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Stair Climbing Wheel Chair

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Abstract: A concept for a stair climbing wheel chair capable of moving in structured and unstructured environments, climbing over obstacles and going up and down stairs. The design of the wheelchair consisting of a frame, a seat and a six DC geared motor linkage mechanism that connects frame and seat. The six DC geared motor linkage moves and rotates the belt, the wheel chair from overturning and to guarantee a comfortable posture to the passenger during different operations. When the wheelchair faces an obstacle such as a step or a stair, it can passively change locomotion mode, from rolling on wheels.

Keywords: Battery, Belt, DC geared motor, Four relay receivers, Wheels

1. Introduction

A civilized society must guarantee fair living conditions for all its members, including physically challenged people. Over the past few years, changing attitudes have made society more sensitive to this issue. Mobility is the most frequent problem for physically challenged people, a problem that the introduction of power wheelchairs has done much to alleviate. However, a power wheelchair is useless when confronted with an architectural barrier.

Wheelchair is a device used by physically challenged people to enhance their personal mobility. For this reason, several wheelchairs with stair climbing ability have been developed. Some of them use tracks, as in these power wheelchairs consume a great deal of energy, compared to power wheelchairs. In addition, they are heavy, approaching and leaving stairs are quite dangerous and slippage, when steering, is unavoidable. Some other solutions adopt a wheel-track locomotion system, as in or in the top chair these designs use a track system only for off road and stair climbing operations, using wheels on ground. Though approaching and leaving continue to be a problem, these wheelchairs are more efficient than previous solutions, in terms of energy consumption. Other solutions, such as the iBot adopt a hybrid locomotion system whose major drawback is the excessive cost required to achieve reasonable safety standards. A more highly evolved device, presented in uses a specific climbing mechanism for step climbing operations and wheels for on-road motion: this solution is lighter than wheel-track wheelchairs and has no problems in approaching and leaving stairs, but still requires many actuators. At present, no commercial device has conquered the market and climbing over barriers continues to be a major problem for the disabled.

There are many types of wheelchairs available in the market like manual or powered wheelchair and the choice of wheelchair depends upon the physical and mental ability of the user. Wheelchair has limitations against architectural barriers on its way. Although as per PWD 1995 act it is mandatory to provide an accessible environment in every public building but numerous buildings in India are designed without considering accessibility for physically challenged and wheel chair users. Many urban cities of India have addressed the problem by providing alternatives for the architectural barriers like providing ramps at the entrance thresholds, lowering curbs, wheeler chair ramps lift etc., but still a wheelchair user must negotiate few architectural barriers. In this study the author have attempted to design a stair climbing Wheelchair concept which can address the problem faced by wheelchair users.

The people with physical disability not only have less living space, but also the quality of life is seriously affected and it also brings big burden to their family. Wheelchair as a means of transport tool plays an important role in the life of those people who are old and disabled. With the society paying more attention to the benefits of elderly and disabled people, barrier free facilities as well as the elevator has been widely popularized, common wheelchairs can easily access many places, but when the user face stairs which often poses as obstacles, people can only step back, even though with the assistance from others, it is still very difficult to overcome these obstacles, which is inconvenient for those people who use wheelchairs.

2. Literature survey

Giuseppe et al. [1], describes the motorized wheelchairs dates back in time with several scientists and researchers evaluating the stair climbing mechanism. This paper evaluates different stair climbing mechanisms viz crawler type, leg type, hybrid type and wheeled type. Various forces and torques acting on the wheelchair

while climbing the stairs are evaluated. Preferably the outer support assembly comprises wheels on either side of the chair. An inner support assembly, closer to the center line of the chair, also supports the seat assembly.

Murray and Takakazu [2], the rear wheels are autonomously driven and front wheels are freewheeling castors. This proposed concept is numerically modeled and power calculations for linear actuator are made. Stair ascent and stair descent operations are described along with figures and equations. The control system and the stair edge sensor system are also investigated. The stepping algorithm is discussed in detail. The influence of external factors like cost, weight, aesthetics, range of operation, safety, operational efficiency, comfort is evaluated.

