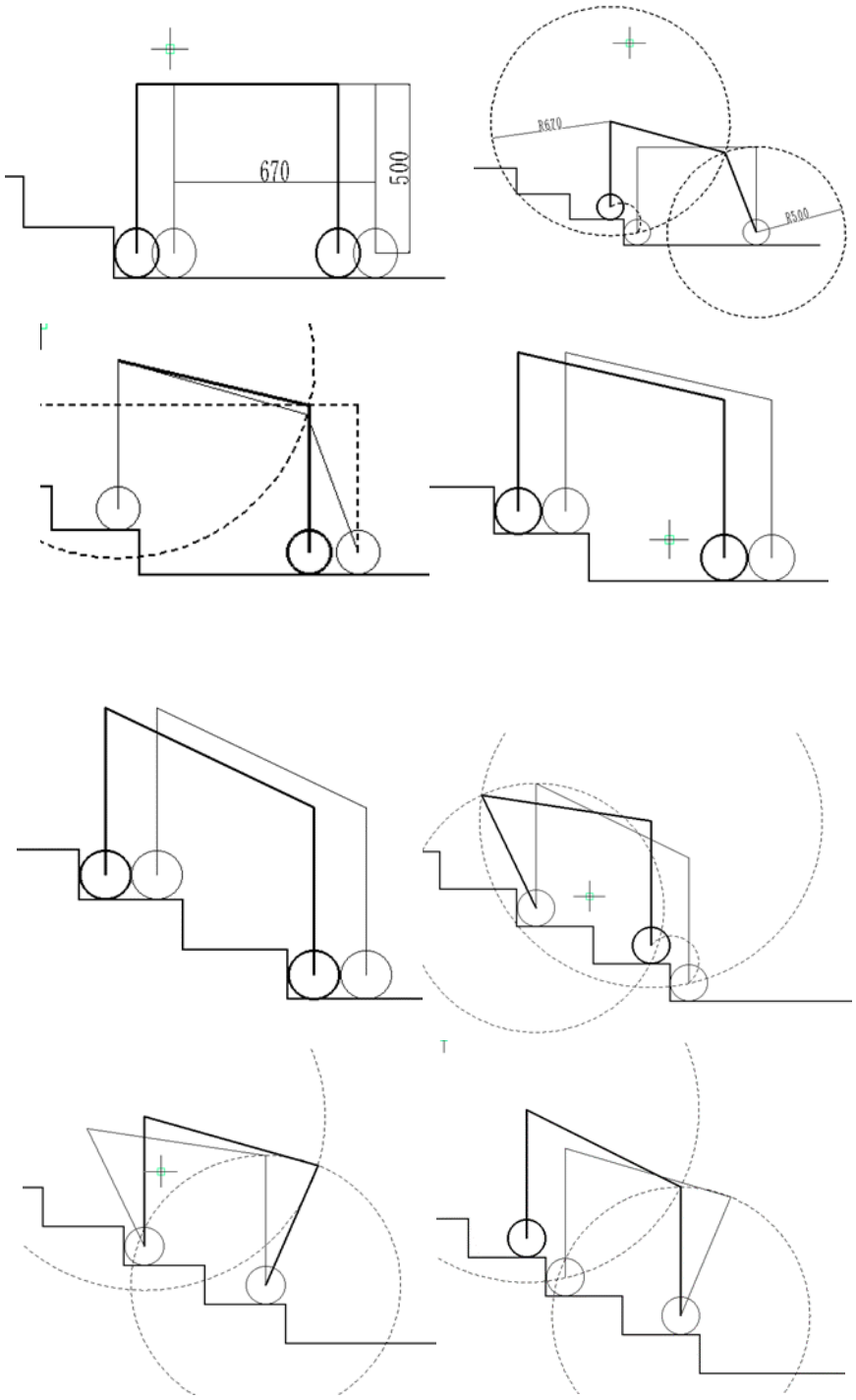
turning stairs or encountering obstacles, and control Mecanum wheels to make autonomous turns. The control system controls the switching of the three modes of the climbing wheelchair.

Climbing method

Due to the characteristics of the parallel four-bar mechanism, the position of the climbing mechanism is always parallel to the position of the front and rear supports. Therefore, to simplify the climbing method, we replaced the climbing mechanism with the support of the front and rear supports.



