
Design and Development of Stair Climbing Robotic Wheelchair

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Abstract

This paper presents the design and implementation of a robotic wheelchair capable of navigating both flat surfaces and staircases. The robot uses a single front-mounted Infrared sensor for detection and navigation. It allows for manual control and can switch to automated stair-climbing mode with a user-controlled button. The algorithm positions the robot at the base of the stairs, raises its front section when the sensor no longer detects an obstacle, and then advances a set distance while continuously monitoring for additional steps. This design emphasizes simplicity and efficiency, offering a practical solution for stair navigation with minimal hardware. This chair increases the lifeline of special ability person who don't climb the stair. In social area special ability person easily access their daily routine by our stair climbing chair.

Keywords: *Wheelchair, Stairs, Autonomous Climbing, Industrial Project, Robotics, Automation & Robotics, IOT.*

PROBLEM STATEMENT

In India, about 20% of people with disabilities have movement-related impairments, affecting their ability to perform tasks or actions. Sadly, globally, 1 in 10 children has a disability, with many of them facing challenges accessing education, leading to a higher likelihood of not attending school compared to children without disabilities.

INTRODUCTION

The project focuses on the design and development of an innovative robotics wheelchair capable of navigating and climbing stairs. This solution aims to address the mobility

challenges faced by individuals with disabilities, providing them with a greater degree of independence and freedom.

The wheelchair is equipped with a unique combination of three wheeled sections, differential drive motors, and adjustable lift mechanisms that allow it to ascend and descend stairs. A key feature of this design is the use of an infrared (IR) sensor, strategically placed on the front of the wheelchair to detect stairs and initiate the climbing sequence. This sensor-driven approach minimizes the need for complex sensor arrays, focusing on simplicity and reliability.

The design also includes an adjustable center of gravity mechanism to ensure stability during stair climbing, making it safe and practical for real-world use. Through this development, the project seeks to provide a practical solution to a common accessibility challenge.

Central Problem of Disability Person with Legs and Backbone Problem is they are can't walk, and they suffering with very pain of backbone so this Disability Person are can't absorb this pain, Our Smart Wheelchair help to give relax able, sustainable, sitting position and movability of indoor and outdoor environment. Cerebral palsy, locomotor disability, Muscular Dystrophy people have to face many problems in life due to this ability. They cannot climb the stairs, the handicap person is completely dependent on others, that's why after research on this problem statement, wheelchair was found as a solution.

OBJECTIVES

- Validate Performance
- Optimize Mechanical Design
- Enhance Stair Navigation
- Ensure Stability

MATERIALS AND METHODOLOGY

The stair-climbing robotic wheelchair was developed using a variety of specialized materials and components to ensure robust performance and adaptability. The key materials used in the construction include.

- **Aluminum Extrusion Profiles**

4V slot aluminum extrusion profiles (800mm) were used for the structural framework, providing strength and lightweight support.

- **Ball Screws**

Two 1000mm ball screws were employed to facilitate the precise movement of the lifting mechanisms.

- **12VDCMotors**

Four motors were used for driving the wheels, providing the necessary torque and control.

- **Nema17 Stepper Motors**

Two Nema17 stepper motors were utilized for precise control of the raising mechanisms.

- **Mini V Wheels and Omni Wheels**

Mini V wheels with a 5mm bore and omni wheels were used to enhance maneuverability and ensure smooth transitions on different surfaces.

- **Arduino Uno**

Two Arduino Uno micro controllers were used for controlling the various components.

- **Motor Drivers**

A combination of DC motor drivers and A4988 step per motor drivers was used to manage the different motors.

- **Sensor**

Infrared sensors were employed to detect the proximity of the stairs and adjust the wheelchair's movements accordingly.

- **Battery**

A 12V battery provided the necessary power to drive the motors and electronics.

The design and development involve a systematic approach to creating a wheelchair that can autonomously climb stairs while still allowing the user to maintain control over general movement. The system's architecture is centered around an Arduino Uno microcontroller that manages eight motors: four for the drive wheels, two for lift screws, one for a sliding counterweight, and one for the rear section's movement. The wheelchair is equipped with a single infrared (IR) sensor mounted at the front to detect obstacles like stairs, allowing the system to trigger the stair-climbing sequence when necessary. Communication between the wheelchair and a custom-built remote control, which features a joystick for directional movement and buttons for stair-climbing activation, is handled through an nRF24L01 radio transceiver module.