Simpson et al. [3], presented that, the stairs will most likely always be a reality in the real world, because of the high level of spatial efficiency they provide when connecting areas of differing vertical elevations. Stairs do present an increased degree of danger compared to such as gentle slopes but this must to some degree by necessity be simply considered. For example, in the planning of any new buildings the target users should be considered. Clearly for public amenities, such as wheelchair users should be considered, but for example in the case of say a private home in Japan where land space is at a premium (more specifically very expensive) multilevel construction is unavoidable and stairs will most likely continue to be used. A compromise situation in the case of families caring for aging parents is often providing all the essential amenities at ground level (barrier free) and using the upper levels for the younger families' respective bedrooms etc.

Morales R et al. [4], describes the mechanical devices, the movements and the trajectory generation of a novel wheelchair prototype capable of climbing staircases. The key features of the design are the use of two decoupled mechanisms for each axle, one used to negotiate steps, and the other position the axle with respect to the chair to accommodate the overall slope. This decoupling makes many different climbing strategies possible, the overall mechanism becoming extraordinarily versatile from a control point of view. A control system is necessary to synchronize the movements of all the actuators of the wheelchair so that its center of mass can follow arbitrary spatial trajectories.

3. Working principle

This project designed and built robots capable of moving on and off road in structured and unstructured environments, going up and down stairs and climbing over obstacles. The moving unit is implemented, has now been adapted to the stair climbing wheelchair, thus providing an effective alternative to existing solutions that can improve physically challenged mobility, as described in the paper presents an evolved version of motorized wheelchair with climbing ability. It investigates a linkage mechanism, and provides a description of the moving unit and the various kinds of movements.

The whole component of the wheel chairs is fabricated using mild steel material due to its high strength and low cost. The components used are wheel arrangement, frame of the chair, mini wheels and fasteners. For the frame of the wheel chair have been used mild steel and for wheel arrangement rollers are used in wheel chair. The mini wheels are of rubber, where the person concerned can easily get the chair facilitates his movement, and reach to any place he wants. We searched for treatment of his problem at least equipment, efforts and costs. And we hope that this project can be implementing on the ground successfully to provide humanitarian service for people with special needs bear the whole load of the person sitting in the chair and the turning wheels are made of plastic material. Here the whole component is run by battery and it is charged by electric supply. . The block diagram of stairs climbing wheel chair is shown in Fig.1.

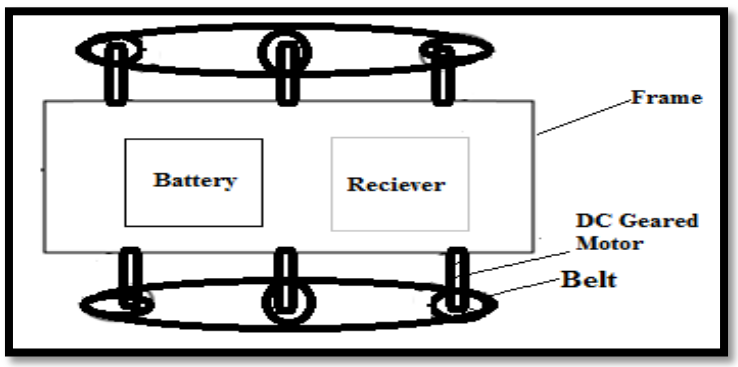

Fig. 1 block diagram of stairs climbing wheel Chair

The movement of the wheel chair is fully based on remote which is controlled by four relay modules and it is connected to battery as well as geared dc motor. When motor is rotating by controlling the remote which motion is necessary to move neither forward nor back ward movement

The main components used in wheel chair are listed below.

- Geared dc motor
- Battery
- Belt
- Wheels
- Controller
- Mild steel frames and rod

3.1 Geared dc motor

Geared dc motors can be defined as an extension of dc motor. A geared dc Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as rpm. The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reduction. This will explore all the minor and major details that make the gear head and hence the working of geared dc motor.

3.1.1 External structure

At the first sight, the external structure of a dc geared motor looks as a straight expansion over the simple dc ones. Fig. 2 shows the external structure of dc geared motor.

