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Mobility for the Exceptionals: An Adaptable Electrified Transportation System for Manual Wheelchair

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Abstract

The survey for the prevalence of handicapped people in India reveals that approximately 4.52% of India's total population is physically challenged. Among the list, about 44% of people suffer from locomotor disability. Satisfaction of their primary need will be fulfilled when they get aid to move but the main problem is that about 31% of India's population belongs to middle class or lower middle class. Their wish to buy an electric wheelchair which costs more than 1 lakh will be hard to get and unaffordable but their wish to move is the motive of our project. Our project "mobility for the exceptional: an adaptable electrified transportation system for manual wheelchair" deals with a plug-and-play electrified locomotor system that can be adaptable to any manual wheelchair. The mechanical system allows motors to turn the rear wheels through friction without permanently modifying the original wheelchair and the controlling systems are also user friendly. This budget-friendly wheelchair system comes in a price range of less than 50000 and that is 50% less than the electric wheelchairs currently available in our market. The goal of the project is to enable people with wheelchairs to navigate outdoor uses and long distances that are not suitable for manual wheelchairs.

Keywords: MCU, ECU, BLDC motor, Li-Ion battery, Throttle

INTRODUCTION

The development of attachable electrification systems for wheelchairs is a significant milestone in the assistive technology industry. The way people with mobility issues perceive increased mobility and freedom has been completely transformed by imaginative remedies.

The concept of "plug-and-play" is used in this context, which refers to the seamless integration of electric power systems into manual wheelchairs, allowing users to transform their normal wheelchairs into motorized vehicles effortlessly, thus expanding their freedom and accessibility. These systems are typically composed of modular parts such as electric motors and battery packs. Arduino was selected because it can be programmed, making it easier and more flexible to manipulate the system technologically than it would be to make changes using only hardware. The user can adjust the speed by adjusting the throttle. An Arduino receives a proportional signal between 0 and 5 volts via a variable resistor [1].

To determine the current flow between the battery and motor, the Arduino was programmed to decipher this signal and then provide a similar signal to the motor microcontroller. The placement of the hand-rim axle behind the wheelchair user's center

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of mass places a lot of strain on the shoulders, which is a significant issue with manual wheelchairs. To avoid backward tipping, the hand rims attached to the driving wheels were positioned far back. However, wheelchair users have been suffering from chronic shoulder overuse injuries as a result of this. The objective of this wheelchair is to directly connect the handlebars to the driving wheel and enhance the ergonomic arrangement of the hand rims [2, 3].

Few wheelchairs on the market integrate affordability with mobility over various terrains. To allow the user to continue exercising while receiving assistance over long distances and steep inclines, it would be ideal to design a wheelchair that is both manual and electric. Many individuals can use a hybrid wheelchair instead of a completely electrical one.

BLOCK DIAGRAM OF THE SYSTEM

The primary management components of the system are the MCU and ECU. ECU is the electrical control unit, and MCU is the motor control unit (Figure 1).

The ECU activates the ultrasonic sensor, which detects obstacles. The ECU sends obstacle data to the MCU, and an alarm is set to alert the user. The ECU also checks the battery status and controls the light output. The motor is connected to the MCU and its main component, which controls motor movement. The acceleration provided by the throttle is adjusted and delivered to the motor through the MCU [4].

COMPONENTS

Lithium-ion Battery

Lithium-ion batteries (Li-ion) are renewable energy storage devices that are frequently used in portable equipment, electric cars, and electronic devices. Its high energy density, lightweight builder, and long-term charge retention are reasons for its appeal. An electrolyte, usually a lithium salt contained in a solvent, separates the two sets of electrodes of the battery (Figure 2).

Electrical energy is produced during discharge because lithium ions travel through the electrolyte from the anode (also known as the negative electrode) to the positive electrode (cathode). This procedure was reversed after refueling. The comparatively low self-discharge rate of lithium-ion batteries, which means that they hold their charge while not in use, is one of their main advantages [5].

They also exhibited a low memory effect, allowing for partial charging without a significant impact on the overall battery life. However, proper management is crucial to avoid overcharging or discharging, which can compromise safety and longevity.

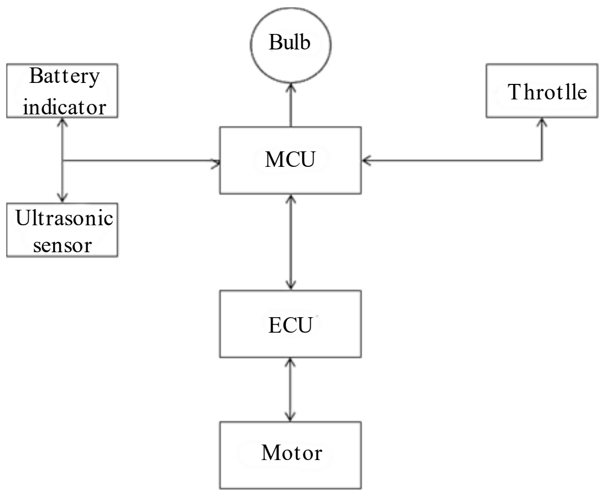

Figure 1. Block diagram of the system.

