Design and Analysis of Hands-Free Wheelchair

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Abstract: Quadriplegia, sometimes known as Tetraplegia, is a type of paralysis that causes sensory and motor function loss in all four limbs. The incapacity of individuals with quadriplegia to move independently is one of the most significant obstacles they encounter. Quadriplegics are unable to use both traditional wheelchairs and normal motorized wheelchairs due to their loss of arm control. This head motion-controlled wheelchair was created to solve and improve the problem of autonomous mobility that those restricted to wheelchairs experience. This wheelchair, built with a six-motor mechanism, is intended for high torque, low-speed operation. As a result, it can readily ascend ramps and slopes. This method makes use of an accelerometer-equipped helmet.

Key Words: Quadriplegia, Tetraplegia, Paralysis, Sensory function loss, Motor function loss, Autonomous mobility, Head motion control, Wheelchair.

I. INTRODUCTION

Quadriplegia, also known as tetraplegia, is a severe form of paralysis that results in the loss of both sensory and motor function in all four limbs. This condition presents significant challenges, particularly in terms of independent mobility, as individuals with quadriplegia are unable to use traditional or even standard motorized wheelchairs due to the loss of arm control. To address this critical issue, a specialized wheelchair has been developed, designed to be controlled by head movements. This innovative wheelchair features a six-motor mechanism optimized for high torque and low-speed operation, enabling it to easily navigate ramps and slopes. The system is integrated with an accelerometer-equipped helmet, allowing users to steer and control the wheelchair through subtle head movements, thereby enhancing their autonomy and quality of life.

II. MOTIVATION

The motivation behind this project stems from the pressing need to enhance the quality of life and independence for individuals with quadriplegia. Traditional mobility solutions fall short for those who have lost arm control, severely limiting their ability to navigate their environment autonomously. This lack of independence can lead to feelings of isolation and dependence on others for basic mobility. By developing a head motion-controlled wheelchair, we aim to provide a practical and empowering solution. The integration of an accelerometer-equipped helmet with a robust six-motor mechanism ensures that users can easily traverse various terrains, including ramps and slopes, without relying on external assistance. This project is driven by the desire to restore a sense of freedom and improve the daily living conditions of those affected by quadriplegia, allowing them to move independently and engage more fully in their communities.

III. PROBLEM DEFINATION

The primary problem addressed by this project is the lack of effective mobility solutions for individuals with quadriplegia, who suffer from paralysis in all four limbs and consequently lose the ability to control traditional or standard motorized wheelchairs. This limitation severely restricts their independence and ability to perform daily activities without assistance. Existing mobility aids do not adequately cater to the needs of quadriplegics, particularly in terms of providing autonomous navigation and ease of movement over various terrains. To tackle this issue, we propose the development of a head motion-controlled wheelchair equipped with a sixmotor mechanism designed for high torque and low-speed operation. This innovative solution aims to empower individuals with quadriplegia by enabling them to control their wheelchair through head movements, facilitated by an accelerometer-equipped helmet, thereby significantly enhancing their mobility and independence.

IV. OBJECTIVE

- Enhance independent mobility for individuals with quadriplegia.
- Improve accessibility across diverse terrains.
- Increase user autonomy.
- Optimize wheelchair performance for smooth and reliable operation.

- Boost user confidence and quality of life by providing an intuitive control system.
- Ensure user safety through controlled, low-speed movement.
- Facilitate ease of use with minimal training requirements.