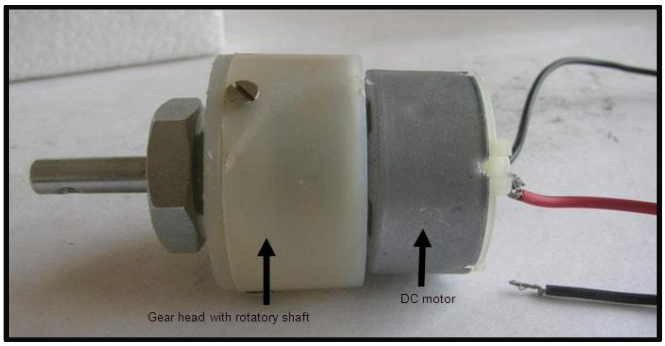

Fig. 2 external structure of geared dc motor

The lateral view of the motor shows the outer protrudes of the gear head as shown in Fig. 2. A nut is placed near the shaft which helps in mounting the motor to the other parts of the assembly.

3.1.2 Internal structure

On opening the outer plastic casing of the gear head, gear assemblies on the top as well as on bottom part of the gear head are visible. These gear assemblies are highly lubricated with grease to avoid any sort of wear and tear due to frictional forces. Fig. 3 shown below is the top part of the gear head. It is connected to rotating shaft and has one gear that allows the rotation. A strong circular imprint shows the presence of the gear that rotates the gear at the upper portion.

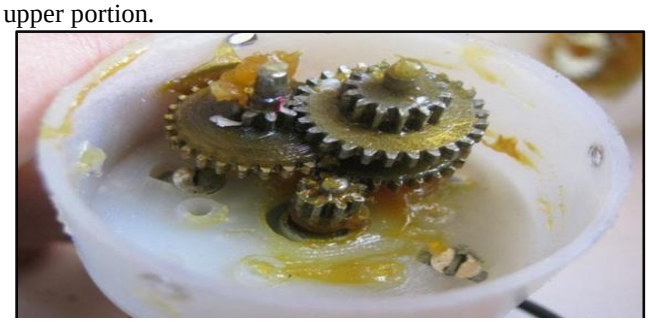

Fig. 3 internal structure of geared dc motor

3.1.3 Working of the geared dc motor

The geared dc motor as shown in Fig. 4 is works over a fair range of voltage. The higher the input voltage more is the rpm (rotations per minute) of the motor. For example, if the motor works in the range of 6-12V, it will have the least rpm at 6V and maximum at 12 V.

