

Original Paper

Design of Multi-functional Elderly Walking Aid Device

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Abstract

With the accelerating aging process of the population in China, the daily mobility and living assistance needs of the elderly have become increasingly prominent. To enhance the autonomy and safety of mobility for the elderly, this paper conducts field visits to nursing homes, rehabilitation hospitals and communities, systematically investigates the current usage status and user pain points of existing mobility AIDS, and proposes an intelligent mobility aid device that integrates functions such as lift assistance, mobility assistance, automatic following, intelligent obstacle avoidance, health monitoring and one-click first aid. The device is structured based on ergonomic principles and integrates multi-sensor technology and intelligent control algorithms to meet the diverse and individualized assistive needs of the elderly, providing an effective solution to mobility assistance problems in an aging society.

Keywords

elderly mobility assistance, product design, demand research, smart controls

1. Introduction

As China's aging society progresses, with the current fertility policy remaining unchanged, by 2050, China's aging population will reach 437 million, and the proportion of people aged 65 and above in the total population will reach 27.8%. Meanwhile, in line with the decisions and plans of the 19th National Congress of the Communist Party of China, the "National Plan for Actively Responding to Population Aging", how to create an environment suitable for the elderly through the design of intelligent and personalized walking AIDS has gradually drawn the attention of all sectors of society.

At present, various studies have been conducted on the design of walking AIDS for the elderly. Zhang Yunfan has designed human-machine compatible walkers based on sensory engineering and U-TRIZ theory, focusing on the high-level emotional needs (Zhang & Hou, 2022) of the elderly. Meng Xiaoyuan designed the elderly rehabilitation walker from the user's perspective to enhance the stick^{l2}iness of the product to elderly users. At present, research on walking AIDS has reached a certain

scale, but with the development of technologies such as artificial intelligence, cloud computing, big data, and the support of various policies, the demand for intelligent walking AIDS is increasing. Based on a systematic investigation of the current usage of existing walking AIDS, this paper combines ergonomics, multi-sensor technology and intelligent control algorithms to design a multi-functional intelligent walking aid for the elderly, aiming to enhance the safety and autonomy of the elderly when traveling.

2. Analysis of the Current Situation and Demand for Elderly Walkers

In the medical field, those who have difficulty moving due to trauma, hemiplegia or disability are called walking AIDS. According to the “Service Specifications for the Allocation of Assistive Devices for the Elderly”, assistive devices for the elderly are mainly used to support the balance of the body, master the sense of direction, and assist in daily travel (Sun & Zhao, 2025) for the elderly whose limb movement is restricted and who cannot walk independently. In 2018, the World Health Organization launched a program called Globalcooperation on Asistive Technology and released the WHO List (Qiu, et al., 2017) of Key Assistive Devices. The list includes walking AIDS such as canes, axillary crutches, elbow crutches, wheeled walkers and wheelchairs. The National Rehabilitation Assistive Devices Research Center of the Ministry of Civil Affairs of China classifies walkers into three (Chen, Ren, & Kong, 2025) categories: non-powered, smart electric walkers and active exoskeletons. Among them, powered walkers, though more expensive, are more intelligent and can better meet the needs of people with mobility difficulties, and have broad prospects for development.

In order to gain a better understanding of the current market situation of walking AIDS, through on-site visits to several health and wellness centers such as Xi ‘an Weiyang Caotan Nursing Home, Rehabilitation Department of Xi ‘an Hospital of Traditional Chinese Medicine, and Xihang Community, the following problems were found among the users of walking AIDS in such places: (1) Users with movement disorders mainly rely on getting up or standing slowly by themselves, consuming a lot of physical energy, and may accidentally fall to the ground, posing a certain safety hazard; (2) For elderly people with mobility issues, they are supported by the staff of the nursing home, but they have time limitations and cannot move around at any time and place, thus unable to sit or stand freely. (3) The use of non-powered walking frames or crutches, which may have some assistive effect, is not suitable for all users due to the different structures and varying product quality of walking frames on the market, and it is physically demanding and dangerous to operate; (4) Moving in a non-powered or powered wheelchair, but the wheelchair is not suitable for users to sit for long periods. If the user needs to stand up and move around, it is difficult for them to stand up alone by their own strength, and they may even fall due to the rolling of the wheelchair wheels, posing a safety hazard. (5) Users with visual impairments or visual impairments often travel using tools such as canes and guide dogs, which consume physical strength and lack intelligence. It can be seen that although the domestic market for walking AIDS is large, most of the existing products on the market have relatively single functions, are

physically demanding to operate and pose safety risks. To sum up, there are many technical contradictions in the nature of existing walking AIDS, such as the inability to simultaneously meet the requirements of safety and lightness of the mechanism, and the contradiction between ease of operation and comprehensiveness of functions. Traditional design methods often struggle to break through the limitations of these contradictions.

To sum up, although the domestic market for walking AIDS is large, the existing products are generally single in function, laborious to operate and have prominent safety hazards. Users urgently need an intelligent walking aid device that integrates multiple functions such as lift assistance, autonomous following, intelligent obstacle avoidance, and health monitoring to adapt to different usage scenarios and physical conditions.