V. PRELIMINARY SURVEY

A preliminary survey of existing mobility solutions for individuals with quadriplegia reveals significant gaps and challenges. Traditional wheelchairs, both manual and motorized, are primarily designed for users who retain some degree of upper body control, rendering them unsuitable for quadriplegics who lack arm function. Alternative technologies, such as sip-and-puff controls and eye-tracking systems, offer some degree of autonomy but often fall short in terms of reliability, ease of use, and accessibility in diverse environments. These systems can be complex, expensive, and may require extensive customization, limiting their practicality for widespread use. Additionally, many existing mobility aids struggle with maneuvering on uneven terrains, ramps, and slopes, further restricting the independence of users. Through this survey, it becomes evident that there is a critical need for an innovative solution that combines ease of control, robust performance, and the ability to handle various terrains, thereby enhancing the overall quality of life for individuals with quadriplegia. This insight drives the development of a head motion-controlled wheelchair equipped with an accelerometer and a six-motor mechanism, addressing these unmet needs effectively.

VI. LITERATURE SURVEY

1. Dr.B.Paulchamy, N.Vinothini, S.Sharukhan et.al "Design and Development of Smart Wheel Chair using Voice Recognition and Head Motion" The challenging problem faced by the paralyzed people is their independent mobility. They need an external help to perform their daily activities. Electric wheelchairs are designed to aid paraplegics. Unfortunately, these cannot be used by persons with higher degree of impairment, such as quadriplegics, i.e. persons that, due to age or illness, cannot move any of the body parts, except of the head. The main objective of this project is to provide an automated system for disabled people. The wheel chair will work based on the head movement of the user. The recognized gestures are used to generate motion control commands to the controller so that it can control the motion of the wheel chair according to the user intention. Design and development of Head motion controlled wheelchair has been achieved using MEM sensors and microcontroller. The system is implemented practically and works well. The MEM Sensor senses the change in direction of head and accordingly the signal is given to microcontroller. Depending on the direction of the Acceleration, microcontroller controls the wheel chair directions like LEFT, RIGHT, FRONT, and BACK with the aid of DC motors.
2. Arunkumar,Gautham et.al "Head Motion Based Wheel Chair Movement for Disable Person" The challenging problem faced by the paralyzed people is their independent mobility. They need an external help to perform their daily activities. The main objective of this project is to rehabilitate the disabled people who cannot perform their voluntary movement. The hardware implementation of the wheel chair will be a mobility aid for the patients who are extremely suffering from the quadriplegia. The wheel chair will work based on the head movement of the user. The recognized gestures are used to generate motion control commands to the controller so that it can control the motion of the wheel chair according to the users intention. Head movement is one of the natural gestures which can be easily tracked. The head movement is the gesture which can be performed by the quadriplegic patients whose body parts below the neck is paralyzed. So the head movement is possible for the patients. The wheelchair includes the accelerometer sensor which detects the movement of head and the controller will process the signal and will transmit to the wheel chair for its navigation. This is will offer a small relief to the patients who are tolerating from this condition. The wheel chair is implemented in a cost effective way which reduces the complexity in the design. It is intended to be used as a human friendly interface for elderly and disabled people to operate wheelchair using their head gestures rather than their hands. This autonomous navigation ensures safety, flexibility, mobility, obstacle avoidance and an intelligent interface.
3. Abhishek Gupta, Neeraj Joshi, Nikhil Chaturvedi et.al "Wheelchair Control by Head Motion Using Accelerometer "the challenging problem faced by

the paralyzed people is their independent mobility. They need an external help to perform their daily activities. Electric wheelchairs are designed to aid paraplegics. Unfortunately, these can not be used by persons with higher degree of impairment, such as quadriplegics, i.e. persons that, due to age or illness, can not move any of the body parts, except of the head. The main objective of this project is to provide an automated system for disabled people. The wheel chair will work based on the head movement of the user. The recognized gestures are used to generate motion control commands to the controller so that it can control the motion of the wheel chair according to the user intention. Design and development of Head motion controlled wheelchair has been achieved using accelerometer sensors and PIC microcontroller. The system is implemented practically and works well. The ACCELEROMETER senses the change in direction of head and accordingly the signal is given to microcontroller. Depending on the direction of the Acceleration, microcontroller controls the wheel chair directions like LEFT, RIGHT, FRONT, and BACK with the aid of DC motors.

