A device to assist a wheelchair upstairs

Proposal

by

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Abstract

Keywords:

1. Shock absorption

2. Wheelchair

3. Stair climbing

4. Assistive

5. S-wheel and triangular wheels

Introduction and Problem Statement

Background:

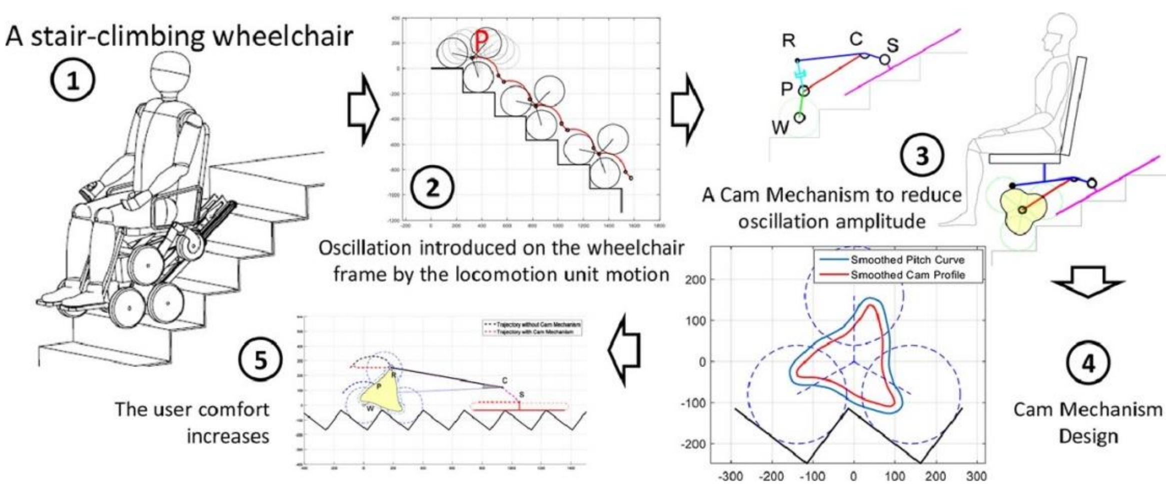
Chinese society is facing a severe aging trend. Data show that by 2023, China's population aged 60 and above has exceeded 400 million, and the elderly population accounting for 30% of the total population. As the elderly population grows, more older adults rely on wheelchairs for daily living and movement. However, the current wheelchair-supporting infrastructure is far from meeting the needs of older people. According to the survey data, many places lack supporting facilities for wheelchairs on and down the stairs, making it difficult for the elderly to travel. According to a survey, about 40 percent of the elderly have encountered a wheelchair unable to get up and down the stairs in their daily life. At the same time, the existing auxiliary equipment also faces many problems. Most of the auxiliary equipment on the market lacks comfort and versatility. According to statistics, more than 60% of the elderly are not satisfied with the existing auxiliary equipment on the market, 40% of the elderly think that the existing auxiliary equipment lacks comfort, and 30% of the elderly think that the existing auxiliary equipment is insufficient.

This graduation project aims to design a new auxiliary equipment to solve the problem of aging trend and wheelchair infrastructure in China, and improve the comfort and versatility of the elderly wheelchair. This study will promote the quality of life of the elderly and promote the attention and solution of the problem of aging, thus laying the foundation for a more friendly and inclusive society.

<u>Literature review 1:</u>

This abstract introduces a new version of the wheelchair. wheelchair with the ability to climb stairs. The wheelchair is capable of climbing single obstacles or stairs through a mixed wheel leg motion unit with a three-wheel cluster structure. The new concept presented in this work is an improvement over the previous version. The stability and regularity of the wheelchair is improved by arranging different functional elements while moving on the stairs. In particular, attention is focused to ensuring that the user's movement during the climbing staircase operation is regular and comfortable. Thus, a cam mechanism was introduced and designed to compensate for the oscillations generated by the rotation of the motor unit on the wheelchair frame. The paper also presents a design method of the cam curve. Furthermore, a parameter analysis of the cam curve and mechanism dimensions was performed to find a cam curve with suitable size and pressure angle, radius of curvature performance.

