A Realtime Head Movement Controlled Wheelchair for Paralyzed People

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Abstract

This article presents a novel solution for physically challenged individuals, specifically those who rely on wheelchairs for mobility. The proposed solution involves the development of a voice-controlled real-time wheelchair system, which is complemented by a mobile application. The system utilizes the HC-05 Bluetooth module, an Arduino UNO microcontroller, high torque DC motors, a 20A motor driver circuit, and a 12V, 7Amp battery. The objective of this project is to enhance the mobility and independence of physically challenged individuals by providing them with an easy-to-use and efficient wheelchair control mechanism. The system aims to provide enhanced control and convenience to users, enabling them to operate their wheelchairs more effectively and efficiently. The wheelchair system utilizes Bluetooth technology to establish a wireless connection between the wheelchair and a mobile device, such as a smartphone or tablet. This connection allows users to control the wheelchair's movements remotely, eliminating the need for physical contact with the wheelchair controls. The mobile application serves as the user interface, providing intuitive and customizable controls that cater to individual user needs and preferences.

Keywords: wheelchair control mechanism, Arduino UNO, HC-05 module, motor driver circuit, high torque DC motors.

1. Introduction

Individuals suffering from paralysis face significant challenges in their daily lives, including limited mobility and dependence on caregivers for basic tasks. Traditional wheelchair controls, such as manual joystick-based systems, can be difficult for paralyzed individuals to operate. There is a crucial need for a user-friendly and intuitive control mechanism that enables paralyzed individuals to manoeuvre their wheelchairs independently. By utilizing head movements, which remain relatively unaffected by paralysis, this innovative wheelchair control system addresses the specific needs of individuals with limited mobility. Assistive technology has revolutionized the lives of individuals with physical disabilities, providing them with increased independence and mobility. One such area of focus is the development of wheelchairs specifically designed for paralyzed individuals. In this context, a head movement-based real-time wheelchair using ADXL345, Battery (12V, & 7Amp), Arduino UNO microcontroller, high torque DC motors, a 20A motor driver circuit, and a 3D printed control panel presents an innovative solution. This system allows individuals with paralysis to control the movement of their wheelchair simply by using their head movements, enabling them to navigate their environment with ease. The head movement-based real-time wheelchair system holds immense significance for paralyzed individuals as it offers them a newfound sense of freedom and control over their mobility. By harnessing the power of accelerometers like the ADXL345, this technology translates head movements into wheelchair commands, allowing users to navigate their surroundings with precision. The integration of a 3D printed control panel further enhances the user experience by providing an ergonomic interface tailored to the unique needs of paralyzed individuals. Moreover, the use of readily available components such as the Arduino UNO microcontroller, high torque DC motors, and a 20A motor driver circuit makes this solution accessible and affordable for a wider range of users.

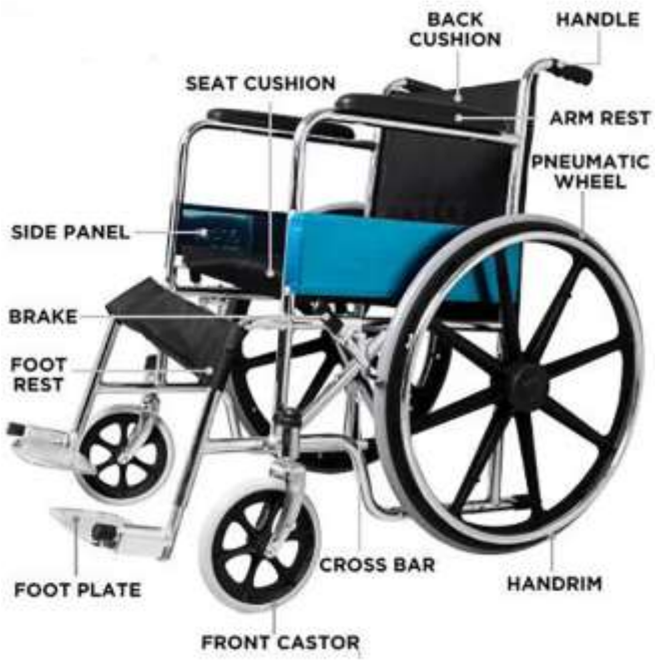

Figure 1: Sample wheelchair of Entros 809B SC (Source: Tata 1mg).

