Back Operated Wheelchair

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Abstract- Our project aims at developing a low cost mobility solution for paraplegics, which is equally good for use by persons with disabled arms and hands. Today many disabled persons are dependent on wheelchairs for their mobility. For instance, in Netherlands, approximately 82 percent of individuals with spinal cord injury (SCI), admitted for inpatient rehabilitation, are wheelchair users (Post and others 1997). [et al Riemer JK Vegter,2010]. Mobility aids currently used in developing nations are not able to fully meet the user's requirements. Various automated wheelchairs available today are designed to satisfy the needs of Paraplegics but not efficient and cost effective solutions up till now have been developed to cater for the needs of the Tetraplegics (i.e. people with all four limbs disabled). In case of Paraplegics also the situation is not very favorable. Thus, our design of a special automated wheelchair operated by back only (BOW) is an attempt to help the tetraplegics around the globe thus enabling them to move around and commute from one place to another without any assistance from anyone. Furthermore, another factor which has been taken into consideration for designing is that the design be very easy to manufacture involving simple mechanisms and be affordable by all needy patients.

Keywords: affordable, automatic, Back operated, physically disabled, tetraplegics, wheelchair.

I. INTRODUCTION

Our main objective is to design a wheelchair capable of commuting people with a special form of disability that is people having both their arms and legs disabled. The inspiration for this project came from a highly viewed inspirational video of Nick Vujicic. Nick Vujicic was born with no arms or legs - but he doesn't let the details stop him. The brave 26-year-old - who is mainly torso - plays football and golf, swims, and surfs, despite having no limbs. Nick has a small foot on his left hip which helps him balance. He uses his one foot to type, write with a pen and pick things up between his toes. The football fan is now a motivational speaker and has travelled to over 24 countries speaking to groups of up to 110,000 people. Having seen Nicks positive attitude towards life gave us the craving to contribute towards such special people. But the question was how. On searching on the internet we discovered that there are innumerous people who have the similar disability as Nick has and some even worse with no small foot or any other organ to support them. Upon researching on various articles about such people we concluded that one of the greatest challenges in their lives is mobility. Some famous figures around the globe that were born without limbs due to Tetra-amelia syndrome or the Hanhart Syndrome are listed below: Joanne O'Riordan (Ireland), Hirotad Ototake (Japan), Marille Adamski-Smith (USA), Christian Arndt (Europe), Piotr Radon (Poland), Yovana Yumbo Ruiz (Lima), Aloisia Wagner (Germany), Nur Damia Irsalina (Malaysia), Rafael Reyes Velaseo (Mexico). Some army veterans including bomb defusal experts who lost their arms and legs during wartime are listed below: Mark Ormrod, Joe Townsend, Taylor Morris, Kevin Trimble, Tom Neathway, Andy Reid. Some people who lost their arms and legs to certain diseases such as Meningitis and Diabetes, car accidents or earthquake victims are listed below: Aimee Copeland, Jan Crispin, Nick Santonastasso, Jane Knight, Ellie Bishop, Harley Slack, Demosi Louphine. People with such physical disabilities face many problems in their day to day life. If some proper mobility solution is not made available to them, then they are forced to stay trapped in their homes or resort to crawling. Thus, in an attempt to providing a solution to encounter this challenge we have come up with an ingenious design of a special automated wheelchair operated with very slight movements of the back of a person. The main aim while designing BOW was to ensure ease of utilization and low of production. The BOW can also be used by other patients with only feet disabled also.

1.1 Other Related Research

1.1.1 Head motion controlled wheelchair

In this concept , a microcontroller system that enables standard electric wheelchair control by head motion is developed. The prototype consists of the digital system (an accelerometer and a microcontroller) and a mechanical actuator. The accelerometer is used to gather head motion data. To process the sensor data, a novel algorithm is implemented using a microcontroller. The output of the digital system is connected with the mechanical actuator, which is used to position the wheelchair joystick in accordance with the user's command. Sensor data is processed by a novel algorithm, implemented within the microcontroller. Thus, user head motion is translated into electric wheelchair joystick position. [et.al Aleksandar Pajkanović, February 2013]

1.1.2 Wheelchair with Tilt sensors

A similar wired system has been developed to assist the physically challenged people suffering from Quadriplegia to control the motion of wheelchair motors by head movements [1]. This paper proposes a system that can assist the disabled people to control the motion of their wheelchair by the hand movements wirelessly. The system proposed can be mounted on primary functioning body part to control the wheelchair movement i.e. hand, head.[et.al Puneet Dobhal,2013]

