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Smart Stair-Climbing Wheelchair using Tri-Wheel Mechanism for Disabled and Elderly

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Abstract: *The proposed system consists of a wheel chair with benefits and modification to facilitate climbing of stairs through its special designed features. The project aims at developing an automatic Stair-Climbing Wheelchair, a mechanism for climbing up and down over stairs for physically disabled and elderly people. It include many features to maximize comfort, ease of use and attractiveness in the home, which is a safe and affordable solution to overcome the needs and challenges that people experience on the stairs.*

A unique mechanism for climbing stairs, used here is a tri-wheel mechanism, due to its simplicity and ease of design. The tri-wheel mechanism can be easily fabricated, thereby reducing the total cost of fabrication of wheelchair. The tri-wheel mechanism for stair-climbing wheelchair makes it easy to climb up and down on stairs. The smart wheelchair is designed to assist disabled and elderly people leading to a higher quality, more independent lifestyle.

Keywords: *Smart Wheelchair, Tri-Wheel Mechanism, Stair Climbing Wheel Chair, Stair Lift*

I. INTRODUCTION

Number of people, all over the world suffers from mobility problems. The causes of the problem may be old age, injury, weakness in the legs, loss of balance, poor eyesight, physical or mental disability of people. The people with physical disability not only have less living space, but also the quality of life is seriously affected. It becomes difficult for them to perform the day-to-day chores smoothly and effortlessly. Living a normal life becomes a challenge.

People, who live in houses with more than one storey, are unable to use the stairs making it difficult or even dangerous. The only possible solution in front of them is to use wheel chairs. Wheelchair is a device used by disabled people to improve their personal mobility. But, in the outside world lack of even surface or the surfaces with digs or holes makes the matter worst. Travelling on public transit becomes difficult.

There exists few models such as escalators and elevators, used to go up and down the stairs but these, are not explicitly for the physically handicapped. For an instance, a physically handicapped cannot use the escalator the only option available to him/her is the use of the elevator. There also exist scenarios where both elevators and escalators cannot be used due to limitations in architecture.

From many centuries several evolutions had happened in many fields. Even in the case of wheel Chairs many evolutions took place from comfortable wheel chair to electronic wheel chair. An automatic Stair-climbing wheelchair can be a good solution for the user and can enhance the mobility to access most of the buildings. In this study we have attempted to design a stair climbing Wheelchair concept which can address the problem faced by wheelchair users.

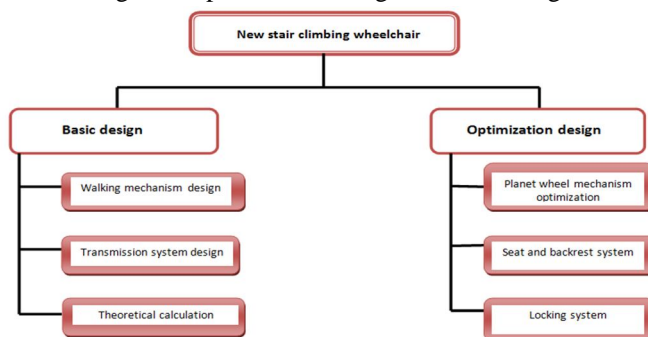
This work is mainly based on disadvantages of existing stair-climbing wheelchair and to overcome this with the help of tri-wheel mechanism. The tri-wheel mechanism is optimized and added to a wheelchair. The tri-wheel mechanism also prevents the wheelchair to climb easily up and down stairs and also to move freely in bump holes, etc. It improves the security and comfort of the wheelchair.

This device improves the security and comfort of the wheelchair and can also prevent the wheelchair from overturning backward. Locking system is added which locks the wheelchair while climbing up and down stairs, making sure it can only move in one direction, and protect the wheelchair from slipping down.

A smart wheelchair can make climbing of stairs for aged and physically handicapped a pleasant affair. Advancement in technologies help disabled people to lead an independent lifestyle and play a more productive role in society. Stair-climbing wheelchair plays an important role in the life of disabled and elderly people.

II. METHODOLOGY

The methodology section outline the plan and method that how the study is conducted. There are two main parts in this chapter which are basic stair-climbing wheelchair design and optimization design. And the design framework is given below



A. Walking Mechanism Design

The walking mechanism is a very important part of the stair-climbing wheelchair; it directly impacts on the stability, safety and comfort of the wheelchair, so all kinds of factors must be considered to choose the walking mechanism. According to the analysis about the advantages and disadvantages between different types of climbing wheelchairs, the following concepts were observed Planetary wheel mechanism has a great advantages among the stair-climbing wheelchairs ,which not only has a simple and compact structure, flexible movement, good stability, small fluctuation range of gravity centre, but also combines the advantages of moving on the ground and climbing stairs. Therefore planetary wheel mechanism is chosen as the walking mechanism in our design.