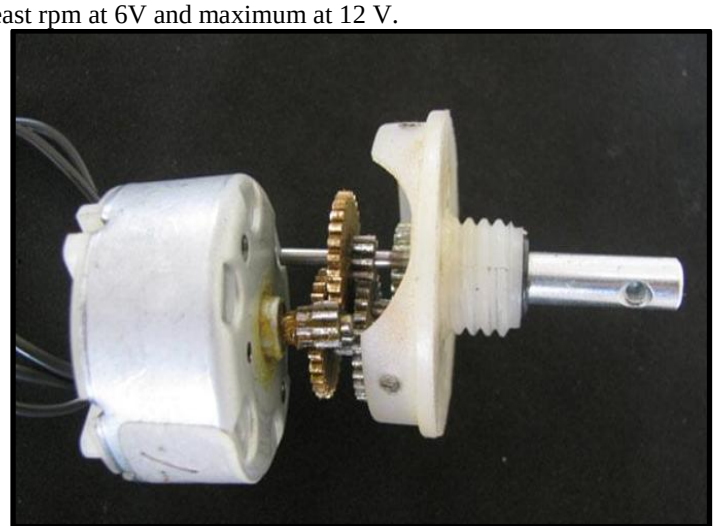

Fig. 4 geared dc motor

The working of the gears is very interesting to know. It can be explained by the principle of conservation of angular momentum. The gear having smaller radius will cover more rpm than the one with larger radius. However, the larger gear will give more torque to the smaller gear than vice versa. The comparison of angular velocity between input gear (the one that transfers energy) to output gear gives the gear ratio. When multiple gears are connected, conservation of energy is also followed. The direction in which the other gear rotates is always the opposite of the gear adjacent to it. In any dc motor, rpm and torque are inversely proportional. Hence the gear having more torque will provide a lesser rpm and converse. In a geared dc motor, the concept of pulse width modulation is applied. In a geared dc motor, the gear connecting the motor and the gear head is quite small, hence it transfers more speed to the larger teeth part of the gear head and makes it rotate. The larger part of the gear further turns the smaller duplex part. The small duplex part receives the torque but not the speed from its predecessor which it transfers to larger part of other gear and so on. The third gear's duplex part has more teeth than others and hence it transfers more torque to the gear that is connected to the shaft**.**

3.1.4 Specification of geared dc motor

- 30rpm 12V dc motors with Gearbox
- 4mm shaft diameter with internal hole
- 125gm weight
- Same size motor available in various rpm
- 2kgcm torque
- No-load current = 60 mA(Max), Load current = 300 mA(Max)

3.2 Battery

The batteries in which a reversible reaction is responsible for the generation of electricity such that they can be reverted to the original reactant state fall under the category of secondary batteries. Recharging is effected by passing electric current through the battery. The oldest form of rechargeable battery is the Lead-Acid battery. Lead Acid battery market is dominating primarily because of the unavailability of any able competitive solution in the market and that they offer lowest cost per watt-hour despite of their low specific energy. The desire to make these batteries maintenance free, the flooded battery type evolved into two variants: Sealed Lead Acid or Gel cells and valve regulated lead acid (VRLA) Batteries. The flooded battery types are still seen in automobiles ups etc. But due to this evolution, the lead acid batteries now cannot charge to their true potential where gassing and water depletion in the acid may take place. Further, these must be stored in fully charged state or else salvation may cause the degradation of the battery performance. The amount of electric power that can be delivered is often a function of amount of lead present. Here we use lead acid battery as shown in Fig. 5.

Fig. 5 lead acid battery

3.3 Belt

It is a mechanical system in which the motion/power is transferred from one shaft to the other by a flexible element called belt. A belt is a loop of flexible material used to mechanically link two or more rotating shafts, most often parallel. Belts may be used as a source of motion, to transmit power efficiently, or to track relative movement. Belts are looped over pulleys and may have a twist between the pulleys, and the shafts need not be parallel. In a pulley system, the belt can either drive the pulleys normally in one direction (the same if on parallel shafts), or the belt may be crossed. Belt drive is one of the most common effective devices transmitting motion and power from one shaft to the other by means of thin inextensible belt over running over to pulleys. This largely used for general purpose on mills and factories especially when the distance between the Shafts is not very great. When the center distance between the two shafts is large than the tight side of the belt should be the lower one the pulley called, driver is mounted on the driving shaft while the shaft while the other, which is mounted on the shaft to which power is to be transmitted is called the driven pulley or follower.

When the belt moves over the pulleys there is always the possibility of slipping between the belt and pulley and hence the character of the motion transmitted is not positive when positive action is required. The belt drive system as shown in Fig. 6.

Fig. 6 belt used in wheel chair

3.4 Wheel

The wheels are made up of plastic as shown in Fig. 7. There are six wheels of 65mm diameter each which is connected to the geared dc motor. The wheels having good resistance to stable the weight. The wheel are fully composited and it can with stand high loads.

Fig. 7 wheels used in wheel chair

3.5 Four relay receiver

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations. A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts, instead using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called protective relays. Magnetic latching relays require one pulse of coil power to move their contacts in one direction, and another, redirected pulse to move them back. Repeated pulses from the same input have no effect. Magnetic latching relays are useful in applications where interrupted power should not be able to transition the contacts. Magnetic latching relays can have either single or dual coils. On a single coil device, the relay will operate in one direction when power is applied with one polarity, and will reset when the polarity is reversed. On a dual coil device, when polarized voltage is applied to the reset coil the contacts will transition. AC controlled magnetic latch relays have single coils that employ steering diodes to differentiate between operate and reset commands. Fig. 8 shows four relay receive.

