Fabrication of Affordable Electric Wheelchair by Retrofitting

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Abstract

A wheelchair is an assistive technology that helps individuals who are unable to move normally owing to injury or other age-related walking impairments (permanent or under treatment). All electric wheelchairs are quite costly and not affordable. Availability of all electric wheelchair will improve the quality of life of the disabled. To make the Electric wheelchair available at lower cost, the possibility of retrofitting a wheelchair is investigated. 24V 13.4A BLDC motors are used and controllers are modified. Speed control is achieved using Arduino, Joystick and L293N motor drivers. Retrofitting an existing wheelchair into an electric wheelchair will take care of the ergonomics as well as all the norms in designing the wheelchair. The retrofitted wheelchair successfully carried a 100kg person at a speed of 20kmph.

Keywords
Self-propelled wheelchair, Joystick, Arduino, Electric Motor, Motor Driver.

1. Introduction
The percentage of the population with physical disabilities has grown in importance, drawing the attention of worldwide health-care organizations, institutions, and businesses interested in inventing and adopting new goods. The actual trend reflects a demand for greater health and rehabilitation services, so that senior and disabled people can become more independent in doing daily duties. Mobility is a fundamental quality of all humans, irrespective of age. Children with disabilities are frequently denied key opportunities and endure significant disadvantages in comparison to their peers. Adults who lose their autonomous mode of transportation become less self-sufficient, resulting in a negative attitude toward them. Loss of movement creates impediments to achieving personal and professional goals. As a result, solutions to assist this demographic group must be developed in order to ensure the elderly and handicapper's comfort and independence. For those people, wheelchairs are essential modes of transportation. As per the article published in Global News Wire (Market_Researhc_Future, 2022), a record growth rate of 6.7% in electric wheelchair utilization is predicted till 2027 in US. Artificial neural networks, genetic algorithms, and fuzzy logic are

examples of intelligent techniques that are used to compute high-level judgments in order to govern systems and solve nonlinear and difficult issues. This human-based reasoning technique is important in a variety of fields, including medicine, robotics, and engineering. Indeed, it is frequently used in the creation of smart healthcare devices such as electric wheelchairs (EWC), where several clever prototypes have been built to meet the needs of each user. Aguilar-Pérez, et al (Aguilar-Pérez et al., 2021) designed a wheel chair that facilitates change in position. All the design parameters are discussed in that paper. Waghe, et al (Waghe et al., 2020) presented how solar power can be used to run the wheel chair.
Many have demonstrated different control systems on small wheeled mobile robots. The use of a cellphone for controlling a bot by passing instructions is demonstrated in (Sankhe et al., 2013). The instructions are given either through touch or through head movement. The use of hand gestures for controlling the motion of a robot is presented in (Kalantri and Chitre, 2013). Sarmad, et al (Sarmad et al., 2021) automated the control of wheel chair using Arduino. Emily Eng, et al (Eng et al., 2020), in their design report, presented various components that can be used in fabrication of a wheel chair.

Pires and Nunes (Pires and Nunes, 2002) used speech recognition and joy stick for giving instructions to a electric wheel chair for navigating through an unpredicted environment. The use of an IR LED positioned behind the head of person in wheel chair for controlling the same is detailed in (Kupetz et al., 2010). Of many types of assistive technologies, a detailed literature survey relating to the use and sip and puff interface for controlling the motion of a wheel chair is presented in (Mougharbel et al., 2013). Different configurations for modeling various actions are explained in the same article. A semi-autonomous wheel chair for visually impaired is proposed in (Uchiyama et al., 2005). The wheel chair proposed in their work used gestures as well as commands from a remote server which receives sensory data from the wheel chair. (Hillman et al., 2002) discussed attaching a robot to wheel chair so as to assist them in their daily routines. (Thai et al., 2020) presented a design of a wheelchair that can adjust its wheels position and orientation according to the terrain profile. The wheel chair can travel at a max speed of 5kmph when a 65kg person sits in the chair. Chi-Sheng Chien, et al (Chien et al., 2014) designed a solar panel powered electric wheelchair.

2. Problem Statement

Loss of muscle response is called Paralysis. Paraplegia is a type of paralysis where all the parts below the pelvis stop to respond. This can be due to trauma or disease. People suffering from Paraplegia cannot move easily because their legs are paralyzed and require wheelchair to move around. These wheelchairs are manually powered and for long distant movement, wheelchairs are modified into tricycles with pedaling as well as steering and braking being done by hands. This is a difficult task. In some cases, we find modified two wheelers being used for movement by these subjects as high-speed transport. But not everyone can afford such high-speed transport because cost of two wheelers has gone high. Also cost of petrol is skyrocketing. This is posing paralysis patients of middle-class section, a problem to acquire affordable transport. To fill this gap, we propose a low-cost electric wheelchair. Most of the electric wheelchairs in the market are priced above Rs. 75,000/-. Thus a low cost electric wheel chair is required for the middle class people. Retrofitting an existing wheel chair offers a strategic solution in this case. This paper thus presents a methodology of converting an manual wheel chair into a electric wheel chair and applying joystick control to the same. The next section details the joystick control that is designed for this wheel chair.