B. Planetary wheel mechanism

The planetary wheel mechanism is constituted by several small wheels that are equally distributed on a tie bar with shapes like “Y” or “+”. The small wheels can revolve on its axis, and it can also make a revolution around the central shaft. Every small wheel revolves on its own axis, when the wheelchair moves on the ground; and every small wheel revolves round the central axis, when the wheelchair goes up or down stairs. The wheelchair moves by means of a Geared Dc motor.. Here, planetary wheels refers to tri wheel mechanism.

C. Obstacle Detector

It is very essential to have an obstacle detector sensor for wheelchair because it shall help the physically handicapped people or senior citizens using this wheelchair to travel independently because an obstacle detector shall ensure safety during the travel time

D. Proposed Mechanism

The proposed mechanism’s operation in barrier free environments, that is relatively flat areas, is based on the use of 2 wheels much the same as a standard powered wheelchair. The front wheels are independently powered and the rear wheels are free-wheeling casters. By independently controlling the front wheels steering is achieved .The wheels used in barrier free mode are 2 wheels of a 3 wheel cluster. By rotating the wheel cluster stairs can be negotiated regarding cluster based operation..For providing heating and cooling therapy, Peltier element is used. This device has two sides, and when a DC electric current flows through the device, it brings heat from one side to the other, so that one side gets cooler while the other side gets cooler while the other gets hotter.

III. DESIGN PROCESS

A. Planetary Wheels System Optimization

Ordinary planetary wheel structure is when the central shaft drives the central gear; the central gear will drive the planetary gear and the planetary wheels to make the wheelchair go forward. When the wheelchair climbs stairs, the planet wheel is locked by the resistance; the whole planetary structure is derived by the central shaft rolling and completes the process of climbing. In this case, planetary gears will bear great torque and impact and will break easily. One idea is got from the car clutch, which is used to control the engine and the wheels transmission separation and combination. Depress the clutch,driving device of the engine is disconnected from the wheels, the power of the engine cannot pass to the wheels; release the clutch, the engine driving device is connected with the wheels, the power of the engine can then pass to the wheels.

B. Seat Backrest System

Most wheelchairs are oblique during the process of climbing up and down stairs, the user will feel uncomfortable, it can easily turnover, which poses a big safety risk. In order to overcome this problem, a seat backrest adjusting device is designed for our wheelchair, so before the wheelchair climbs up and down stairs, this device will adjust an angle for the seat and backrest to make sure the seat of the wheelchair keeps level with the ground all the time. It consists of a round handle (5), helical gear shaft (4), helical gear shaft (8) and the worm and gear mechanism (7), (10) as shown in fig. The working principle for the seat and backrest system is: the user through the handle controls the helical gear shaft rotation, helical gear shaft will transfer torque to helical gear and drives the worm rotation, finally the worm transfer torque to the main shaft, and makes the seat backrest system adjust to any angle.

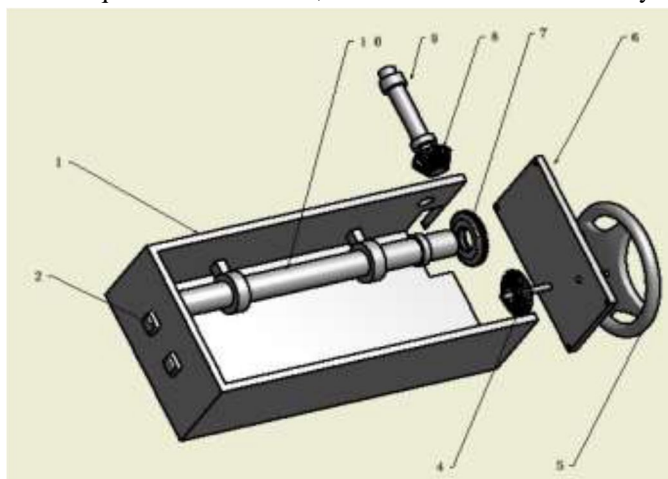


Fig -3.1: Seat backrest System

C. Locking System Design

When the stair-climbing wheelchair climbs stairs, there is danger of falling down the stairs, in order to protect the user and avoid this kind of situation to happen we installed a ratchet mechanism locking system on the central axis. When the wheelchair goes up and down stairs, people can screw the handle to lock the wheelchair and thus prevent the wheelchair from slipping down stairs.