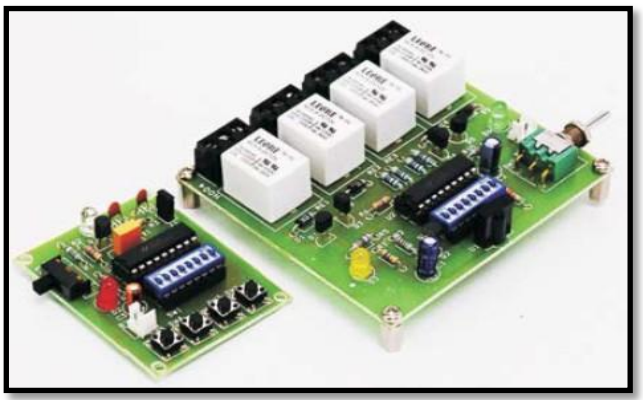

Fig. 8 four relay receivers

Relays are used for:

- Amplifying a digital signal, switching a large amount of power with a small operating power.
- A telegraph relay, repeating a weak signal received at the end of a long wire.
- Controlling a high-voltage circuit with a low-voltage signal, as in some types of modems or audio amplifiers.
- Controlling a high-current circuit with a low-current signal, as in the starter solenoid of an automobile.

- Detecting and isolating faults on transmission and distribution lines by opening and closing circuit breakers (protection relays).
- Isolating the controlling circuit from the controlled circuit when the two are at different potentials, for example when controlling a main powered device from a low-voltage switch. The latter is often applied to control office lighting as the low voltage wires are easily installed in partitions, which may be often moved as needs change. They may also be controlled by room occupancy detectors to conserve energy.

4. Material selections for stairs climbing wheel chair

The material selection for stair climbing wheel chair is listed below.

4.1 Mild steel

Mild steel, also called as plain-carbon steel, is the most common form of steel because its price is relatively low while it provides material properties that are acceptable for many applications, more so than iron. Low-carbon steel contains approximately 0.05–0.3% carbon making it malleable and ductile. Mild steel has a relatively low tensile strength, but it is cheap and malleable; surface hardness can be increased through carburizing. It is often used when large quantities of steel are needed, for example as structural steel. The density of mild steel is approximately 7850 kg/cm3 and the Young's modulus is 210 GPa (30,000,000 psi).

4.2 Wheel

There are different types of materials for wheels, they are given below.

4.2.1 Filled rubbers

In tyres rubbers are usually filled with particles like carbon black or silica. They consist of a tread and a body. The tread is the part of the tire that meets the road surface. The portion that is in contact with the road at a given instant in time is the contact. Treads are often designed to meet specific product marketing positions.

4.2.2 Polyurethane

Polyurethane (PUR and PU) is a polymer composed of a chain of organic units joined by carbonate (urethane) links. While most polyurethanes are thermosetting polymers that do not melt when heated, thermoplastic polyurethanes are also available. The main ingredients to make polyurethane are isocyanates and polyols. Other materials are added to help processing the polymer or to change the properties of the polymer.

4.2.3 Steel

Steel is an alloy of iron, with carbon being the primary alloying element, up to 2.1% by weight. Carbon, other elements, and inclusions within iron act as hardening agents that prevent the movement of dislocations that naturally exist in the iron atom crystal lattices.

4.3 Frame

A specially designed wheel frame is required to hold the motors together on each side of the shaft. In the existing design, the power transmission to the single or double wheel is useless to climb the stairs due to height factor of stairs. The design of the straight wheel frame became more complicated and was needed to be modified with its curved- spherical shape to give proper drive, which creates more frictional force. For these reason, three wheel set on each side of vehicle attached with frame was introduced to provide smooth power transmission to climb stairs without much difficulty.

Frame arrangement is suitable to transmit exact velocity ratio also. It provided higher efficiency and compact layout with reliable service. Easier maintenance was possible in case of replacing any defective parts such as nut, bolt, washer, etc.