The head movement-based real-time wheelchair system, incorporating the ADXL345 accelerometer, Battery (12V, & 7Amp), Arduino UNO microcontroller, high torque DC motors, a 20A motor driver circuit, and a 3D printed control panel, makes several notable contributions. Firstly, it offers paralyzed individuals an intuitive and accessible means of controlling their wheelchairs, leveraging their head movements. This allows for greater independence, improving overall quality of life. Secondly, the system utilizes commonly available and affordable components, making it accessible to a wider range of users. Thirdly, the integration of a 3D printed control panel provides a customizable interface that can be tailored to the specific needs and preferences of individual users. Overall, this innovative solution represents a significant advancement in assistive technology, enabling paralyzed individuals to regain control over their mobility and live more fulfilling lives.

1.1 Problem definition

The problem at hand is the limited mobility and independence experienced by paralyzed individuals, which can significantly impact their quality of life. Traditional wheelchair control mechanisms often rely on physical dexterity or the use of upper extremities, making them unsuitable for individuals with paralysis. Therefore, there is a need to develop an alternative control system that utilizes head movements to operate a wheelchair in real-time. This system should be reliable, user-friendly, and capable of accurately translating head movements into corresponding wheelchair commands. Additionally, the solution should be cost-effective, easily implementable, and customizable to cater to the varying needs and preferences of different users.

2. Related work

Kumaran, and Renold described the implementation of a voice-based wheelchair system for individuals with disabilities [1]. It likely discusses the integration of voice recognition technology to enable wheelchair control through voice commands. The conference paper provides insights into the design, development, and evaluation of the voice-based wheelchair system. Wanluk et al. [2] focused on a smart wheelchair that utilizes eye-tracking technology for control. The paper likely explores the integration of eye-tracking sensors and algorithms to enable individuals with disabilities, specifically those with limited motor control, to operate the wheelchair through eye movements. The conference paper presents the design, implementation, and evaluation of the eye-tracking-based smart wheelchair system.

Aruna et al. [3] discussed a wheelchair system that combines voice recognition and touch screen control for individuals with paraplegia. The paper likely explores the integration of voice recognition technology and a touch screen interface to provide users with multiple control options. The conference paper presents the design, implementation, and performance evaluation of the voice recognition and touch screen-based wheelchair system. Chauhan et al. [4] presented a study on the implementation of a voice-controlled wheelchair system. The paper likely discusses the design considerations, hardware components, and software algorithms used to enable wheelchair control through voice commands. The conference paper may also include performance evaluations and user feedback on the voice-controlled wheelchair system.

In [5], it refers to the official data collected by the Census of India in 2021 regarding disability. It provides statistical information about the prevalence of disabilities in India, including various categories and types of disabilities. The data serves as a valuable resource for researchers, policymakers, and organizations involved in disability-related initiatives and programs. In [6], The World Health Organization (WHO) published the "World report on Disability," which presents a comprehensive overview of disability globally. The report addresses the prevalence, impact, and barriers faced by people with disabilities, as well as their rights and inclusion. It provides insights into the challenges and strategies for improving the lives of individuals with disabilities and promoting their full participation in society. In [7], Simpson focused on smart wheelchairs and discusses various studies, advancements, and technologies related to smart wheelchair systems. It provides a comprehensive overview of the state-of-the-art in smart wheelchair research at the time, including sensing, control, navigation, and user interface aspects. In [8], Parikh, et al. discussed the integration of human inputs with autonomous behaviors on an intelligent wheelchair platform. It explores the development of a system that combines user control and autonomous capabilities, allowing the wheelchair to adapt to user commands while also providing intelligent navigation and obstacle avoidance. Ruzaij and Poonguzhali [9], focused on the design and implementation of a low-cost intelligent wheelchair. It discusses the development of an affordable intelligent wheelchair system, including the integration of sensors, control mechanisms, and user interface components. In [10] Klabi, et al. focused on advanced user interfaces for intelligent wheelchair systems. It explores innovative approaches and technologies for enhancing the user interface of intelligent wheelchairs, aiming to improve the user experience and enable more intuitive and efficient control of the wheelchair's functionalities.

Abid et al. [11] presented the design and development of a Bluetooth controlled electric wheelchair. It discusses the integration of Bluetooth technology to enable wireless control of the wheelchair using a mobile application. The study highlights the implementation and functionality of the system. Pandey et al. [12] focused on the development of a Bluetooth controlled wheelchair for physically disabled individuals. It describes the design and implementation of the system, emphasizing the wireless control aspect using Bluetooth technology. The study explores the practicality and usability of the wheelchair for the intended user group. Li et al. [13] discussed the design and implementation of a Bluetooth-based smart wheelchair for disabled people. It presents the integration of Bluetooth technology for remote control of the wheelchair through a mobile application. The paper highlights the features and functionalities of the system, focusing on improving the mobility and independence of physically challenged individuals.