Giuseppe Quaglia, Matteo Nisi, Design of a self-leveling cam mechanism for a stair climbing wheelchair, Mechanism and Machine Theory, Volume 112, 2017, Pages 84-104, ISSN 0094-114X,
https://doi.org/10.1016/j.mechmachtheory.2017.02.003



The benefits of this wheelchair include:

1. Climbing ability: the ability to climb stairs enables users to deal with different terrain

and obstacles and improve the convenience of travel.
2. Stability and regularity: Through the improved arrangement of functional elements and the introduction of the cam mechanism, we increase the stability and regularity of the wheelchair when moving on the stairs, providing users with a more comfortable experience.
3. Design improvement: Compared to the previous version, the wheelchair design has been improved through the application of different elements arrangement and cam mechanism to improve the performance.

However, this wheelchair may have some potential drawbacks:

1. Complexity: Due to the use of mixed wheel leg motion units and cam mechanisms, this wheelchair may be relatively complex and require higher manufacturing and maintenance costs.
2. Weight and size: For climbing ability and cam mechanism function, the wheelchair may be heavier and larger than conventional wheelchairs, potentially affecting the ease of carrying and storage.
3. Limit of use: For stair-climbing wheelchairs, such as special stair structures or ramp conditions. Users need to choose the appropriate use scenario according to the specific situation.

Literature review 2:

This abstract describes a self-climbing stair wheelchair that can provide unrestricted and independent mobility to people with limited mobility.

Michael Hinderer, Petra Friedrich, Bernhard Wolf, An autonomous stair-climbing wheelchair, Robotics and Autonomous Systems, Volume 94, 2017, Pages 219-225, ISSN 0921-8890,
https://doi.org/10.1016/j.robot.2017.04.015

The benefits of this wheelchair include:

1. Unlimited mobility: The wheelchair climbs the stairs independently, enabling limited people to gain unlimited mobility, no longer limited by obstacles such as stairs, improving their independence and quality of life.
2. Improving the quality of life: Ability to act is important to ensure the quality of life, social contact and independent life of the elderly. The introduction of this wheelchair can help them better participate in social activities, enhance social communication and enjoy life with independent decision-making.
3. Dynamic stability and flexibility: The wheelchair uses dynamic stability to move on only one axis, resulting in highly flexible driving characteristics. Meanwhile, its compact size also increases the convenience of handling in indoor or small Spaces.

However, this wheelchair may have some potential drawbacks:

1. Technical complexity: The design and implementation of self-climbing wheelchairs may be relatively complex and require advanced technical and engineering knowledge. This can result in higher manufacturing costs and higher maintenance and maintenance requirements.
2. Relying on electricity: The wheelchair needs electricity to drive its mobility and climbing functions, so there is a dependence on battery charging or power supply. This may have restricted wheelchair use in certain settings or venues.
3. Limit of use: Although the wheelchair is climbing stairs independently, there may still be some special circumstances or use restrictions under specific stair structures. Users need to pay attention to choose the appropriate staircase and operating environment when using it.

Something in common:

Stair climbing ability: The wheelchairs in both papers were designed to climb stairs to provide better mobility and independence for people with limited mobility.
Improving stability: The wheelchair design in both papers focused on improving stability, reducing bumps and discomfort during stair climbing or other complex conditions by introducing special institutions or mechanisms.

Difference:

Movement mechanism: The wheelchair in the first paper uses a mixed wheel leg motion unit, while the wheelchair in the second paper is based on a leg mechanism. These are two different mobility mechanisms that may have different effects on aspects of flexibility, stability and size of the wheelchair.
Design concept: The wheelchair design in the first paper focuses on improving stability and regularity by changing the arrangement of functional elements, while the wheelchair design in the second paper emphasizes dynamic stability and highly flexible driving characteristics. This reflects the differences in the design philosophy between the two papers.