Figure 2. Li-ion battery.

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Despite these considerations, the high energy density and versatility of lithium-ion batteries make them a preferred choice for powering a diverse range of electronic devices and electric vehicles, contributing to the widespread adoption of portable and rechargeable technologies in modern society.

BLDC Motor

An electric motor that uses direct current (DC) and does not include brushes or a commutator is known as a brushless DC (BLDC) motor. The design of BLDC motors is more accurate and reliable than that of conventional brushed DC motors [6].

They consist of a permanent magnet rotor and stator with coils, and the commutation, or the switching of currents in the coils, is performed electronically. This electronic commutation is typically managed by a controller that directs the flow of current to specific coils at precise moments, ensuring a continuous rotation of the motor. Compared with their brushed counterparts, BLDC motors provide a number of benefits, such as greater efficiency, longer lifespan, and lower maintenance demand. The lack of brushes reduces wear and friction, rendering the operation quieter and smoother. Electric cars, robotics, computer peripherals, and—most pertinent to your question—motorized wheelchair systems represent just a few of the many possibilities for these motors (Figure 3).

Their efficiency, reliability, and precise control make BLDC motors a popular choice for mobility solutions, providing users with smoother and more responsive experience with motorized devices such as hand bikes for wheelchairs [7].

Throttle

In engines with combustion, throttle is an essential component that controls the flow of fuel and air into engine cylinders. It is essential to moderate engine speed and power output.

Typically, the throttle is positioned within the intake manifold of the engine and consists of a butterfly valve. The driver dictates the throttle’s position through the accelerator pedal. The throttle opens as the pedal feels depressed, increasing the engine power by permitting more fuel and air to mix and enter the combustion chambers (Figure 4).

Conversely, releasing the pedal causes the throttle to close, thereby reducing the airflow and fuel intake and slowing down the engine. Modern vehicles often employ electronic throttle control systems, where sensors and computerized modules manage throttle operations based on driver input and engine conditions. This electronic control enhances fuel efficiency, emission control, and overall engine performance [8].

WORKING

The engine and wheel comprise the drive unit, which is responsible for producing the power required to move the wheelchair forward.

Figure 3. BLDC motor.

Figure 4. Throttle.

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The automobile engine must be powerful enough to move a 250-pound user up to five miles per hour at a steady pace. Additionally, the motor has a variable output so that consumers can choose the speed. To make the gadget portable, the ideal motor must be light; yet, reducing weight and increasing power output are competing goals. Balancing these aims was a trade-off when selecting a motor. The motor cost and power are other compromises.

The drive unit is securely attached to the wheelchair, and force is transferred from the drive unit to the wheelchair by the attachment/suspension subsystem. For a wheelchair user with normal upper-body strength and mobility to connect and detach the drive unit to their wheelchair, the attachment mechanism needs to be incredibly simple to use. For the drive unit to remain in position, any joint or part must become strong and rigid. Simple and sturdy attachment to the chair frame without requiring permanent alteration would be possible with a tubing clamp composed of material greater in diameter than the frame. Simple hand tools were used to remove the clamp, which was secured in place with screws or hose attachments [9, 10].

Additionally, this clamp may include a holed boss to which the hitch pin may be fastened. The attachment would be restricted in all other directions but may swivel about one axis owing to the hitch pin. Although the power platform is a straightforward component, it needs to be sturdy enough to support the weight of the device’s battery. The Arduino was selected because of its programmability, which makes it much simpler to manipulate the system digitally than it would be to make changes using only hardware. The user can adjust the speed by adjusting the throttle. The Arduino receives a proportional signal between 0 and 5 volts via a variable resistance.

The motor controller was given a matching signal from the Arduino, which was designed to read this signal and determine how much current should travel between the battery and the motor.

CONCLUSION

In conclusion, our plug-and-play wheelchair electrification system is a transformative solution that addresses longstanding challenges in mobility assistance. By seamlessly integrating various wheelchair models and prioritizing user-friendly design, safety, and adaptability, the system has the potential to redefine the landscape of assistive technology. Modular adaptability, efficient power management, and customization options empower users, offering them a level of control and personalization previously unavailable. Moreover, affordability and compliance with industry standards make this technology accessible to a broader user base, ensuring that advanced mobility solutions are within reach for individuals with diverse needs and financial considerations. As we witness positive outcomes across healthcare, rehabilitation, education, and various other settings, it becomes evident that our electrification system transcends mere convenience; it fosters independence, inclusion, and a sense of empowerment for individuals with mobility challenges. The applications span a spectrum from daily living to emergency scenarios, underscoring the versatility and societal impact of the system. Continuous refinement based on user feedback and emerging technologies will further enhance the system’s capabilities. The journey does not end here; it extends into a future in which advanced mobility solutions play a pivotal role in shaping a more accessible, inclusive, and empowering world for individuals with mobility impairments.

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