Subramanian et al. [14] presented a smartphone-based Bluetooth controlled wheelchair specifically designed for physically disabled people. It outlines the development of the wheelchair system, emphasizing the integration of Bluetooth connectivity and the use of a smartphone as a control interface. The study evaluates the performance and usability of the wheelchair through experimental results. Bafagih et al. [15] focused on the design and development of a Bluetooth-controlled smart wheelchair tailored for physically disabled individuals. It discusses the technical aspects of the system, including the integration of Bluetooth technology and the development of a mobile application for controlling the wheelchair. The study emphasizes the importance of user-centric design and evaluates the wheelchair's performance and usability through user feedback and testing.

3. Existing system

A wheelchair is a device used for transportation by the disabled and the elderly. There are several types of smart wheelchairs on the market. In some cases, for example, a person with Amyotrophic Lateral Sclerosis (ALS) or Parkinson's disease, it may be extremely difficult or unusual for such a patient to use a standard type of framework. They are based on motion, eye position, Bluetooth recognition, brain waves, and so on. A self-propelled manual wheelchair incorporates a casing, seat, perhaps a few footplates (footstools), and four wheels: typically, two caster wheels in front and two large wheels in back. They created the control system, which includes both software and hardware. Bluetooth-controlled posture change and driving were achieved, the hardware circuit and software program were tested and debugged, and Bluetooth control of the wheelchair recognition rates for the same individual were satisfactory. Nevertheless, because it recognizes a large number of Bluetooth devices, it cannot be used in congested areas.

4. Proposed system

The head movement-based real-time wheelchair for paralyzed people operates by utilizing a combination of components to translate head movements into wheelchair commands. Here is an explanation of the working operation and methodology of this system in Figure 2 using the provided components:

4.1 Working

Wheelchair: The wheelchair itself serves as the physical platform for the system. It incorporates the high torque DC motors, motor brackets, mild steel gears, and other necessary mechanical components to facilitate movement.

ADXL345: The ADXL345 accelerometer is the key component for detecting and measuring the user's head movements. It is an advanced sensor capable of detecting acceleration along three axes (X, Y, and Z). The accelerometer is connected to the Arduino UNO microcontroller and provides real-time data on the user's head movements, which are then processed to generate corresponding wheelchair commands.

Battery 12V, 7A: The 12V, 7A battery provides the necessary power supply for the entire system. It ensures a reliable and sufficient power source to drive the high torque DC motors and other electronic components.

High torque DC motors 12V, 30Kg, 5A: The high torque DC motors are responsible for driving the wheelchair's movement. These motors are designed to deliver significant torque to move the wheelchair smoothly across different surfaces. They are connected to the motor brackets and gears to transmit rotational motion to the wheelchair's wheels.

Motor bracket 3mm: The motor brackets provide support and stability to the high torque DC motors, ensuring proper alignment and attachment to the wheelchair's frame. They help secure the motors in place and allow for smooth transmission of power.

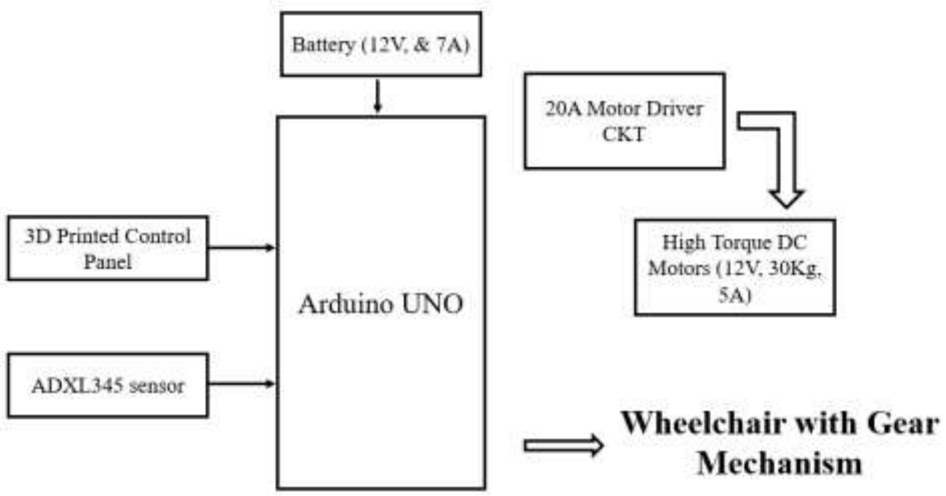

Figure 2: Proposed block diagram of head movement-based real-time wheelchair with gear mechanism.