The control software is developed using the Arduino IDE and includes algorithms for basic movement as well as an automated stair-climbing sequence. In manual mode, the user can move the wheelchair forward, backward, left, and right using the joystick. When approaching stairs, the user can initiate the automated sequence where the wheel chair first detects the step with the IR sensor. The front section then lifts until the sensor no longer detects the step, at which point the wheelchair drives forward onto the step. The rear section of the wheelchair then slides and lifts to follow, while a sliding counterweight adjusts to maintain balance. The sequence continues until all steps are climbed.

Safety mechanisms are integrated into the system, including an emergency stop function accessible via the remote control and feedback loops to monitor motor performance, preventing overload or jamming. The prototyping phase involves assembling the hardware components and loading the control program onto the Arduino for initial testing. Iterative testing refines the system's performance, adjusting motor speeds, sensor thresholds, and timing to ensure reliable operation under various conditions. User testing in real-world scenarios provides valuable feedback for further refinement, focusing on usability and safety.

The Arduino will be configured with the necessary operating system and libraries for IR sensor, stepper motor. To control and send, receive the signal from other components.

The IR sensor will be connected to the Arduino and configured for stair analyzing, stair detection.

The DC or Stepper motor will be movement as per the user requirement. Users send the signal to Arduino and Arduino control the motor as per requirement.

INNOVATION

- **Smart Adaptability**

Utilize Arduino microcontroller to enable real-time adjustment of mechanical linear actuators, stepper motors, and DC motors, allowing the wheelchair to dynamically adapt to various stair configurations.

- **Advanced Sensing**

IR sensor technology with Arduino for accurate detection of obstacles and terrain variations and navigation capabilities.

- **Customizable Configuration**

Design the wheelchair with modular components that can be easily reconfigured to accommodate different user preferences and mobility requirements.

RESULT AND DISCUSSION

The stair-climbing robotics wheelchair successfully demonstrated its ability to navigate stairs autonomously using an infrared (IR) sensor for step detection.

User tests showed the system was intuitive to control, with a responsive joystick interface. The wheelchair- maintained stability during stair climbing, aided by an adjustable center of gravity. However, the reliance on a single IR sensor occasionally led to detection issues, suggesting that additional or alternative sensors could improve performance.

Overall, the project successfully integrated autonomous stair-climbing capabilities with manual control, offering a valuable mobility solution. Further refinements, such as enhancing sensor accuracy and motor control, could lead to a more reliable and versatile assistive device.

Table no.1: Capacity

Sr. No	Material	Properties
1	Ultimate Tensile Strength	400-450MPa
2	Yield Strength	290-320Mpa
3	Elastic Module	70 Gpa
4	Poisson's Ration	0.33
5	Shear Strength	250 Mpa

FUTURE SCOPE

- **Enhanced Safety Features**

Future stair climbing wheelchairs may incorporate advanced safety features to prevent accidents and injuries. This might include real-time monitoring of vital signs, collision detection systems, and emergency response mechanisms.

- **Technological Innovations**

Continued advancements in robotics, sensors, and materials science could lead to more efficient and user-friendly stair climbing wheelchairs. This might include features such as better stability control, smoother transitions between terrains, and improved battery life.

- **Integrated Sensor Technology**

Integration of advanced sensor technology, including LiDAR, radar, and depth sensors, could enable stair climbing wheelchairs to perceive their surroundings more accurately. This enhanced perception could facilitate smoother navigation and better obstacle avoidance capabilities.

- **Smart Monitoring System**

We will design the smart monitoring wheelchair. The patients' blood pressure, heart rate measurement, patient's medicine schedule set on the screen, all this function we will implement.

- **Compact and Light Weight Design**

Continued advancements in materials science and engineering could lead to the development of stair climbing wheelchairs that are lighter and more compact without compromising durability or performance. This would improve maneuverability and ease of transport, particularly in tight spaces.

