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A Multifunctional Intelligent Electric Wheelchair Nursing Bed

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Abstract: This paper presents the conceptualization and realization of a multifunctional intelligent electric wheelchair nursing bed, designed to address the limitations of existing products on the market, such as excessive size, single functionality, poor mobility, lack of toilet assistance, and insufficient leg rehabilitation training. The system integrates core functions including electric mobility, stepless adjustment of standing-sitting-lying postures, toilet assistance, and passive leg training, adopting a modular mechanical structure and intelligent control technologies (incorporating voice interaction and remote APP control). This design not only significantly improves users' life autonomy and comfort but also reduces the overall volume and manufacturing costs of the device, making it suitable for scenarios such as hospitals, nursing homes, and families. Ultimately, this work contributes to optimizing the elderly care support system and promoting the development of intelligent aging-friendly products.

Keywords: Intelligent Nursing Bed; Electric Wheelchair; Posture Stepless Adjustment; Toilet Assistance; Passive Leg Training

I. Introduction

According to the prediction of the National Health Commission of China, the population aged 60 and above in China will exceed 400 million by 2035, which has led to a surge in the demand for care for disabled and semi-disabled elderly individuals. Traditional nursing models, which rely heavily on manual care, are increasingly struggling to meet this demand—shortages of professional nursing staff result in heavy care burdens, while the inefficiency of manual operations affects the quality of life of the elderly.

This study develops a multifunctional intelligent electric wheelchair nursing bed, aiming to improve the autonomy and comfort of the elderly's daily life through integrated function design and intelligent control, and promote the popularization of high-quality elderly care equipment. The design aims to integrate electric mobility, stepless standing-sitting-lying posture adjustment, toilet assistance and passive leg training into a single device to meet diversified care needs, while optimizing the mechanical structure to reduce volume and improve mobility for multi-scenario adaptation, adopting modular design and cost-effective components to lower manufacturing costs, and integrating intelligent control modules to reduce the operation threshold for users with limited mobility.

II. The Design Scheme of the Device

A. Display of The Device

As illustrated in Fig.1, the multifunctional intelligent electric wheelchair nursing bed is composed of a frame, a posture transformation mechanism, an auxiliary care mechanism, a movement mechanism, and a drive system. Users can control all functions of the wheelchair through physical buttons or an APP: they can control the movement motor to enable the wheelchair to achieve omnidirectional movement; they can control the electric push rod of the posture transformation mechanism to switch the wheelchair from a sitting position to a lying flat position or assist in standing up from a sitting position; and they can control the motor of the auxiliary care mechanism to realize leg relaxation exercises or open the sliding plate to use the toilet function. Through modular design and intelligent control, this product solves the problems of traditional wheelchair beds such as large volume, single function, and complex operation, and significantly improves users' life autonomy and comfort.

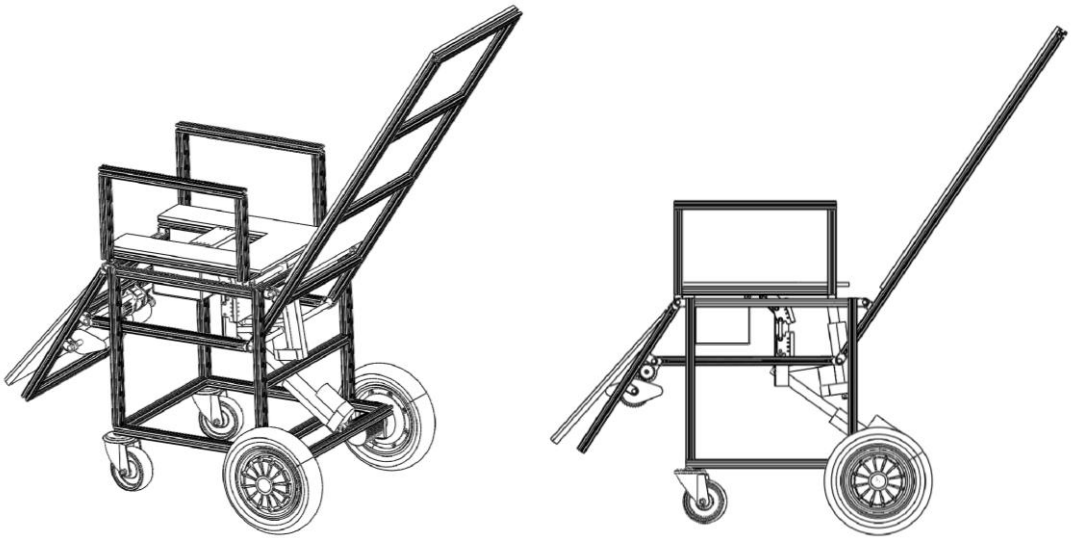


Fig.1: Design Scheme and structure of the multifunctional intelligent electric wheelchair nursing bed

