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Design and research of multi-functional intelligent wheelchairs for the elderly with disabilities

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Abstract: In *order to solve the nursing problems caused by the mobility of the elderly, this paper designs a multi-functional intelligent wheelchair for the disabled elderly, which realizes the functions of assisted movement, assisted rehabilitation, medication classification and reminder for the disabled elderly by integrating four-wheeled walking device, split chair back, assisted stand-up mechanism, leg massage mechanism and intelligent medicine box. This facilitates elderly care to reduce the pressure on caregivers. This paper provides a set of feasible design schemes for smart wheelchairs.*
Keywords: *multi-functional intelligent wheelchair; split back; help get up of the institution; Smart medicine box*

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I. Introduction

Globally, the population is aging at an unprecedented rate, and the number of people with disabilities for a variety of reasons continues to increase. According to the World Health Organization, by 2050, the proportion of the world's population over 65 years old will reach 9.6% (about 759 million)[1][1], especially the elderly and people with disabilities show a strong desire for more autonomous, safe, and dignified ways of traveling. With the improvement of living standards, reducing the care burden of families and caregivers has also become an urgent social issue. Traditional wheelchairs can no longer meet the pursuit of self-care and self-reliance by this group, so it is crucial to develop intelligent wheelchairs with a higher degree of intelligence and more comprehensive functions [2].

At present, many researchers or companies have carried out wheelchair design. Many foreign research institutes are vying to conduct research in related fields, such as MIT's wheelesley, France's VAHM, Germany's MAID, Spain's SIAMO, Canada's AAI company's TAO project, and the EU TIDE project. With the continuous development of scientific and technological progress and computer technology, the intelligence of wheelchairs has also been improved. For example, the Model C2 smart wheelchair developed and produced by WHILL in Japan has been well received by consumers for its stylish appearance, safe and reliable driving mode [3], and has also won a rich economy. This urgently needs to develop a new type of smart wheelchair for the elderly with reduced mobility.

II. The overall structure and working principle of the multi-functional intelligent wheelchair

2.1 Overall design

The multi-functional intelligent wheelchair for the elderly with disabilities designed in this paper is mainly composed of several core modules, such as four-wheeled walking device, split chair back, assisted lifting mechanism, leg massage mechanism and intelligent medicine box, which cooperate with each other to complete the functions of assisted transfer and assisted care for the disabled elderly. The overall structure of the smart wheelchair is shown in Figure 1.

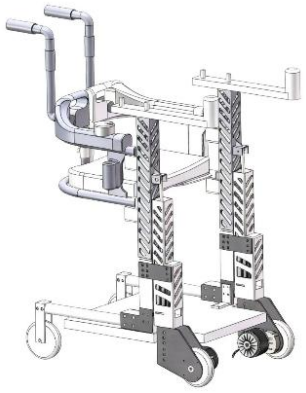


Figure 1 The overall structure of the intelligent wheelchair

The wheelchair is mainly designed to be ergonomic in size, as shown in Table 1.

Table 1 Main dimensions (length, width and height)

parameter	Size (mm)
Long× wide× high	854.07*580*1267.01
Backrest width	570
Backrest height	500
Handle diameter	40

2.2 Working principle

The main functions of the multi-functional smart wheelchair for the disabled elderly are free movement, assisting to get out of bed to achieve bed transfer, intelligent medication, remote control, and the functional modules are shown in Table 1.

Table 2 Table of functional modules

Functional modules	Drive mode
Front-wheel drive dual drive	The DC geared motor drives the front wheel traveling device
The back of the chair opens and closes	The freestanding backrest can be separated on the left and right for easy access to bed
Putter lift	The actuator independently controls the mating track to achieve lifting
Smart medicine box	The motor is directly connected to the partitioned medicine box to achieve regular medication
Bluetooth control	Remote control of wheelchair posture via Bluetooth module

Before working, the back of the chair is closed, and the transfer of the person on the bed to the wheelchair begins after pushing the smart wheelchair to the front of the bed. The steps are as follows:

1) After lifting the elderly up, open the seat and place the elderly's armpits on the soft support of the armrest, so that the elderly's center of gravity is tilted towards the seat.

2) Then start the electric actuator, and the slide rail will drive the old man upwards to lift the old man and leave the bed slightly.

3) Merge the chair surface, and the elderly can sit on the chair to complete the bed transfer.

4): Return the actuator, and the elderly can use the APP to control the forward or backward direction and speed of the smart wheelchair.

5: The smart wheelchair also has a smart medicine box and a health monitoring module, which can reflect the physical condition of the elderly in real time.

III. Design and implementation of the main devices of multi-functional intelligent wheelchairs

3.1 Four-wheeled running gear

In order to adapt to complex terrain, the front wheel of the four-wheel traveling device adopts wear-resistant rubber wheels. This rubber wheel has good grip and flexibility, with a diameter of 130mm and a stable ride on uneven ground, and the rear wheel is a universal wheel with a diameter of 50mm. The walking speed is designed to be 2~3m/s, and the cruising range is five kilometers, which can be adjusted according to the actual situation. (as shown in Figures 2 and 3).