Voltage Display: The voltage display component is used to monitor the battery's voltage level. It provides real-time information about the battery's charge, ensuring that the wheelchair user is aware of the remaining battery capacity and can recharge it when necessary.

3D printed Control panel (PLA material): The 3D printed control panel serves as the user interface for controlling the wheelchair. It is specifically designed to accommodate the user's head movements and provide easy access to the control buttons and switches. The control panel is made of PLA (Polylactic Acid) material, which is lightweight and durable.

Battery charging socket: The battery charging socket allows for easy and convenient recharging of the wheelchair's battery. It provides a connection point for the charger to replenish the battery's power supply.

On/Off switch: The On/Off switch controls the overall power supply to the system. It enables the user to turn the wheelchair on or off as needed, conserving battery life when the wheelchair is not in use.

Reset button: The reset button serves as a means to reset or restart the system in case of any technical issues or errors. Pressing the reset button helps restore the system's functionality and brings it back to its initial state.

4mm mild steel Gears 2 (left and right): The mild steel gears are an integral part of the wheelchair's drive system. They are connected to the high torque DC motors and transmit rotational motion to the wheels, allowing the wheelchair to move forward, backward, or turn in different directions.

20A motor driver circuit: The 20A motor driver circuit acts as an intermediary between the Arduino UNO microcontroller and the high torque DC motors. It controls the power supply to the motors and regulates their speed and direction based on the commands received from the microcontroller.

In summary, the working operation of the head movement-based real-time wheelchair involves the ADXL345 accelerometer capturing the user's head movements, which are then processed by the

Arduino UNO microcontroller. The microcontroller translates the head movements into specific wheelchair commands and sends them to the 20A motor driver circuit.

4.2 Methodology

The methodology for the head movement-based real-time wheelchair involves integrating the mentioned components into a functional system. The high torque DC motors are securely mounted on the motor bracket and connected to the 20A motor driver circuit. The motor driver circuit receives control signals from the microcontroller and regulates the motor currents, accordingly, controlling the wheelchair's movement. The microcontroller, such as the Arduino UNO, acts as the brain of the system. It receives commands from the ADXL345 sensor. The microcontroller processes these commands and sends corresponding signals to the motor driver circuit to control the motors' speed and direction. The voltage display, battery charging socket, On/Off switch, and reset button provide additional control and monitoring functionalities, enhancing the usability and safety of the wheelchair. To ensure proper mechanical integration and customization, the 3D printed control panel is designed to house the necessary controls and switches. It is strategically positioned on the wheelchair to provide easy access and intuitive operation for the user. By following this methodology and integrating these components effectively, the head movement-based real-time wheelchair for paralyzed people can be constructed, allowing users to navigate their surroundings using intuitive head movements.

4.3 Operation

The system utilizes the ADXL345 sensor, an Arduino UNO microcontroller, high torque DC motors, a 20A motor driver circuit, and a 12V, 7Amp battery. The objective of this project is to enhance the mobility and independence of paralyzed individuals by providing them with an easy-to-use and efficient wheelchair control mechanism. The wheelchair is equipped with an accelerometer that allows users to control the movement of the wheelchair through a head movement connection. The ADXL345 sensor enables seamless communication between the head movement and the Arduino UNO microcontroller, which serves as the control unit for the wheelchair. The Arduino UNO receives commands from this sensor and processes them to drive the high torque DC motors. To ensure the safe and reliable operation of the wheelchair, a 20A motor driver circuit is employed. This circuit acts as an interface between the Arduino UNO and the high torque DC motors, enabling precise control over the wheelchair's speed and direction. The 12V, 7Amp battery provides the necessary power to drive the motors and sustain the system's operation for an extended period.

Table 1: Wheelchair specifications.