B. Mechanical architecture and control strategy

1) Posture transformation mechanism

As shown in Fig. 2, the posture transformation mechanism is crucial for meeting the user's posture adjustment needs, integrating two sub-mechanisms to achieve both auxiliary standing and stepless sitting-lying switching. The fixed-axis rotation lifting mechanism is composed of a fixed-axis rotation frame, double-sided armrests, and a U-shaped opening seat plate; driven by an electric push rod, the frame rotates around the fixed axis, tilting the U-shaped seat plate to assist the user in standing up, and a limit switch is installed at the bottom of the seat plate to prevent over-rotation and ensure safety.

The parallelogram folding mechanism is connected to the backrest support plate and leg support frame via connecting rods; by extending or retracting the electric push rod, the diagonal length of the parallelogram structure is adjusted continuously, realizing stepless angle adjustment of the backrest and leg support frame within the range of 0°~90°, thus completing the switching between sitting and lying postures. To address the problem of insufficient load-bearing capacity of the electric push rod, the push rod is installed at the front end of the wheelchair, and components with large thrust load and slow movement speed are selected to ensure stable posture adjustment.

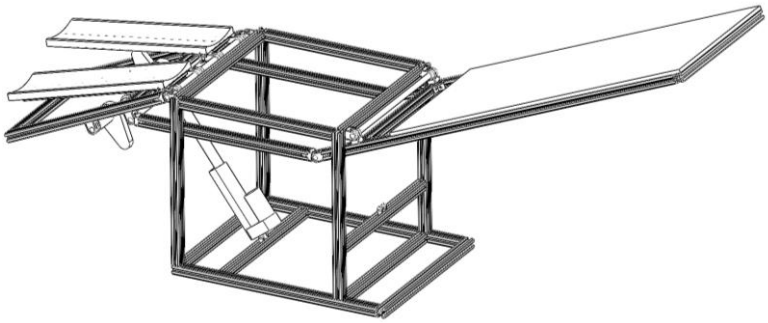


Fig. 2 Posture transformation mechanism

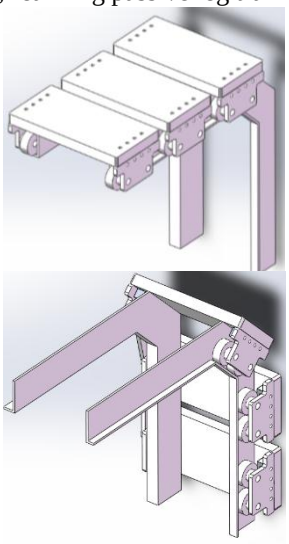
2) Auxiliary care mechanism

The auxiliary care mechanism is designed to solve the key pain points of toileting and leg rehabilitation for the elderly, with two core modules that have undergone optimization based on initial design defects.

For the toilet assistance module, the original design intended to use an iris mechanism, which would realize opening and closing by rotating a control ring to adjust blades. However, this scheme had three major defects. It had a large volume that was incompatible with the narrow internal space of the wheelchair. It also had incomplete closure that led to odor leakage after use. Additionally, it had an uneven surface that affected sitting and lying comfort. The optimized design adopts a guide rail and sliding plate structure, as shown in Fig. 3. When the toilet port is closed, the upper surface of the sliding plate is flush with the U-shaped seat plate,

ensuring no impact on user comfort. When in use, the motor drives the sliding plate to move along the guide rail, opening the toilet port. Meanwhile, excrement is collected in a sealed container to avoid odor pollution.

For the leg training module, the original design used a ratchet mechanism with two motors and two sets of ratchet groups to control the up-and-down movement of the leg support plates. But this scheme had several issues. It had high manufacturing costs and a complex structure. Moreover, the large torque on the leg support plates (when installed at the rotating shaft) increased maintenance difficulty. The improved design adopts a single motor + cam set structure. The motor drives the cam set via a synchronous belt. The leg support plates are fixed on the rotating shaft and fall naturally under gravity. When the user's legs are placed on the support plates, the plates fit closely with the cam set. When the motor starts, the cams drive the leg support plates to move up and down, realizing passive leg training with a simpler structure, lower cost, and easier maintenance.



