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 the benefits and modification to facilitate climbing of stairs through its special designed features. The purpose of this work aims at developing an automatic Stair-Climbing Wheelchair, a mechanism for climbing upstairs and down stairs for physically disabled people. A Stair-Climbing Wheelchair is a chair that moves upstairs and downstairs. It has speciality to maximize comfort, ease the usage and attractiveness in the home, which is a safe and affordable solution to conquer the challenges that disabled 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 move up and down on stairs. The smart wheelchair is designed to assist disabled and elderly people leading to a higher quality, more independent lifestyle.

***IndexTerms* – smart wheelchair, tri-wheel mechanism, stair climbing wheel chair, stair lift.**

I. INTRODUCTION

Infrastructure becomes the need of the hour in any country or region of the world owing to all the difficulties physically disabled people and senior citizens face every day of their life due to lack of infrastructure and special arrangements at public places as well as in homes. This scenario can be changed by having proper facilities or an optimized solution can be to use technology to overcome this problem. The proposed work presents an approach to bring in modification in the design of wheelchairs which is the most used equipment among all. A lot of technologies have been launched at present which are extremely helpful for people but the biggest drawback of it is its cost. Majority of the equipments like exo-skeleton and robotic based prosthetics are not accessible to all as it is very expensive although reliable. This smart wheel chair design uses a special tri-wheel mechanism based on a simple principle that when the wheel chair is used for climbing stairs it has one wheel of tri-wheel at one stair while other two become the support mechanism and make an angle towards the next stair and the process goes on repeating till the stairs are completed.

This device can also prevent the wheelchair from overturning backward, and improve the security and comfort of the wheelchair. Locking system is an essential system provided as an anti-slip mechanism. This mechanism brings in another advantage of security to the one's using it. There are times when there is no facility of using lifts or escalators or ramp arrangements which bring in the need to use this smart wheel chair in a more widespread use among the ones who need it. The modifications needed in the plain wheel chair system would be Advancement of wheelchair(i.e. removal of wheels and addition of new system)

- Designing of track and its installation.
- Fitting of chair on the track.
- Final analysis of stair lift.

II. DESIGN PROCESS

2.1 Walking mechanism design

The wheel-chair has to be designed in a manner such that it can move on a plain ground as well as can move upwards and downwards. An analysis is undertaken to study the advantages and disadvantages between different stair-climbing wheelchairs ,which has a simple and compact structure, flexible movement, good stability, small fluctuation range of gravity centre. Planetary wheel mechanism is chosen owing to its stated advantages.

2.2 Planetary wheel mechanism for stair-climbing wheelchair

The planetary wheel mechanism is constitute of several small wheels that are equally distributed on a tie bar with shapes like "Y" or "+". These small wheels rotate on its axis and can make a revolution around the central shaft. when the wheelchair moves on the ground every small wheel rotates on its own axis and every small wheel revolves round the central axis. The wheelchair moves by means of a Geared Dc motor. The planetary wheels refers to tri-wheel mechanism. In an ordinary planetary wheel structure the central shaft drives the central gear. The central gear will drive the planetary gear and planetary wheels to make the wheelchair move forward. While climbing stairs, planet wheel in the wheelchair is locked by resistance. The whole planetary structure is derived by the central shaft rolling and completes the process of climbing. In this system, the planetary gears will have to bear a great torque and impact and will break down easily.

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2.3 Proposed Mechanism

The project emphasizes its operation in hurdle 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 hotter.

III. METHODOLOGY

This section outlines the plan and methods of the study that was conducted. There are two important parts in this section which includes basic stair-climbing wheelchair design and optimized design. The design framework is given below:

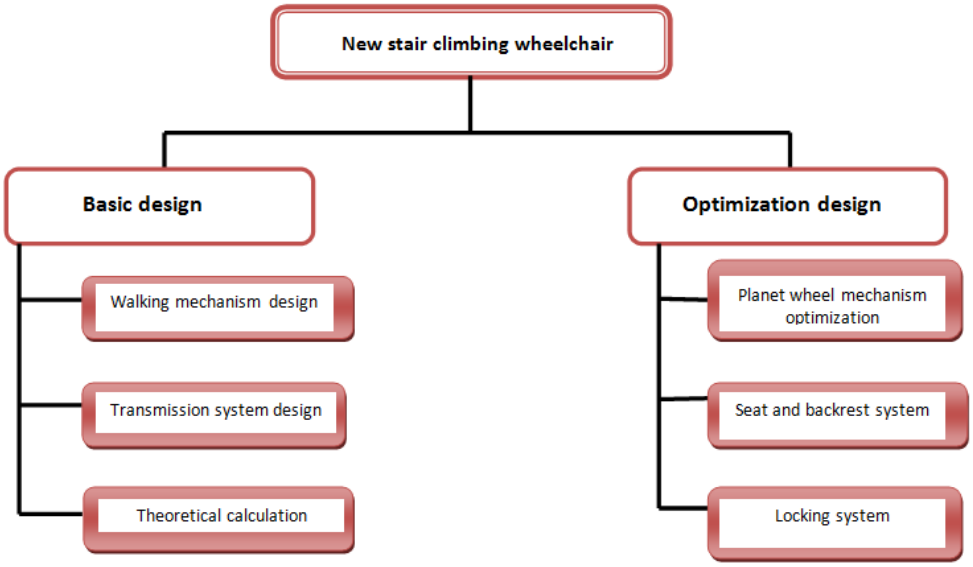

Fig 2.1. Methodology

3.1 PLANETARY WHEELS SYSTEM OPTIMIZATION

An ordinary planetary wheel structure consists of a central shaft drives the central gear. The central gear drives the planetary gear and planetary wheels to make the wheelchair move forward. While climbing stairs, planet wheel in the wheelchair is locked by resistance. The whole planetary structure is derived by the central shaft rolling and completes the process of climbing. In this system, the planetary gears will have to bear a great torque and impact and will break down easily.

