Design of a New Type of External Traction Device of Wheelchair based on STM32 Chip

To cite this article: Zhongming Dai et al 2019 J. Phys.: Conf. Ser. 1176 052050

View the article online for updates and enhancements.
Design of a New Type of External Traction Device of Wheelchair based on STM32 Chip

Zhongming Dai, Canyi Du*, Zhijie Chen, Meng Yuan and Guoling Peng

School of Automobile and Transportation Engineering, Guangdong Polytechnic Normal University, Guangzhou, China

*Corresponding author e-mail: micandu@163.com

Abstract. Compared with manual wheelchair, electric wheelchairs are more suitable for long-distance walking. But the price of electric wheelchair is high and it is inconvenient to carry. In this paper, a new type of external traction device of wheelchair based on STM32 chip was designed, which was versatile, light weight and easy to carry. The traction device was mainly composed of car body, electric wheel, drive control system, electronic intelligent steering system, speed control system, pre-crash safety system and etc. It had a variety of functions and was easy to operate, providing excellent solutions for wheelchair users.

1. Introduction

Wheelchair is more and more popular as a walking tool for the elderly with lower limb disability and mobility inconvenience. Manual wheelchair is only suitable for indoor and short distance use, which consumes too much energy. For many elderly people and disabled people, electric wheelchairs have better application prospects under the circumstances of economic permission.

At present, there are some wheelchair traction devices in the market, but these traction devices need to hold the handle all the time to control the direction, which is easy to lead to fatigue due to long-term manual driving, and the device has the problems of high power consumption, low safety and comfort. In view of the problems of the wheelchair traction device mentioned above, a new type of external-mounted traction device of wheelchair based on STM32 chip was designed with the electric wheelchair as the pillar. This traction device, which was used in conjunction with ordinary manual wheelchairs, can not only realize the function of the electric wheelchair, but also had the advantages of low cost, small size and powerful function. It was of great practical significance to improve the self-care ability of the disabled and the elderly, and to lighten the burden of the family and society.
2. Design of a new external traction device of wheelchair

A new type of traction device of wheelchair based on STM32 control system will be developed to overcome the shortcomings of ordinary manual, ordinary electric wheelchair and ordinary wheelchair tractor. The overall structure design of the tractor is shown in Fig.1, including driving steering device, automatic lifting device, Bluetooth remote control device, and also equipped with speed control system and anti-collision safety system. The traction front wheel is fixed on the fixing frame through the front fork 6. The fixing frame is clamped on the foot frame of the wheelchair through the fixing clamp 1, the driving steering device is arranged on the bottom cover, the front end is equipped with the front lighting lamp 7 and the two sides are provided with the steering lamp 8, which are respectively used for the night illumination and the steering reminder. The Bluetooth remote control device is fixed to the wheelchair handle.

Figure 1. Schematic diagram of a new external traction system of wheelchair
1-Fixing clamp; 2-Protecting shell; 3-Pulling front wheel; 4-Angle adjusting joint; 5-Width adjusting button 6-Front fork; 7-Front lights; 8-Steering lamp; 9-Push-rod motor

3. Design of automatic lifting device

In order to facilitate users to adjust the wheelchair backrest angle according to their own needs and to create certain conditions for driving the wheelchair to walk, the new type of tractor was designed with the automatic lifting device for front wheel of wheelchair, as shown in Fig.2, which was a mechanical structure not available in common traction devices. It took the push-rod motor as the power source, dragged the wheels of the traction head forward and backward through the extension of the push-rod motor, and indirectly lifted or dropped the front wheel of the wheelchair, so that the height of the front wheel of the wheelchair can be adjusted in the safe range. Therefore, it can provide comfortable backrest angle for users and create certain conditions for driving wheelchair to walk.

Figure 2. 3D model of automatic lifting device
The working principle of the automatic lifting device is shown in Fig.3. According to the degree of freedom of the planar mechanism, it can be seen that the mechanical structure of this design has 5 movable parts, 7 low pairs and 0 high pairs. According to the formula of degree of freedom:

\[ F = 3n - 2PL - PH \]

The design degrees of freedom of the above-mentioned mechanical structure can be obtained as follows:

\[ F = 3\times5 - 2\times7 - 0 = 1 \]

Therefore, it is necessary for the mechanism to be able to move, only one source of motion is needed. The advantages of the above structure are that it required fewer motion sources, has simple structure and is easy to use. Assuming that the initial state of the structure is shown in Fig.3, when the telescopic mechanism composed of 1 and 2 is contracted, the movable part 3 can only move parallel to the right side under the constraint of the lower pair A and B, thus causing the angle between the hinges of the movable parts 3 and 4 to become larger and the angle between the hinges of the movable parts 4 and 5 to become smaller. Since the movable part 3 can only move parallel to the right, the hinge C can only move to the upper right direction with respect to the movable part 3, thus causing the angle of hinge D to become larger. In the same way, this principle was applied to the automatic lifting structure of the project, which can indirectly lift the small front wheels of the wheelchair through the expansion and contraction of the push rod motor, and the backrest angle can be adjusted and the conditions for driving wheelchairs can be created.