Fig. 9 shows the assembly of the stair climbing wheel chair.

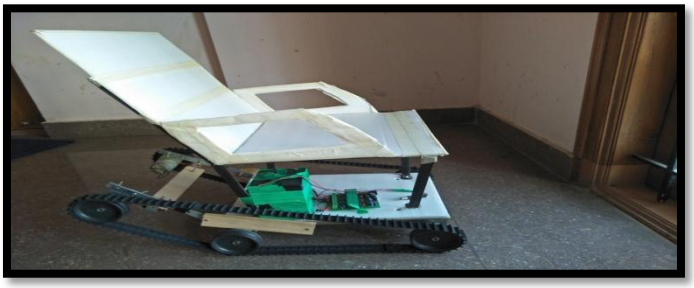

Fig. 9 assembly of stair climbing wheel chair

5. Advantages, disadvantages, applications and future scope

The advantages, disadvantages and applications of stairs climbing wheel chair are given below.

5.1 Advantages

The advantages of stairs climbing wheel chair are

- Stair climbing ability.
- Easy to control.
- Movement will be smoothing on any matt/surface.
- It works with more efficiency.
- Self-controlled operation of wheelchair without helper.
- It can move in all direction.
- Simple autonomous operation on stairs and steep slopes possible. Operation as a standard wheel chair to some extent possible.

5.2 Disadvantages

The disadvantages of stairs climbing wheel chair are

- Need electric power to charge battery.
- It works with limited weight and chair climbs the stair backwards.

5.3 Applications

The applications of stairs climbing wheel chair are

- It is used for physically challenged people.
- It is used travel from one place another in structured or unstructured environments.
- It may be used in hospital for patients

5.4 Future scope

The future enhancement of our project is we have to rectify the problems that we have encountered during descending of the wheel chair in stairs. We had a smooth travel while ascending but while coming down from the steps, we found some vibration problem and to overcome this we have planned to install springs and braking system, so that wheel chair will be in a good control while descending also. One more gear can be used near the handle for easy rotation of handle. To increase the speed of the wheel chair gears and sprockets sizes can be varied.

6. Conclusion

This designed stair climbing wheelchair can climb up stairs up to angle of 30 degree. In this wheelchair rubber crawler provide proper grip on step while climbing up stair cases. It can be operated by handicapped person without help of any person. It can also climb maximum step height up to 180 mm. This track based wheel chair is not depending upon the tread width no matter tread how much long but it can climb up stair case angle up to 30 degree. Maximum payload was 80 kg. It can travel on rough as well as flat surface. In layman terms, some future steps have been proposed and some practical steps have been taken towards even better steps for human and humankind a vision of providing mobility equality for all. As paper conclude that Disabled people are increasingly able to lead an independent life and play a more productive role in society with the help of stair climbing wheelchair. Combined with the computed torque method, a novel control law applied to holonomic or non-holonomic systems is derived, with the active tension of the track controlled for WT wheelchair robot during the stair-climbing process simultaneously. The simulation of each of output and each expected reference input of the generalized coordinate shows the effectiveness of the proposed control law, the experimental results of the stair-climbing process for wheelchair robot verifying its obstacle-navigating performance, and the patterns analyzed above are embodied in the experiment.

References

[1]. Giuseppe Quaglia, Walter Franco and Riccardo Oderio, Motorized wheel chair with stair climbing ability, *International Journal of Innovation Of Machine And Materials, 46(11),* 2009, 1601-1609.

[2]. Murray J Lawn and Takakazu Ishimatsu, Modeling of a stair climbing wheel chair mechanism with high single step capability *International journal of Robotics and Machines, 11(3)*, 2003, 323-332.

[3]. Simpson RC, LoPresti E, Cooper RA (2008). How Many People Would Benefit from a Smart Wheelchair? *Journal of Rehabilitation Research and Development*, 45(1), 2008, 53-72

[4]. Morales R, Gonzalez A, Feliu V, Pintado P Environment adaptation of a new staircase-climbing wheelchair, *Autonomous Robots Journal, 23(10)*, 2007, 3995-4001.