1.1.3 Voice and gesture based electric powered wheelchair

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A voice and gesture based system has been developed to control a wheelchair using voice commands and moment of hand i.e. Mems sensor is connected to hand. The system is divided into two main components: speech recognition module with Mems sensor and wheelchair control unit. In the speech recognition module, hidden Markov models are used as the main method in recognizing voice commands. The Mems sensor senses the angle of the hand, i.e. according to the tilt of hand And it gives voltages to microcontroller. The wheelchair control unit is developed using ARM controller. [et.al K.Sudheer, November 2012]. Although these systems are indeed a very advanced and efficient mobility solution for the quadriplegics but their cost is very high and manufacturing difficult due to expensive and sophisticated components used. Our design has made use of purely mechanical mechanisms apart from motors and batteries, thus making it easier to repair, manufacture, and maintain. This concept aims to increase the user comfort while operating the wheelchair unit and reduce the overall costs involved.

II. THE DESIGN PROCESS

The designing has been achieved using 3D CAD software- Pro Engineer Wildfire 5.0.

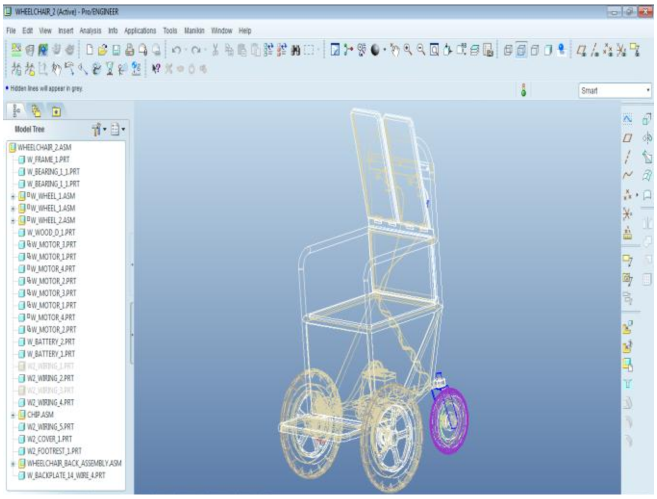

Fig. 1: Initial design in Pro-E

The design of main components is described below:

2.1 The Frame

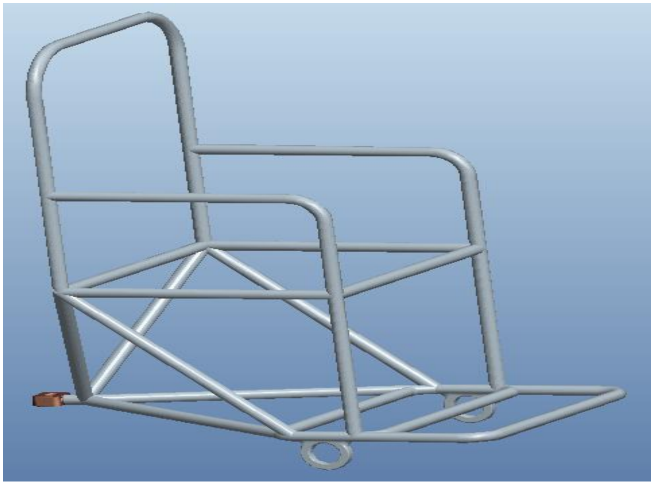

Fig. 2: Design of frame

The frame is designed for a tri wheel system. The front two wheels are the driving wheels and the rear wheel is a free rotating wheel. This type of design accomplishes two purposes. It helps in cost reduction as the material for the frame is reduced; one rear wheel is required instead of two and has reduced a wheel joint. The other purpose of the design is that it gives it a unique and appealing look. The reason for a front wheel drive is that it provides a better stability as compared to a rear wheel drive with the same concept of tri wheels also if the free rotating wheel would have been in front it would have caused interference with the feet of the user. The material recommended is low thickness steel tubes as they have a low weight and high strength. The dimensions for the design of the frame are referred from a standard wheelchair frame. The dimensions are listed below:

Total body width(mm)	folded width(mm)	Seat width(mm)	Rear-wheel-Size(inch)	Front-wheel-Size(inch)	Seat height(mm)
700	350	400	7.5"	12"	500

Total length(mm)	Cushion depth(mm)	Height of the lazy back (mm)	Total height(mm)	Load(kg)
1200	420	430	920	120

Fig. 3: Standard dimensions for design of wheelchair frame

2.2 The Wheels

The wheel design has been referred from the standard wheel models available and is listed below:-

Front wheel has five spokes and is 12” in diameter.

Rear wheel is free to rotate about an axis and is 7” in diameter.

Fig. 4: Wheels

2.3 The Back Controls

The back control system comprise of two pads acting as push buttons and a tensed wire sliding over a connector.