![Figure 3. Mechanical structure diagram of automatic lifting device](image)

4. **Electronic intelligent steering device**

The steering device of the new external tractor was mainly composed of high-power steering gear, front fork and helical gear. The reason for choosing helical gears is that they have good meshing, smooth transmission, low noise, high load-carrying capacity and few minimum teeth without undercutting. The ideal model is shown in Fig.4:

![Figure 4. Model of Steering gear](image)
The drawing head pushed the rocker return after steering. Because the accuracy of steering gear angle was too low, there will still be a situation that can not be completely corrected. In order to avoid this situation, an automatic control system was designed. MPU-6050 gyroscope sensor was used in the system. The sensor is an integrated six-axis processor, which combines gyroscope and accelerometer. The gyroscope was installed horizontally above the drawing head. The initial angle of the gyroscope was taken as a given value, and a compensation angle was given according to the angle deviation of the actual installation. The circuit of MPU-6050 sensor module is shown in Fig.5. The module circuit has four interfaces: VCC, GND, SDA and SCL. SDA and SCL are connected with stm32, and the data transmitted by MPU-6050 is read through IIC communication protocol. The gyroscope sensor continuously measured the angular velocity of the motion of car body at a certain frequency, and obtained the angle of the car body in the vertical direction by integral algorithm. Incremental PID algorithm was used to calculate the deviation between the given value and the return value in proportion, integral and differential, and through their respective adjustment coefficients, and then output to the controller. The controller continuously adjusted the angle of the steering gear to achieve auto-correction.

![Figure 5. Circuit schematic](image)

5. Other devices

5.1 Speed control device

Speed control device was a kind of device that when the user pushed the rocker forward, it will send a signal to the driving control module. At this time, the driving control system will issue instructions to let the drawing head advance at a low speed, it’s working principle is shown in Fig.6. If the user felt that the speed was not fast enough, he can press the acceleration button at the top of the rocker. The device repeatedly sent signals to the driving control module. Then the driving control system will send signals again to slow the speed of the tractor. When the acceleration button was released, the drawing head will continue to drive at the same speed. In addition, the rocker was equipped with an electronic hand brake, which can slow down the tractor to a certain speed until it reached zero.
5.2 Anti-collision Safety System

Through the comprehensive design of camera recognition, ultrasonic ranging and voice broadcasting, a set of anti-collision system was formed. Firstly, openmv was used for machine vision learning to learn a large number of objects and situations that may appear on city sidewalks, and the data were processed systematically, so that openmv can recognize and identify objects that may cause interference and injury to the pulling device. In addition, the assistant design of ultrasound can effectively judge the distance between pedestrians and obstacles, and input the parameters of safe distance in advance. When the distance between pedestrians and obstacles was less than the preset value, the alarm will be triggered. The data detected by openmv and infrared will communicate with Arduino CPU in I2C mode. When Arduino received the parameter values from machine learning, it executed the corresponding instructions to provide a travel aids for users. In this way, it was greatly convenient for users to travel, and had certain practical significance for improving travel safety.

6. Design of power management system

The power management system consisted of power management module, DC/DC module, display, main circuit and control devices, as well as various sensors of voltage, current and temperature. The system took STM32 as the main controller, which can realize the monitoring, inquiry and display of the system's electricity, voltage, current and temperature. At the same time, its external integration of the management module of charge-discharge of lithium battery, the detection module of battery's electricity, the boost module of DC/DC and the control module of single-key switch. And It had built-in switching circuit of power supply and protection module of charge-discharge. STM32 MCU collected the voltage of lithium batteries by DS2781, and then realized the measurement of battery power by A/D conversion. Through program automatic processing, it had the functions of over-charge protection, over-discharge protection, over-temperature protection, over-current protection, protection of short circuit and sound-light alarm, which can guarantee the safe and reliable operation of the DC 36V power supply system. Moreover, STM32 MCU has standard library function, which makes it very easy to develop chip driver. Finally, the process of DC voltage boost was realized by the voltage converter, and the power supply to the relay equipment was completed.

7. Conclusion

A new type of external-mounted wheelchair traction device based on STM32 chip was used in conjunction with ordinary manual wheelchair. The traction device used motor as power source to drive the whole wheelchair, and had the advantages of manual wheelchair and electric wheelchair. Users can control the speed and steering of wheelchair by remote control, and avoid collision with obstacles, which greatly improves the comfort and safety performance. It was of practical significance to
improve the self-care ability of the disabled and the elderly, and to lighten the burden of family and society.

Acknowledgements
This work was financially supported by the Education Research Innovative Project of Guangdong University(2017GXJK102) & Natural Science Foundation of Guangdong Province(2018A030313947).

References
[1] Yang Hao. A Starting Point of the Study for Senior People's Rational Driving Styles[J]. Idea & Design. 2015, (04): 63-67
[2] Shi Xuewen, Du Yong, Qin Chuan, An Dong. Research and Design of Electric wheelchair Control system Based on Wireless Communication Technology [J]. Electronic Technology. 2018, (08): 90-92.
[3] Zhang Lin, Ma Ruiqing, Shi Guodong, Xiang Likang. Research on a New Control Policy for Motion Controller of the EPWs [J]. Small & Special Electrical Machines. 2012, (07).
[4] Zhao Yujie. The research on intelligent obstacle avoidance system for electric wheelchair[D]. Hebei Normal University Of Science & Technology. 2017.
[5] Guo Feng, Fang Kai, Yang Sheng, Ru Jinchao. The design & implementation of an electronic steering system for the material handling vehicle [J]. COMPUTER ENGINEERING AND APPLICATIONS. 2000, (07) : 155-168.
[6] Wang Xinmin. Connotations and Teaching Orientation of Triangle Stability, Journal of Neijiang Normal University. 2017, (12).
[7] Li Bo, Li Dequan. Design of multiple output DC/DC power supply applied to lithium-ion batteries management system [J]. Chinese Journal of Power Sources. 2018, (10) :1533-1535.