- **Speed Control Algorithm Development**

An algorithm will be developed to calculate the desired speed for the stair climbing wheelchair a pre-defined safe following distance threshold. This algorithm may involve incorporating reaction time considerations into the safe following distance calculation.

- **System Logic and Decision Making**

The system will prioritize the information from the machine learning model for stair detection and distance estimation. The IR sensor data will be used as a input, The system will use a pre- defined decision logic to determine the most reliable distance information based on sensor data quality and potential discrepancies.

LIMITATIONS

- The cost of the wheelchair is more expensive. The componts of the chair are much expensive, so chair cost is high.
- The system architecture is more complicated, the main up/down mechanism required more accurately accuracy.
- While they excel at climbing standard indoor stairs, stair climbing wheelchairs may struggle with uneven or outdoor terrain. Gravel paths, steep inclines, or rough surfaces can pose challenges.
- There's always a risk of accidents, especially during the transition from one surface to another. Users must ensure they are properly secured in the wheelchair and follow safety guidelines closely

RESULT



Figure no.1: Stair Climbing Wheel Chair

CONCLUSION

This paper presented the design, development, and implementation of a stair-climbing robotic wheelchair. The proposed system effectively combines mechanical, electrical, and software components to achieve autonomous stair climbing capabilities. Future work will focus on enhancing obstacle avoidance, increasing payload capacity, and improving energy efficiency.

However, there are also considerations to keep in mind. While stair climbing wheelchairs offer a solution to vertical mobility challenges, they may not be suitable for all environments or users. Factors such as stair design, space constraints, and user comfort must be considered.

Additionally, there may be limitations in terms of weight capacity, battery life, and maintenance requirements that users and caregivers need to consider.

Overall, stair climbing wheelchairs represent a promising advancement in assistive technology, but their effectiveness and suitability depend on various factors. Further research and development are needed to address existing limitations and optimize their functionality for broader.

The conclusion regarding stair climbing wheelchairs is multifaceted. These innovative mobility aids offer significant benefits in terms of accessibility and independence for individuals with mobility impairments.

They enable users to navigate environments that were previously inaccessible, such as buildings without ramps or elevators. Stair climbing wheelchairs can enhance users' quality of life by providing greater freedom. Our stair climbing robotics chair new innovation of India to help the people to access their daily life easily.

REFERENCES

1. Grand View Research: Personal mobility devices market size, share, and trends analysis report by product (Walking Aids, Wheelchairs, Scooters), By Region (Europe, APAC, North America, MEA), And Segment Forecasts, 2021–2028. Technical report, San Francisco (2021).
2. Belcher, M.J.H., Frank, A.O.: Survey of the use of transport by recipients of a regional Electric Indoor/Outdoor Powered (EPIOC) wheelchair service. *Disability and Rehabilitation*, 563–575 (2004). <https://doi.org/10.1080/09638280410001684055>.
3. Ferreira, A.F., Leite, A.D., Pereira, L.d.F., Neves, J.M.d.J., de Oliveira Pinheiro, M.G., Chang, S.K.J.: Wheelchair accessibility of urban rail systems: Some preliminary findings of a global overview. *IATSSdf Research* (2021). <https://doi.org/10.1016/j.iatssr.2021.01.003>.
4. "Stair Climbing Mechanical Wheelchair" by Prof. V. V. Ahire, Mr. Chinmay Vyavahare, and Ms. Ankita Pawar (2021): This study presents a mechanical wheelchair designed with a stair-climbing wheel arrangement, aiming to ease mobility challenges for disabled individuals. The design considers standard stair dimensions in India and focuses on creating a user-friendly and repairable wheelchair suitable for rural areas.
5. "An Optimization Design for the Stair-Climbing Wheelchair" (2012): This research introduces a stair-climbing wheelchair featuring a compact structure capable of

navigating flat terrains, inclines, stairs, and obstacles. The design utilizes software modeling and simulation to ensure structural integrity and functionality.

6. "Design and Prototype a Stair-Climbing Wheelchair" (2023): This article proposes two innovative designs to enable stair-climbing capabilities in motorized wheelchairs. The designs aim to improve daily life for individuals with disabilities and provide solutions for emergency evacuations requiring immediate building exit.