4. Aishwarya.N.P.Rao , Anupama.R et.al "NECK MOVEMENT BASED WHEELCHAIR TO ASSIST THE PHYSICALLY CHALLENGED" The challenging problem faced by quadriplegics and paralyzed people is their need for independent mobility. They need external help to perform their daily activities. The main objective of this project is to provide an automated system for disabled people to control the motor rotation of wheelchair based on neck movement of physically challenged person. To facilitate these people for their independent movement, tilt sensor is fitted on person neck. Based on the neck movements, the accelerometer (tilt sensor) will drive the motor fitted to the wheelchair. The wheel chair can be driven in any of the four directions and it can also be controlled by using android app (Blynk app). The automated wheelchair is based on simple electronic control system and the mechanical arrangement that is controlled by a Controller. The ultrasonic sensors help to avoid obstacles, using the environment information gathered during navigation. The temperature sensor and heartbeat sensor constantly measure the parameters and display it on LCD.

VII. PROJECT SCOPE

The scope of this project encompasses the design, development, and testing of a head motion-controlled wheelchair specifically tailored for individuals with quadriplegia. This includes the integration of an accelerometer-equipped helmet to capture head movements, which will be translated into directional commands for the wheelchair. The project will involve creating a robust six-motor mechanism to ensure high torque and low-speed operation, allowing the wheelchair to navigate various terrains, including ramps and slopes, effectively. Additionally, the project will focus on ensuring user comfort and safety, incorporating features that protect users during operation and providing a comfortable seating arrangement for prolonged use. The development process will include extensive user testing and feedback to refine the control interface and ensure the system is intuitive and user-friendly. Ultimately, the project aims to deliver a reliable, accessible, and practical mobility solution that significantly enhances the independence and quality of life for individuals with quadriplegia.

VIII. DIAGRAMS

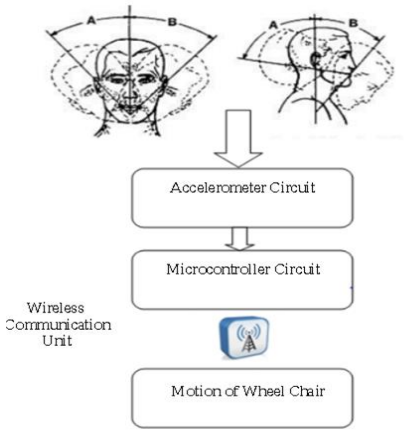
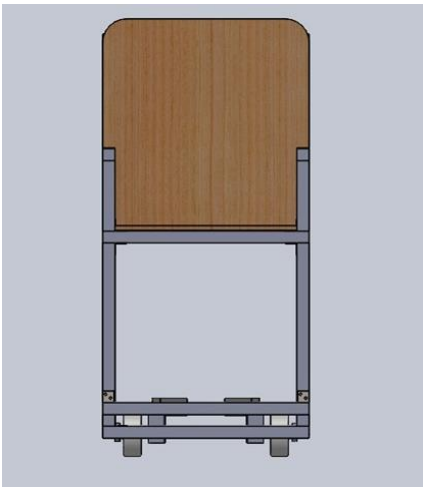
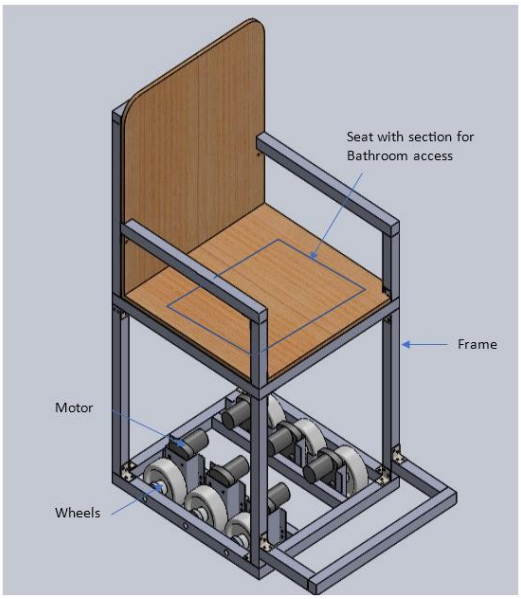