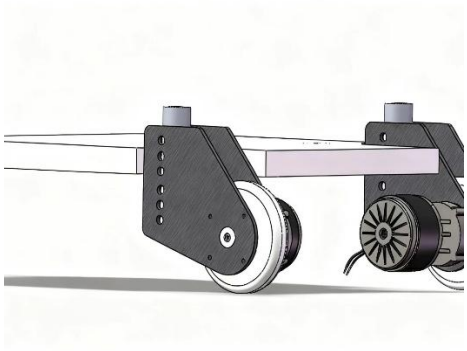


Figure 2 Front-wheel drive

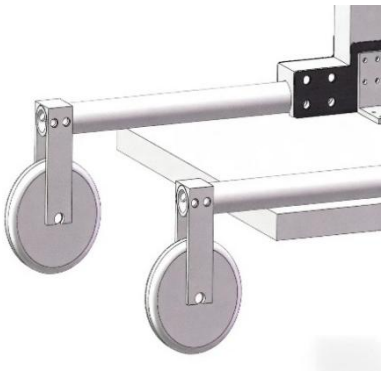


Figure 3 Rear wheel steering

3.2 Deployable seatback device

Figure 4 belongs to the unfoldable chair back, the split chair back is fixed by the actuator mounting frame and a embedded column, the front fixed shaft is 350mm, the back backrest is 400mm to facilitate the elderly to lean on, the rear armrest height is 20mm and extends 10mm backwards, which is convenient for gripping, when the chair is merged, it can be locked by the rear lock, the mating lock, the split chair back and the pusher lifting device cooperate with each other, which can realize the opening and closing of the chair behind the back, which is convenient for the elderly with inconvenient legs and feet to get on the wheelchair on the bed 。

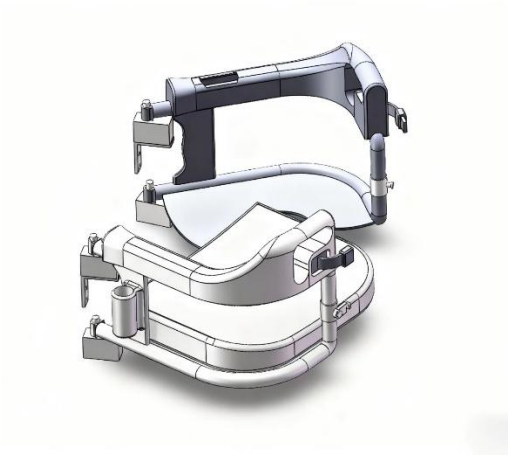


Figure 4 Deployable seatback device

3.3 Electric actuator lifting device

The lever lifting mechanism is shown in Figure 5, and the lifting mechanism to which it belongs includes, the left electric push-dry mounting frame, the right electric push-dry mounting frame, and the size of the push rod is (the center distance of the fully retracted hole is 200mm, and the stroke is 100mm). There is a card slot on the upper part of the actuator mount, which can be combined with the top of the actuator, when the actuator 1 and the actuator 2 rise at the same time, the seat is lifted, and this mechanism is similar to the crank slider mechanism. The mechanism controls the up and down movement of the chair through the up and down expansion of the actuator, and the push speed can be adjusted to a maximum of 30mm/s.

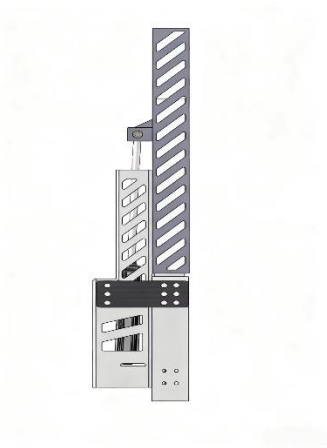


Fig. 5 Electric actuator lifting device

3.4 Intelligent control device

The wheelchair introduces a Bluetooth module, which can be remotely controlled by a mobile phone app, and has a variety of built-in smart devices, such as smart medicine boxes and health monitoring modules

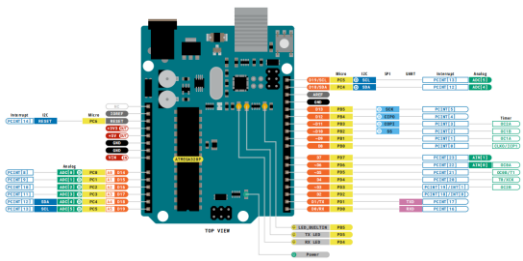
The diameter of the medicine box is 70mm, the interior is divided into 6 compartments of equal size, the wall thickness is 4mm, and several drugs can be placed, and the power system of the medicine box is composed of a high-performance DC brushless motor, which can be rotated at any angle, as well as rotated regularly and reminds the elderly to take medicine. The lower end of the smart medicine box has a hole to mate with the output shaft. (as shown in Figure 6)