Parameter	Dimension
Seat width	39cm
Height	100cm
Size from top handle to wheel	31cm
Size from front handle to wheel	40.4cm
Wheel diameter	50.6cm
Length of steel bar at base	40cm
Length of leg rest	30.6cm
Distance between each leg rest	10.5cm

5. Hardware Results and discussion

5.1 ADXL3445 sensor

The ADXL345 is a 3-axis, digital accelerometer that can measure acceleration up to ±16g. It has a compact design and operates with low power consumption, making it suitable for a wide range of applications, including robotics, gaming, and industrial equipment. The pin diagram includes seven pins, each of which has a specific function. The pins are as follows:

- Chip Select (CS) - This pin is used to select the device for communication when using the SPI interface. It is an active low pin, which means it is pulled low to select the device.
- Data Out (SDO) - This pin is used to output data from the device when using the SPI interface.
- Data In (SDA) - This pin is used to input data into the device when using the SPI interface.
- Clock Input (SCL) - This pin is used to provide the clock signal when using the SPI interface.
- Ground (GND) - This pin is connected to ground.
- Power Supply (VCC) - This pin is used to supply power to the device. The device can operate with a supply voltage between 1.8V to 3.6V.
- Interrupt Output (INT) - This pin is used to output an interrupt signal when certain events occur, such as when the device detects motion or when it reaches a certain threshold.

Overall, the ADXL345 pin diagram provides a clear understanding of the functionality and purpose of each pin, making it easier for designers to incorporate the device into their designs.

5.2 Machining process with outcome

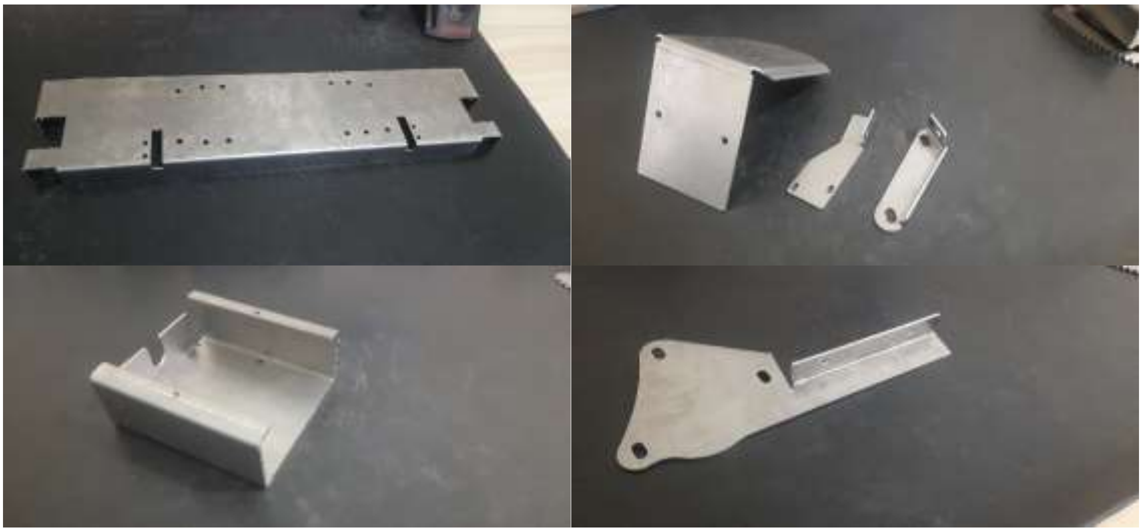

Figure 3: Manufacturing process and final machining pieces.

Figure 4: Wheels alignment and gear fixing.

Figure 5: Final setup after wheel alignment with gear mechanism.

Figure 6: Output snaps of wheelchair controlling with head movement. Front (top left). Left (top right). Right (down left). Back (down right).

6. Conclusion

In conclusion, the development of a head movement-based real-time wheelchair for paralyzed individuals utilizing components such as the wheelchair itself, a 12V, 7A battery, high torque DC motors (12V, 30Kg, 5A), motor brackets (3mm), voltage display, a 3D printed control panel (PLA material), a battery charging socket, an on/off switch, a reset button, 4mm mild steel gears (2 for left and right), a 20A motor driver circuit, and the ADXL345 accelerometer represents a significant advancement in assistive technology. This system addresses the specific needs of paralyzed individuals by providing them with an intuitive and accessible means of controlling their wheelchair through their head movements. The integration of the ADXL345 accelerometer allows for accurate translation of head movements into wheelchair commands, enabling users to navigate their environment with precision and ease. The use of high torque DC motors and the 20A motor driver circuit ensures smooth and reliable movement of the wheelchair, accommodating various terrains and obstacles. The 3D printed control panel, designed with PLA material, provides a customizable interface that can be tailored to individual users' preferences, enhancing the overall user experience.

7. Future scope

While the head movement-based real-time wheelchair system presented here is a significant step forward, there are several avenues for further improvement and development such as sensor integration, wireless connectivity, control algorithms, ergonomic design, and the integration of environmental sensors. Continued research and development in these areas will lead to further improvements in mobility and independence for paralyzed individuals, ultimately enhancing their quality of life.

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