Technical applications:

The wheelchair in the first paper introduces a cam mechanism to compensate for the oscillations, while the wheelchair in the second paper uses an autonomous climbing system and describes how the leg mechanism works. This suggests that the two papers differ in technology application and institutional design.
By studying these two papers, we can understand the impact of different design ideas and technical applications on wheelchair performance. These differences in design and technology can provide inspiration and references to help us better balance stability, flexibility and user experience when designing wheelchair aids. At the same time, it also reminds us that we need to choose the most suitable design scheme based on specific needs and use environment, and combine different technologies with design concepts to provide better mobile solutions.

Problems, challenges and importance:

Connecting problems between auxiliary equipment and wheelchair:
Challenge: Ensure that the connection between the auxiliary device and the wheelchair is secure, stable, and easy to install and remove.
Importance: Good connection can ensure the reliability of power and information transmission between auxiliary equipment and wheelchair, and improve the safety and performance of the whole system.

Auxiliary equipment power problems:
Challenge: Choose the right power system, such as electric drive or power device, and solve power supply, endurance, control problems.
Importance: The design of the power system directly affects the convenience and efficiency of the auxiliary equipment. Providing enough power can reduce the physical consumption of the elderly and increase the freedom and independence of movement.

Auxiliary equipment weight issues:
Challenge: Balancing the structural strength and weight of the auxiliary equipment and reducing the weight of the equipment itself for easier carrying, storage and operation.
Importance: The weight of the auxiliary equipment directly affects the use convenience and carrying ability of the elderly. Reducing the weight of the equipment can reduce the burden of users and improve their use experience.

Selection and innovation of auxiliary equipment wheels:
Challenge: Choose the right tire type and size to solve the anti-skid, anti-turbulence, adapt to different terrain problems. At the same time, through innovative design, improve the performance of tire materials, structure and shock absorption technology.
Importance: The wheel is a key component of the auxiliary equipment, which directly affects the handling, stability and driving comfort of the equipment. Optimizing the selection and design of the wheels helps to improve the performance and adaptability of the equipment in different road conditions.

Statement of the Goal

Our team wanted to design a new assistive device to solve the problem of wheelchair going upstairs and improve the comfort and versatility of elderly wheelchairs. This study will promote the quality of life of older people and promote the attention and resolution of aging problems, thus laying the foundation for a more friendly and inclusive society.

Project Plan

Main plan:

The main objective of this project is to design an assistive device that allows wheelchair users to safely and efficiently navigate stairs without compromising the wheelchair's normal functionality on flat ground.

To start building the device, we will follow a systematic approach that includes the following steps:

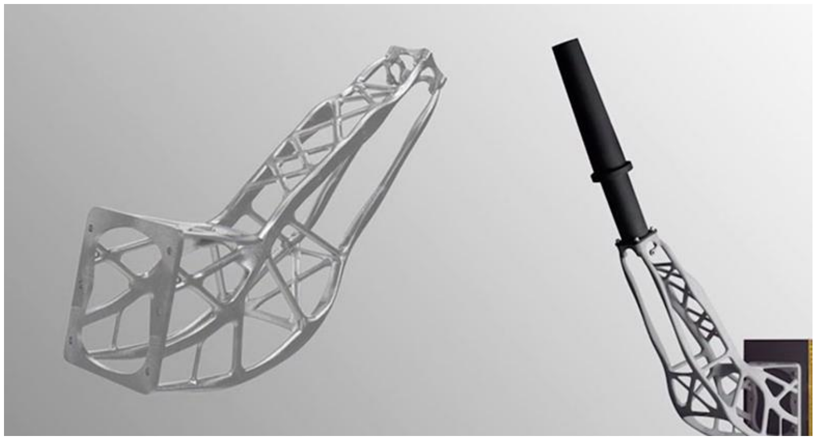
1. Research and Analysis:

- Gather information on existing assistive devices and technologies.
- Analyze the specific requirements and constraints of the project.
- Identify suitable design methodologies and principles.