(a) (b)

Fig. 3: Toilet assistance module (a) and leg training module (b)

3) Movement mechanism

The movement mechanism and drive system form the basis for the device's mobility and intelligent control. In the movement mechanism, the two rear wheels serve as driving wheels, each driven by an independent motor, and the controller adjusts the speed difference between the two motors to achieve differential steering, ensuring flexible movement in narrow spaces such as corridors, while the front wheels are universal wheels to improve movement stability.

C. Selection and Design of Hardware Circuits

To realize the automation control of the device, an electrical control part and a power supply part are used. Its core control chip adopts STM32F103ZET6, which integrates modules such as motor drivers. This integration reduces the space occupied by electrical control components and facilitates program control and wiring. The main control board integrates 4 motor drivers, which are mainly used to drive the rotation of rollers and rotating shafts.

After debugging and calculation analysis, considering the overall weight of the vehicle and work efficiency, chassis motors and stepper motors with chips RZ7899 and TB67S109A respectively are adopted to control and drive the vehicle's travel. Both of these motors use 24V DC power supply. The motors installed on other mechanisms also use 24V DC power output, and they are brushless working motors with RZ7899 chips. Servos and push rods with relays are directly controlled by the core control chip. All pins are directly connected to the STM32 main controller.

III. Conclusion

The multifunctional intelligent electric wheelchair nursing bed has a simple overall structure, relatively low cost, and is compact and convenient. Through modular design and intelligent control, the product integrates functions including mobility, stepless adjustment of standing-sitting-lying postures, toilet assistance, and passive leg training. It solves the problems of existing wheelchair beds on the market, such as large size, single function, poor mobility, and lack of toilet assistance and leg rehabilitation training. This significantly improves users' life

autonomy and comfort, and the product is suitable for various scenarios such as hospitals, nursing homes, and families.

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References

[1]. Zheng, Z. J. Edible Legumes in China [M]. Beijing: China Agricultural Press, 1997: 133. (In Chinese)
[2]. Ding, L., Zhang, L. F., Lai, S. J. Research on the Application of Plant Protein in Meat Products [J]. Food Research and Development, 2021, 42(4): 193-197. (In Chinese)
[3]. Ertugrul, U., Namli, S., Tas, O., et al. Pea Protein Properties Are Altered Following Glycation by Microwave Heating [J]. LWT - Food Science and Technology, 2021, 150(3): 111939.
[4]. Chang, C. Y., Jin, J. D., Chang, H. L., et al. Antioxidative Activity of Soy, Wheat and Pea Protein Isolates Characterized by Multi-Enzyme Hydrolysis [J]. Nanomaterials (Basel, Switzerland), 2021, 11(6): 1509.
[5]. Liu, M., Sun, G. W., Zhang, H. T., et al. Nutritional Characteristics of Pea and Pea By-Products and Their Application in Animal Feed [J]. Hunan Feed, 2021(2): 40-45, 48. (In Chinese)
[6]. Xu, Z., Wang, Y. J., Chen, X. M., et al. Research Progress on Pea Protein and Pea Antioxidant Peptides [J]. The Food Industry, 2020, 41(6): 258-262. (In Chinese)
[7]. Li, H. T., Chai, Q., Wang, Q. M., et al. Water Use Characteristics of Maize-Green Manure Intercropping Patterns Under Different Nitrogen Application Levels in Oasis Irrigation Areas [J]. Scientia Agricultura Sinica, 2021, 54(12): 2608-2618. (In Chinese)
[8]. Zhang, X. H., Che, Z. X., Zhang, J. D. Effects of Maize Intercropping with Green Manure on Soil Respiration and Soil Organic Carbon [J]. Territory & Natural Resources Study, 2021(4): 75-79. (In Chinese)
[9]. Zhang, X. C., Yu, X. F., Ma, Y. F., et al. Effects of Sowing Date of Vicia sativa on Biomass and Water Use Efficiency of Intercropped Potato in Semi-Arid Areas [J]. Arid Zone Research, 2020, 37(6): 1618-1626. (In Chinese)
[10]. Zhang, Y., Di, W. T., Wang, J. J., et al. Research Progress on Resource Utilization of Intercropping in the Agro-Pastoral Ecotone of Northern China [J]. Chinese Journal of Ecology, 2017, 36(9): 2623-2632. (In Chinese)
[11]. Chen, G. R., Wang, L. M., Yang, R. P., et al. High-Efficiency Cultivation Techniques and Application Prospects of Legume-Non-Legume Intercropping in Different Ecological Regions of Gansu [J]. Journal of Agricultural Science and Technology, 2017, 19(3): 63-71. (In Chinese)