3. Design of Multi-functional Intelligent Walking AIDS

3.1 Overall Design Ideas

Based on the above research results, this paper proposes an intelligent walking aid device that integrates functions such as assistance in starting, assistance in walking, automatic following, intelligent obstacle avoidance, health monitoring and one-click first aid. The device adopts a modular design concept, and its overall structure consists of six modules: the lift system, the walking system, the power system, the following system, the control system, and the health detection system. The device supports two modes of use: standing walking mode and sitting movement mode. In a home setting, users can choose the smart navigation mode to automatically go to the designated room; In residential or outdoor Settings, the direction of travel can be controlled via the remote control to meet diverse usage needs.

3.2 Mechanical Structure Design

The entire device is framed with 6061 aluminium alloy, ensuring sufficient strength while maintaining lightness. In terms of the assist device, it consists of a seat plate, an electric push rod, a lifting mechanism and a foot pedal. The user controls the electric push rod to slowly lift the seat plate via the remote control to assist in getting up. The push rod travel is set to 100mm, the seat plate is lifted at a 30 ° Angle, and the lifting process is smooth with less impact on the body. The walking aid uses four McNamm wheels with DC brushless motors to achieve omnidirectional movement and flexible steering, with a minimum turning radius of up to 0.5m. The support device includes adjustable height handrails, extendable handrails and retractable footrests. The armrest height can be adjusted between 771mm and 1032mm, and the seat height can be adjusted between 307mm and 421mm to meet the needs of users of different heights.

3.3 Control System Design

The control system takes STM32F407 as the core processor and integrates multiple functional modules. The following module uses UWB positioning technology. The communication frequency between the base station and the tag is 6.5 GHz, and the positioning error is controlled within ± 10 cm. The system

controls the motor through position-based PID algorithm to achieve automatic following of the walker to the user. The obstacle avoidance module integrates RPLIDAR A1 lidar and infrared sensors to detect obstacles ahead and around in real time. When the system detects an obstacle within a safe distance, it automatically slows down, stops, or plans a detour path. The motor drive module uses a 250W DC brushless motor, combined with a planetary gear reducer with a 1:10 transmission ratio, to achieve smooth, low-noise drive control. The health detection module, based on the STM32F103 core chip, integrates temperature, heart rate and blood pressure sensors, and is equipped with an OLED display and alarm module to monitor the user's health status in real time. The one-click emergency module automatically sends location information and health data to preset contacts after the user presses the button, buying precious time for emergency response.

3.4 Smart Path Planning

For navigation needs in a home setting, the device uses an improved ant colony algorithm for path planning. The improved basic ant colony algorithm is as follows:

$$\eta_{ij} = \frac{1}{d'_{ij}} \quad (1)$$

$$d'_{ij} = \frac{1}{\sqrt{(x_j - x_i)^2 + (y_j - y_i)^2} + \sqrt{(x_{end} - x_j)^2 + (y_{end} - y_j)^2}} \quad (2)$$

The algorithm combines the A* algorithm to generate the initial pheromone distribution and introduces an endpoint direction weight to improve the heuristic function, thereby effectively enhancing the path search efficiency and convergence speed. The simulation results show that in a 10 m × 10 m home environment, the improved algorithm shortens the path length by 21% compared to the traditional ant colony algorithm and reduces the number of convergence iterations by 60%, which can meet the requirements of real-time navigation.

3.5 Ergonomics and Safety Design

The design of the device is strictly in accordance with GB 10000-1988 "Chinese Adult Body Dimensions" standard to ensure that key parameters such as handrail height, seat height, and seat depth are suitable for the vast majority of elderly users. In terms of safety, the system adopts a layered protection strategy. The mechanical layer is equipped with an electromagnetic brake system with a power-off self-locking force of over 200 N and a manual parking latch as a backup. The electrical layer is equipped with overload current protection, which automatically cuts off power when the motor load current exceeds 15A, as well as low battery warning, which triggers both beeping and LED alerts when the battery level drops below 20%. The interaction layer features a recessed button design, which effectively prevents accidental touches and enhances operational safety.

4. Conclusion

Based on the context of an aging society, this paper, through field research, identified the shortcomings

of existing walking AIDS and the needs of users, and designed and implemented a multi-functional intelligent walking aid device for the elderly. The device takes ergonomics into full consideration in its structural design, integrates multi-sensor technology and intelligent algorithms in its control system, and has comprehensive functions such as helping to get up, helping to walk, automatic following, intelligent obstacle avoidance, health monitoring and emergency rescue, which can effectively enhance the mobility autonomy and safety of the elderly. In the future, product cost control will be further optimized, user interaction experience will be improved, and cloud-based health data management and remote care service models will be explored to promote the application of smart walking AIDS in elderly care institutions and families.

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References

- Chen, W., Ren, Z. M., & Kong, L. B. (2025). Research on the Design of Walkers for the Elderly from a Usability Perspective. *Journal of industrial design*, (3), 29-32.
- Meng, X. Y., Du, J. Y., Chen, G. Q. et al. (2023). Design and finite element analysis of multifunctional rehabilitation walker. *Journal of Machine Design*, 40(S1), 14-18.
- Qiu, Z. Y., Guo, J. X., Yang, J. et al. (2017). Rehabilitation 2030: Realization of United Nation Sustainable Development Goals 2030. *ChinJRehabil Theory Pract*, 23(04), 373-378.
- Sun, M. X., & Zhao, Z. F. (2025). Design of Elderly Mobility Aid Products Based on AHP-DEMATEL/QFD Theoretical Model. *Packaging engineering*, 46-48(10), 128-138.
- Zhang, Y. F., & Hou, N. B. (2022). Design of elderly walker based on kansei engineering and U-TRIZ theory. *Journal of Machine Design*, 39(9), 155-160.