2. Conceptualization and Design:

- Develop design concepts that integrate the S-shaped wheel mechanism for the front active wheel and the triangular wheel system for the rear. (Design of machine elements class)

- Use topology optimization techniques to optimize the device's performance and efficiency. (Scientific computing for mechanical engineering class)



- Design the power system, control system, and damping system, considering the project's requirements. (Dynamics & control of mechanical system class)

3. Prototyping and Testing:

- Build a small-scale prototype of the assistive device based on the finalized design.

- Conduct comprehensive functionality tests, including stair navigation and stability on flat ground.

- Use appropriate measurements, such as angles, forces, and motion tracking, to evaluate the device's performance.

To ensure the functionality of the device, we will carry out the following detailed validation steps:

a) Stair navigation testing:

- The device will be placed in front of stairs for stair navigation testing.

- The test will include evaluating the device's ability, stability, and safety while navigating stairs.

- We will use sensors to monitor the device's position and posture on the stairs and record relevant data to assess its performance.

b) Stability testing on flat ground:

- The device will be placed on flat ground for stability testing.

- The test will assess the device's stability and resistance to tilting on flat surfaces.

- We will use force sensors to measure the forces and pressure distribution on the device and evaluate its stability.

c) Functionality measurements:

- We will use angle measurements to assess the device's range of motion and posture control ability.

- Force sensors will be used to measure the forces applied by the device on the ground and handrails.

- A motion tracking system will record the device's movement trajectory and speed.

d) User feedback:

- We will invite wheelchair users to participate in the testing and gather their feedback and opinions.

- User feedback will help us evaluate the device's usability and user experience.

Through these detailed validation steps, we will be able to comprehensively assess the device's performance and make improvements and optimizations based on the test results.

Time plan:

Phase 1: Research and Concept Development (2 weeks)

- Conduct research on existing assistive devices and technologies for stair navigation.
- Brainstorm and develop initial concepts for the device.
- Identify key design requirements and constraints.

Phase 2: Preliminary Design (2 weeks)

- Create 2D and 3D CAD models of the device.
- Perform structural and stability analysis using simulation software.
- Optimize the device's design for weight and strength.

Phase 3: Detailed Design and Component Selection (3 weeks)

- Finalize the device's design, considering user feedback and optimization results.
- Select appropriate components, such as motors, sensors, and shock absorption systems.
- Conduct feasibility studies and cost analysis for the selected components.

Phase 4: Prototyping and Testing (4 weeks)

- Build a small-scale prototype of the device based on the finalized design.
- Conduct comprehensive functionality tests, including stair navigation and stability on flat ground.
- Use appropriate measurements, such as angles, forces, and motion tracking, to evaluate the device's performance.

Phase 5: Iterative Design and Optimization (3 weeks)

- Analyze the test results and user feedback to identify areas for improvement.
- Make necessary design modifications and optimizations to enhance the device's performance.

- Conduct additional testing and validation to ensure the effectiveness of the improvements.

Phase 6: Final Design and Documentation (2 weeks)

- Finalize the design based on the iterative improvements.

- Create detailed technical documentation, including drawings, specifications, and user manuals.

- Prepare a final project report summarizing the design process, testing results, and recommendations for future enhancements.

Resources and Budget:

- CAD software licenses for design and simulation.

- Prototyping materials and equipment.

- Testing equipment, including sensors and motion tracking systems.

- Budget for component selection and procurement.

Team Plan:

- Assign team members specific tasks based on their expertise and interests.

- Hold weekly meetings to review progress, discuss challenges, and make collective decisions.

- Maintain effective communication channels within the team to ensure smooth coordination.

Timeline (2-week intervals for 3 months):

Week 1-2: Research and Concept Development

Week 3-4: Preliminary Design

Week 5-6: Detailed Design and Component Selection

Week 7-10: Prototyping and Testing

Week 11-12: Iterative Design and Optimization

Week 13-14: Final Design and Documentation

Please note that the provided timeline and activities are a general outline. Adjustments may be necessary based on the complexity of the project and the availability of resources.