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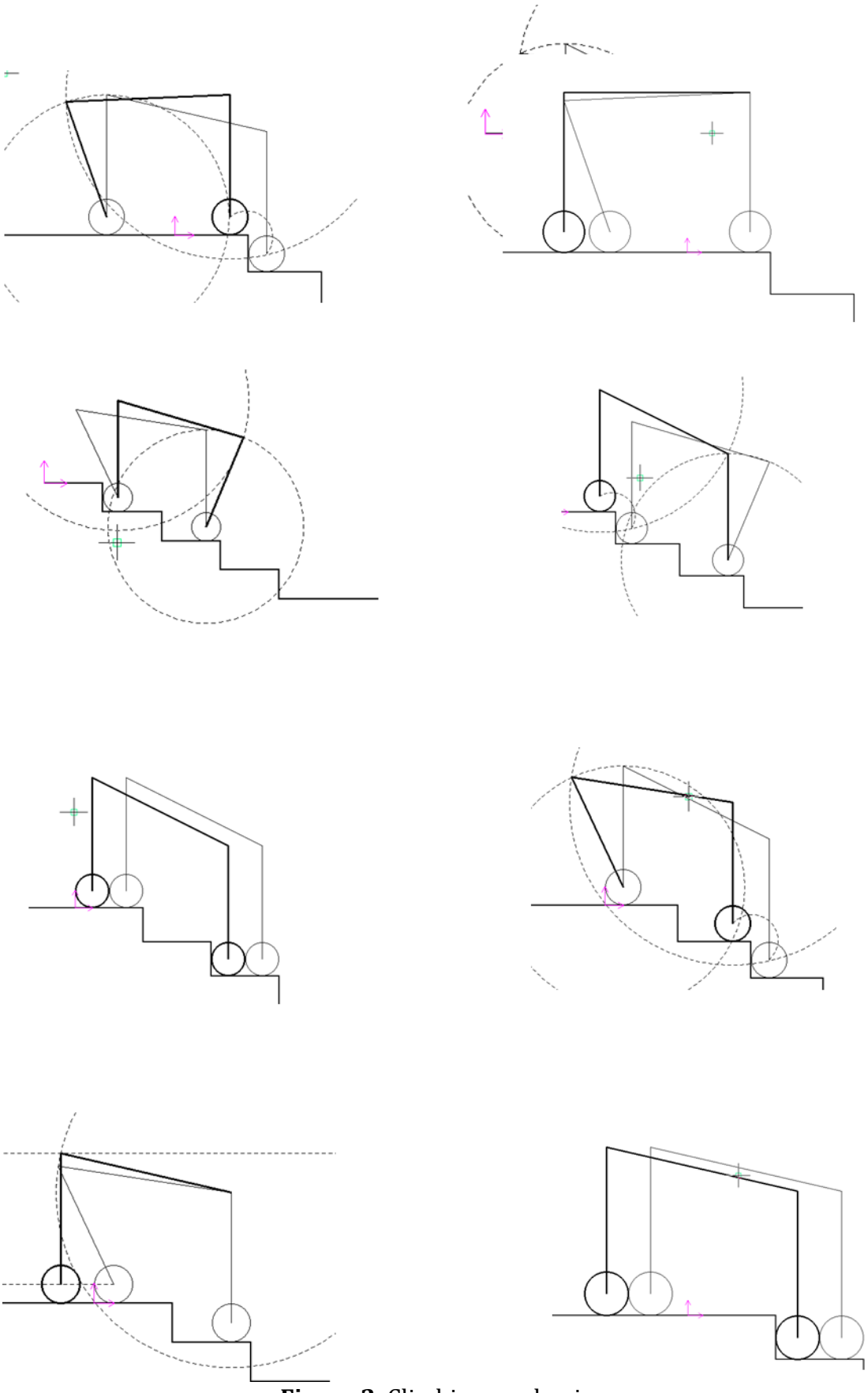

Figure 2. Climbing mechanism

This climbing movement is a full cycle process from entering the stairs to leaving the stairs. It is divided into three phases. In the preparation phase of climbing, find the distance to the

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stairwell, and prepare for climbing. The way of movement is to climb the stairs. Before entering the next staircase each time, the front climbing mechanism will return to the state perpendicular to the ground, ready to climb the stairs. When leaving the stairs, the rear climbing mechanism will remain vertical to the stairs. When climbing out of the stairs, it returns to a flat walking state. The climbing operation ends. The realization of the climbing movement is based on the wheelbase adjustment mechanism, so that the angle of the front and rear wheel frames can be changed, instead of a particular perspective.

3. Conclusions

(1) A new type of step-supporting wheelchair for climbing stairs was designed and optimized more intelligently to make it more similar to a climbing robot and ensure the advancement of wheelchairs.

(2) Based on the four-bar mechanism, a climbing mechanism is designed to complete the essential functions of climbing a building.

(3) A special climbing method is designed so that the wheelchair always maintains four contact surfaces with the ground during the climbing movement, ensuring the stability of the wheelchair and the safety of the occupants (4) The use of Mecanum wheels can ensure the flexibility of the movement, and cooperate with the control system to greatly improve the obstacle avoidance ability of the climbing stairs wheelchair, reduce the operating complexity of the occupants, and also improve the climbing stairs wheelchair or It is safe and reliable during flat sports.

(5) By using the wheelbase adjustment mechanism, the wheelbase can be changed to suit most of the stairs, which improves the adaptability and universality of the wheelchair.

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