D. Battery and Motor Selection

The batteries can be roughly divided into physical and chemical batteries. Moreover, batteries of a chemical type which can be repeatedly charged are called rechargeable batteries. There are various types of rechargeable batteries: lead-acid battery used for automobiles, nickel cadmium rechargeable battery called a small rechargeable battery, nickel metal hydride battery, lithium ion rechargeable battery, etc. lead acid battery has been chosen because of the following reasons:

- 1) Lead-acid battery has the advantage of long service life, low price, and can store a large current discharge.
- 2) It has a small volume and light weight.
- 3) The selected motor needs 24V storage battery.

Robotic motor (reverse forward motor) is used. The motor is primarily used as the engine when the wheelchair moving on the ground or climbing up and down stairs, so the rated power should be much higher.

Current	Voltage	Power	Load
13.7A	24V	0.5HP	150kg

Table -1: Specifications

E. Tri Wheel

The tri-star is a novel wheel design originally by Lockheed in 1967 in which three wheels are arranged in an upright triangle with two on the ground and one above them, as shown in Figure 1. If either of the wheels in contact with the ground gets stuck, the whole system rotates over the obstruction. A Tri-Star wheel consists of a three spoked wheel, with 3 leaf wheels on the end of the each spoke, all powered. This means, at rest, each Tri-Star wheel is likely to have two leaf wheels in contact with the ground. On the flat ground, the leaf wheels will simply turn, and give simple and relatively efficient grip.



Fig -3.2: Tri wheel

1) *Tri Wheel Working Mechanism:* Tri-wheel function is same as the lever. It climbs stairs due to the rolling action of wheels.

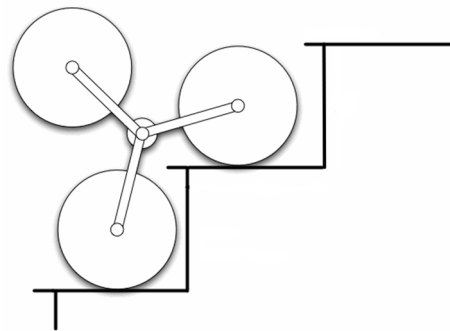


Fig -3.3: Tri-Wheel Working Mechanism on stairs

The design of wheel is simple. It consists of three wheels, each wheel in mount shafts are mounted in the form of vertices. These set of wheels can negotiate different types of surfaces like surface with sand and mud. It allows to travel over obstructions like rocks, holes, in rolling action and the third wheel remains idle. When an obstruction occurs, the lower front wheel will stop moving forward, but the driving axle remains in motion and the top wheel will now come into action as a wheel usually lands on top of obstruction and rest of assembly will move over the obstruction. The same process repeats until the required destination is reached.

In our work, we have replaced normal wheels with tri wheel for comfortable movement and to overcome obstacles like holes, bumps and stairs on the way.

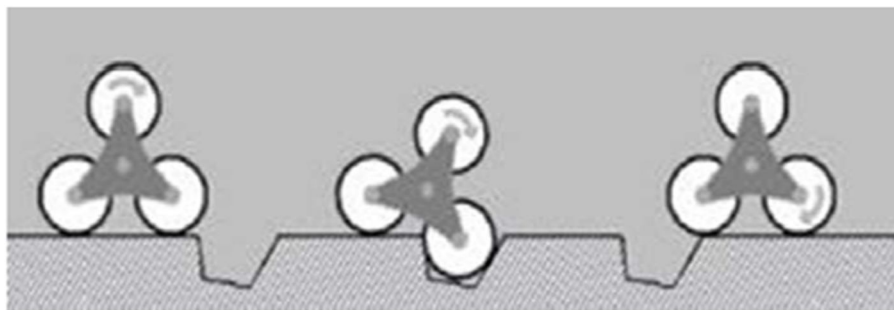


Fig -3.4: Tri-Wheel Working Mechanism on uneven surface.

IV. CONCLUSIONS

In this project we have designed a new kind of stair-climbing wheelchair, which has compact structure, can cope with flat or inclined terrain, stairs and obstacles. This paper presents a summary of current state-of-the-art smart wheelchairs and a new designing approach to create a sustainable wheelchair that is both affordable and durable. An obstacle detector is also added to ensure safety while using the wheelchair and making the use of wheelchair safe and secure for physically handicapped people and senior citizens. There is still a scope of future modifications like adding up a system of voice commands to control the movement of wheelchair, adding a tracking mechanism on wheelchair to track the person using it in case of any emergency or health related issues.



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