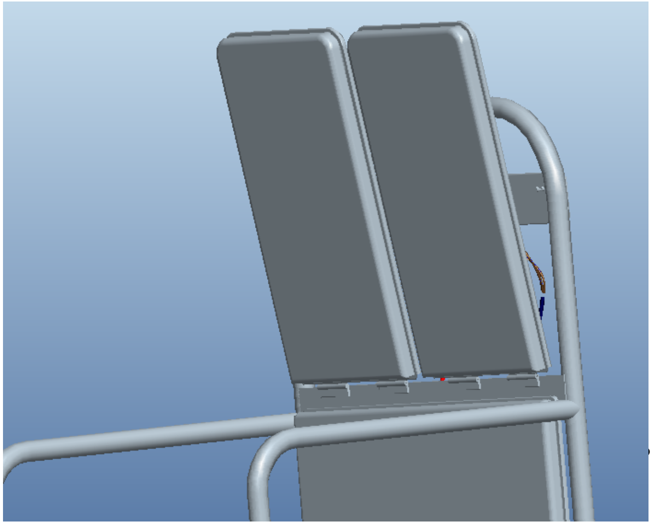

Fig. 5: Back Controls

The pads are attached to the frame with the help of hinges at the lower end and compression springs at the upper end. The hinges provide a rotating axis to the pads whereas the compression springs provide support and define the degree of rotation. The pads are operated by pushing them towards the frame by the back of the person. When the pressure is reduced on one or both the pads the compression springs help them to get to their original position. The pads can be operated in such a ways that there are five different configurations of the positions of the pads.

Table 1: Configuration of wheelchair and position of pads

Configuration	Position of pads
Configuration 1	Both pads at forward position (Default)
Configuration 2	Pad 1 slightly pushed back; Pad 2 at forward position
Configuration 3	Pad 2 slightly pushed back; Pad 1 at forward position
Configuration 4	Both pads slightly pushed back
Configuration 5	Both pads completely pushed back

Pad 1 is the left pad and pad 2 is the right pad. The push buttons are operated by a switch mechanism. Two yellow insulated wires with a small area of insulation removed are joined to the pads at one end and a set of weights are hung at the other end as shown in the figures. The weights help to keep the wires in tension at all times. These wires slide over connectors installed in the frame as shown in (fig 6). The connectors are further connected to connections coming from motors and batteries in such a way that the wire from the positive terminal of battery (one coming out of each blue and red covering is connected to connector at left pad while the wire from the corresponding connector at the frame goes to the right motor thus completing the circuit. The yellow wire acts as a breaking switch. When the left pad is in forward position the connector at frame is in contact with the insulated portion of wire hence no current is passed. The same happens when the pad is pushed back completely. But when the pad is slightly pushed, the non-insulated portion of the wire comes in contact with the connector at frame and current is passed through it resulting in rotation of the right wheel. The various configurations described above and their effects are summarized below:

Table 2: Configuration of wheelchair and their effects

Configuration	Motor in action	Movement of wheelchair
Configuration 1	None	Stationary
Configuration 2	Right motor	Turns left
Configuration 3	Left motor	Turns right
Configuration 4	Both motors	Moves forward
Configuration 5	None	Stationary

Advantages of this system

Two stationary positions makes it possible for the user to rest his back by completely pushing the pads backwards when the wheelchair is not in motion and it also ensures that the wheelchair does not move when the user has left the wheelchair that is when the pads are in forward position. In other words, the wheelchair will only move when the pads are slightly pressed. The displacement range or sensitivity of the pads can be adjusted easily as per requirements just by varying the length of the non-insulated portion of the yellow wire.

2.4 Final Design

Fig. 6: Final design (front view)

Fig. 7: Final design (rear view)

2.5 Challenges faced

The challenges faced during the designing process are:

- Modeling of frame, especially near the rear wheel as the tubes are in an angled plane.
- Adding details such as screw threads, hinges, tyre treads etc.
- Modeling of wheels.
- Modeling of wire mesh, specially where it is wrapped around the frame as the mesh has completely random turns and curves.