3. Joystick Control System

As mentioned in the problem statement, retrofitting an normal wheel chair to electric wheel chair is done as a part of the project detailed in this paper. For this two 24V 250W e-bike conversion kits are made use of. These kits are available online in Amazon (Amazon, n.d.). The specifications of the motors are given in table 1.

Table 1. Specification of the motor

Quantity	**Specification**
Voltage	24 Volt DC.
Output	250 Watt.
RPM (after Reduction)	300
Rated Current	12.2A.
Gear Ratio	1:09.8
Torque Constant	9 N.m (90 kg-cm).

Torque stall	45 N.m (550 kg-cm).
Sprocket	9Tooth 1/8" bicycle chain.

The e-bike conversion kit consists of MY1016 controller. To give joystick control to this wheel chair, the accelerators are replaced with L298N motor drivers. These drivers are interfaced to Arduino. A joystick is also connected to Arduino. Based on the position of the joystick, Arduino sends instructions to motor driver circuits which in turn control the voltage signal being given to the controller, thus controlling the speed of the motors. The circuit diagram used for designing the control system is shown in Figure1. The developed control system is tested initially for running motors that are not mounted on a wheel chair. Once it is ascertained that the control system is running fine, the system is then assembled on the wheel chair. The brakes used by the wheel chair are solenoid brakes. Thus the motor driver used to control a wheel is used to control the solenoid brakes too. This is shown in circuit diagram detailed in Figure 1.

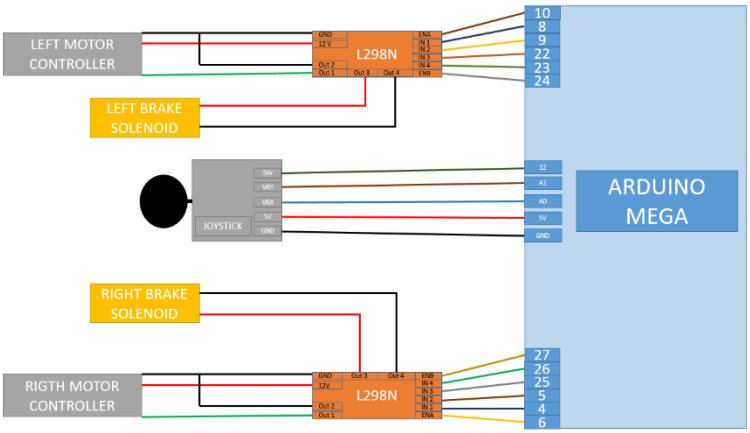

Figure 1. Circuit Diagram

4. Retrofitting of Wheel chair

Once the control system is developed, then the wheel chair is retrofitted with the developed control system. The motors drive the wheels throgh chain drives. A wooden based of 45cm X 45cm is used to mount the batteries as well as clamp the driving motors. The Control sytem is safely enclosed in a box. Four 12V-7AH batteries are used to drive the total wheel chair. A set of two batteries power one wheel. Mounting of these batteries are shown in Figure 2. Each motor powers the wheel using chain drive. This transmission is shown in Figure 3. The joy stick for controlling the wheel chair is placed on the left hand rest of the wheel chair so that it be easyly operated. The joystick used is shown in Figure 4. Figure 5 show a stage in fabrication of the wheel chair and Figure 6 shows the overall wheelchair.

Figure 2. Four 12V, 7AH battries powering the wheelchair

Figure 3. Transmission from Electric

Figure 4. joystic control

Figure 5. Retrofitting the wheel chair in workshop

Figure 6. Final Wheel Chair

5. Conclusions

Electric wheelchairs are quite costly are far from reach to the middle class. This paper details how a normal wheel chair can be retrofitted to an electric wheel chair and how the stock controller can be rigged to be controlled using Arduino. The overall cost of the project (for retrofitting) is around Rs. 25000/- which is almost 1/3rd of the general cost of a electric wheel chair in market. The only drawback, which is still desirable, is that high speed drives are not possible with this wheel chair. The electric wheel chair developed is manual. Since Arduino controller is used, it is open source and thus other assistive technologies can be further implemented to make this semi- and fully autonomous.

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