Fig.6 Medicine box model diagram

IV. Design and implementation of electronic control system

This project uses the Arduino Uno R3 as the main controller. It is based on ATmega328p microcontroller, clocked at 16MHz, 32K ROM, 2K SRAM, 1K EEPROM. It operates at 5V and has 14 digital IO pins, 6 of which support PWM outputs and 6 analog inputs. Pin configuration

This paper uses the PWM output functions of the D9, D10, and D11 digital IO pins to drive three L298N drivers, with the pin configuration shown in Figure 7.



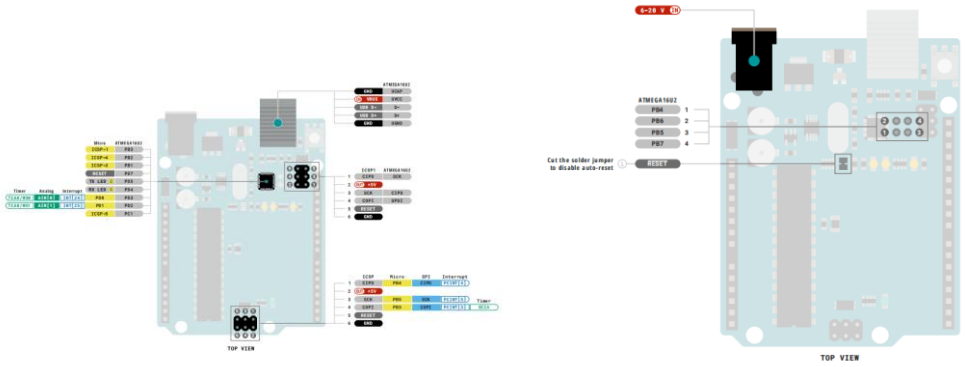


Figure 7 Pin configuration

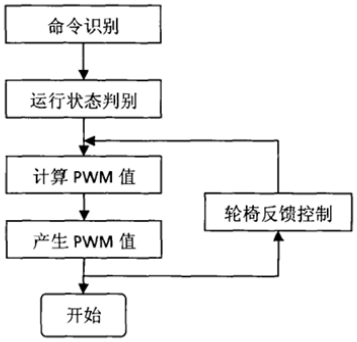


Fig. 8 Control logic **[4]**

V. Prototype implementation

According to the design, verify and develop prototypes
As shown in Figure 9.

Figure 9 Physical drawing

After testing, the wheelchair can bear the daily needs of the disabled elderly under the condition of suitable materials, and all functions can operate normally.

VI. Innovation points

6.1 Structural innovation

The wheelchair adopts a split design concept and integrates multiple functional modules such as movement, lifting, Bluetooth, opening and closing, etc. Compared with wheelchairs on the market, the shape is unique and the overall structure of the equipment is simplified, reducing manufacturing and maintenance costs.

At the same time, the close cooperation between the functional modules improves the overall operating efficiency of the equipment.

6.2 Technological innovation

(1) Innovatively complete the overall design and execution structure design of multi-functional assistive wheelchairs, mainly including the design of motor two-wheel drive walking structure, with an openable and retractable backrest design to meet the entry and exit of wheelchairs for the elderly with reduced mobility.

(2) The leg massage mechanism adopts cross-linear guides, which is convenient for multi-position and multi-angle massage to help the elderly relieve fatigue and rehabilitation.

(3) Set up a smart medicine box to provide medicines regularly and quantitatively through a timer to prevent the elderly from forgetting them.

(4) Intelligent control is achieved through microcontroller control algorithm, integrated electronics development and APP design.

(5) The overall structure is compact and meets the requirements of ergonomic design.

6.3 Life innovation

(1) The bed and chair handover function not only reduces the cost of manpower and time, but also makes the elderly painless from the bed to the wheelchair, so that the elderly will not be afraid of getting out of bed, or unwilling to move, and even produce a lot of negative emotions.

(2) The function of foot massage serves the elderly, reduces muscle necrosis caused by long-term muscle inactivity of the elderly, and reduces the pressure of caregivers.

(3) The smart medicine box can remind the elderly to take medicine regularly and quantitatively, and store it in different sections, which is convenient and accurate, reducing the mental pressure of guardians.

(4) The health monitoring system makes the physical condition of the elderly under the control of the guardian at home at all times, which makes the elderly and guardians very reassured, and greatly provides the safety of the elderly.

VII. Conclusion

The purpose of studying this wheelchair is to help the disabled elderly to live a better life, through visits, questionnaires, and in-depth research into the elderly group to get the most needed functions of this type of people, and the research finally proves its feasibility, and it is our honor to be able to help these elderly people, and achieve the expected goals of the project.

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