III. THE FABRICATION

Using our design as a guideline we have attempted to fabricate a prototype to test its production feasibility and utilization feasibility and to perform reliability analysis. The fabrication is done in a workshop with access to lathe machines, drilling machines, cutting machines, grinding machines, milling machines, bending machines, welding , machines, and other mechanical tools and equipment. Some of the various fabrication processes undergone are listed below:

Fig. 8: Various fabrication processes done at various parts

Fig. 9: Final assembled view of wheelchair

2.6 Calculations for gear design

RPM of the motor: 660
Desired speed of wheelchair: 6 MPH = 10 KMPH = 166000 mm/min
Diameter of wheel: 12 inch = 305 mm
Circumference of wheel: 305*3.14 = 958 mm
Thus, desired rpm of the wheel will be given as: 166000/958 = 173

Hence,
the desired gear ratio: 660/173 = 3.8

Taking the pitch circle diameter of driving gear = 50 mm

Therefore,
pitch circle diameter of driven gear: 50*3.8m= 190mm

2.7 Specification of gears

Spur gears of involute 16 degree system
Number of teeth of driven gear: 57
Pitch circle diameter of driven gear: 190 mm
Number of teeth of driving gear: 15
Pitch circle diameter of driving gear: 50 mm
Material of gears: Mild steel
Gear ratio: 3.8

2.8 Specification of battery

Manufacturer: Exide
Indicated voltage: 12 V
Indicated capacity: 35 Ah

2.9 Specification of bearings

Standard ½ inch high speed bearing salvaged from the gear box of a Tata Indica.

2.10 Specification of shaft

Material: Mild steel
Lathe turned, lathe cut

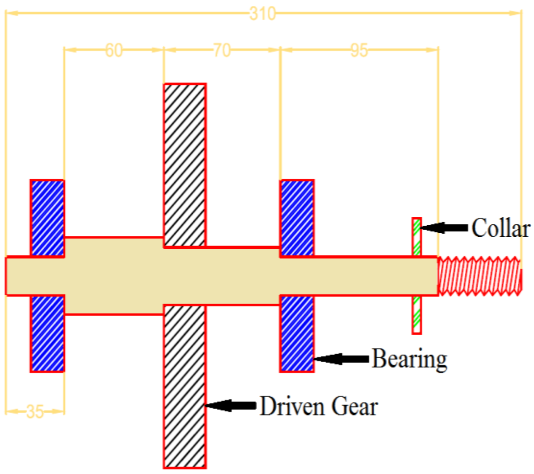

Fig. 10: Shaft

2.11 Specification of other materials

Frame tubes: Stainless steel
Bearing clamps: Mild steel, lathe drilled and lathe cut
Support plates: Mild steel
Wood: ½ inch plywood
Cushions: Standard commercial foam.

2.12 Specification of motors

Standard wiper motor
Nominal voltage: 12V
Nominal power: 50W
Nominal current: 1-1.5 A
Speed: 660 rpm

2.13 Time utilized for fabrication

The time taken for fabrication of this first model was approximately 36 hours. Estimated time for a remake with improvements is less than 10 hours. Estimated time required to make one wheelchair in case of mass production is less than 5 mins.

IV. RESULTS

Upon successfully fabricating the first model of the BOW we have tested it for three hours making it go through obstacles, making it carry heavy weights and reliability of pad switches by frequent fluctuation of movement direction. In these test we have found out that the gear ratio will have to be increased as the BOW is a bit underpowered. Also the speed of BOW is touching 6 MPH whereas the standard safe speed of electric wheelchair is around 4 MPH hence, the increase in gear ration will also help in reducing the speed of the wheelchair. There in minimal wear in the connectors due to the sliding of the non-insulated wire on it. Apart from these minor hitches the BOW's performance exceeds expectations. The pads are very easy and comfortable to operate. The turning radius of BOW is almost 360 degrees.

V. DISCUSSIONS

As a first model the BOW has shown exceptional performance. Although there are still a lot of minor glitches which need to be addressed for example the gear ratio and the wear in the connectors. A few improvements can also be made by adding a braking system as a safety measure to the BOW. The seats and the pads are quite comfortable, although there seemed to be a requirement of better arm rests to improve the ergonomics of the BOW. After at least two or three remakes of the BOW with improvements and testing, the BOW will be ready for production and use by the disabled persons.

VI. FUTURE WORK

As the work described in this paper progresses, we will continue to develop the BOW by further assessing its capabilities and identifying the shortcomings and the scope for improvement. The next step is to design an automatic braking system for the BOW, redesign the gears and induct these improvements in the model 2 of BOW. Furthermore, after the successful completion of the second model we will test its reliability by rigorous use. Also, we will request disabled persons to actually take a test run on the BOW and provide their precious feedbacks so that we can further improve our design.

VII. CONCLUSION

Our aim for design of this research project was to enable persons having disabled legs and/or arms to commute independently from one place to another in the form of a reliable and easy to operate wheelchair. To pursue this goal a prototype called the BOW was developed as our initial work. This prototype is fully functional and it gives a very good solution to the identified challenge. Although this is the first model, but with the consequent second model having the required improvements, the BOW will prove to be a safe and economical solution to this challenge. Hence by using BOW, the persons with such disabilities will be able to upgrade their living standards at least by some extent.

VIII. ACKNOWLEDGEMENTS

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