3.2 SEAT BACKREST SYSTEM

4 The wheelchairs are inclined during the process of climbing upstairs and downstairs. The user may feel uncomfortable. Also, the chair in oblique position can easily turnover, which poses a big safety risk. In order to overcome this problem, a seat backrest adjusting device is designed for wheelchair. Before the wheelchair climbs up and down stairs, Seat Backrest System will adjust an angle to make sure that seat of the wheelchair keeps up level with the ground all the time.

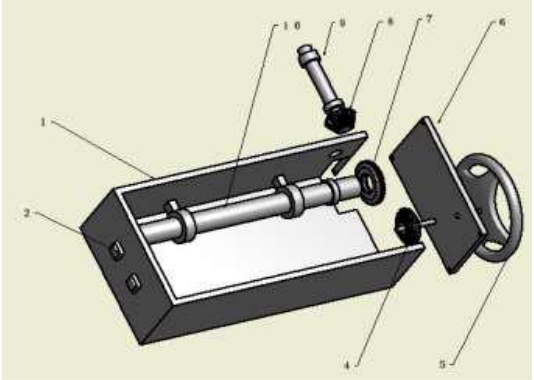

Fig. Seat Backrest System

It consists of a round handle , helical gear shaft , helical gear shaft and the worm and gear mechanism. The working principle for the seat and backrest system is that: the user controls the rotation of helical gear shaft with the handle, helical gear shaft will transfer torque to helical gear thereby driving the worm rotation. Finally the worm transfer torque to the main shaft making the seat backrest system adjustable to any angle.

3.3 Locking system design

When the stair-climbing wheelchair moves up the stairs, there is danger of falling down the stairs. Hence 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 moves up and down stairs, people can screw the handle to lock the wheelchair. This prevents the wheelchair from slipping down the stairs.

3.4 Storage battery selection

The batteries are usually available in two kinds: physical and chemical batteries. The chemical batteries could be repeatedly charged and hence are called as rechargeable batteries. Typical examples of rechargeable batteries are: 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:

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

3.5 Tri wheel

The tri-star is a novel wheel design originally by Lockheedin 1967[9] 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[10]. A Tri-Star wheel consists of a three spoked wheel and three leaf wheels. The three leaf wheels attached on the end of each of the spoke wheels. All these wheels are powered, which imply that, at rest, each Tri-Star wheel will have exactly two leaf wheels in contact with the ground surface. On the flat surface, the leaf wheels will simply turn giving a smooth and relatively efficient grip to the wheelchair and thus design is an efficient one comparing it to all other designs which are available

Fig. 3.1. Tri wheel

3.6 Tri wheel working mechanism

The tri-wheel function will be same as l the lever it climbs stairs due to the rolling action of wheels.

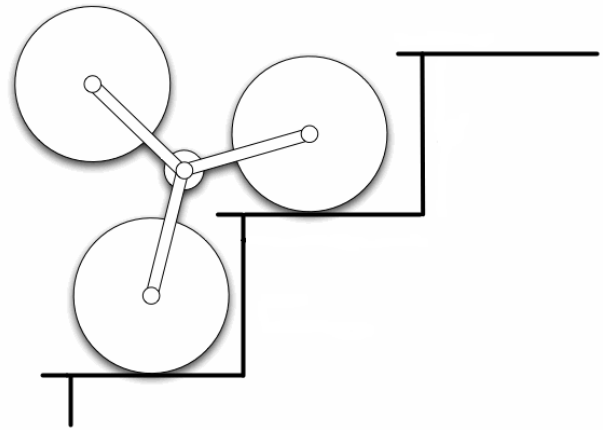

Fig. 3.2. Tri-Wheel Working Mechanism

This wheel design is very simple one and it consists of three wheels, each wheel in mount shafts are mounted the almost like vertices of the fashion. These set of wheels can handle problems related to different types of surfaces like surface with sand and mud. It allows traveling over obstructions like rocks, holes, in rolling action and the third wheel remains idle. When any hurdle comes in the way , the lower front wheel will stop moving forward but the driving axle remains in motion and the top wheel comes into action as a wheel usually lands on top of obstruction and rest of assembly will move over the obstacle. The same process repeats until the required destination is reached.

IV. CONCLUSION

In our work, we designed a novel stair-climbing wheelchair that can help to overcome problems related to uneven or inclined terrain, stairs and obstacles. All parts of the wheelchair are designed in AutoCAD. There is no perfect system that makes physical disabled people fully independent. Various control system could be used to control and cope with different type of physical disabilities. This paper serves a summary of current state-of-the-art smart wheelchairs. Various technologies are available which are used to operate and control the wheel mechanism of wheelchair. This information is gathered to publicize status of existing types of smart powered wheelchair so that the improvement can be incorporated into it.

V. FUTURE WORK

We consider that there are some improvements that need to be done in the future, for example:

i. Make a prototype and perform experimental tests on it. Then find new parts which need to be modified and improve.
ii. Move up stairs and downstairs without any assistance.
iii. Develop the intelligent control making it more automated.
iv. Extra wheels are to be added for turning of wheelchair.
v. Sensor could be used to control adjusting angle for the seat and backrest system instead of manual control.
vi. Voice command system can be added for control mechanism.

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