Fig. 1. Block Diagram of System

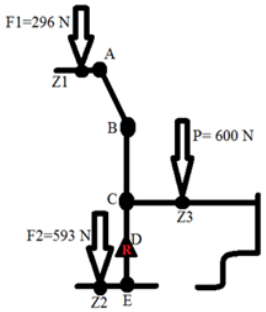




IX. ADVANTAGES

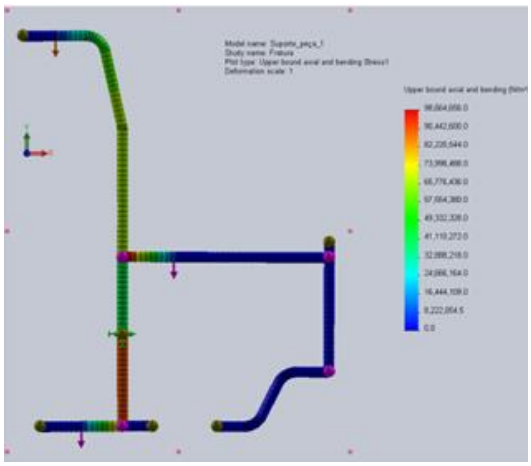
- Enhanced Independence: Users can control movement independently, reducing reliance on caregivers.
- Improved Accessibility: The six-motor system allows for stable navigation on ramps and slopes.
- Greater Autonomy: Control through head tilts enables users to manage their movements intuitively.
- High Torque for Smooth Operation: Motors are optimized for reliable performance on uneven terrains.
- Safety at Low Speeds: Controlled speeds enhance safety, especially on inclines.
- User-Friendly Interface: Head-motion control requires minimal training, making the wheelchair accessible.
- Enhanced Comfort: Ergonomic seat and back support ensure user comfort during extended use.
- Boost in Confidence and Quality of Life: The device's ease of use fosters greater engagement in daily activities.

X. RESULTS



Stresses in bars:

- Z1 A = 34.6 MPa
- A B = 69.4MPa
- B C = 69.4MPa
- D E = 87.2 MPa
- Z2 E = 82.8 MPa



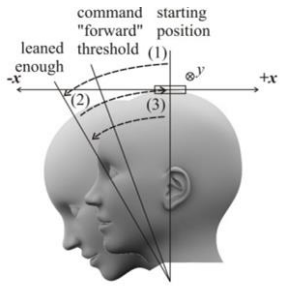


Fig. 5 – *An example of issuing a command – "forward".*

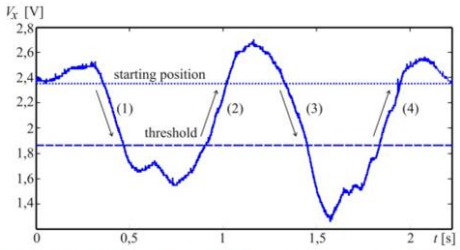


Fig. 6. – *Accelerometer x axis data while issuing the command "forward".*

XI. CONCLUSION

In conclusion, the development of a head motion-controlled wheelchair represents a significant advancement in mobility solutions for individuals with quadriplegia. By addressing the critical need for independent mobility, this project combines innovative technology with practical design, offering a robust, user-friendly solution that enhances accessibility and autonomy. The integration of an accelerometer-equipped helmet and a six-motor mechanism ensures reliable performance across various terrains, including ramps and slopes. This

wheelchair not only improves the physical capabilities of users but also boosts their confidence and quality of life by reducing dependence on caregivers. Through rigorous testing and user feedback, the project aims to deliver a safe, comfortable, and effective mobility aid that empowers individuals with quadriplegia to navigate their environments with newfound freedom and ease.

XII. REFERENCES

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