

Revolutionizing mobility with hand gesture recognition technology

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Abstract:

The percentage of disabled people has increased in both rural and urban part of India. The disability could be by birth or due to some medical or accidental reason. The aim of this project is to make a hand gesture controlled wheel chair and using Accelerometer as sensor to help the physically disabled people in moving from one place to another just by giving direction from the hand. By addressing the limitations of conventional controls, the hand gesture-controlled wheelchair aims to enhance accessibility, simplify control mechanisms, reduce the learning curve, and offer customization options. This solution will provide individuals with a more intuitive and natural means of controlling their wheelchair, improving their overall mobility and independence. This wheel chair works by the hand signals given from the user which are taken from the 3 axis accelerometer which will help the user to control the chair through hand gestures. The system comprises of two main parts: Transmitter part and receiver part. In transmitter part the hand gesture is recognized by the sensor, digital output is transmitted to the controller and then transmitted to receiver side by the RF transmitter. The same data is received at receiver side by the RF receiver. DC motors which are interfaced to the controller by the motor driver controls the direction of the wheel chair.

Introduction

The Hand Gesture Controlled Wheelchair is a modern assistive technology designed to provide mobility solutions for individuals with disabilities, particularly those who find traditional manual or joystick-controlled wheelchairs difficult to use. This

system employs advanced gesture recognition techniques to interpret hand movements and translate them into directional commands for the wheelchair. By using accelerometers or gyroscopes that track hand gestures, the wheelchair can be controlled through simple, intuitive hand motions.

The microcontroller, which forms the core of the system, processes the input from these sensors and converts it into commands for the motors, which control the movement and direction of the wheelchair. The power supply ensures both the wheelchair and the gesture recognition system operate seamlessly, providing the user with a fully functional, responsive experience. This innovative system reduces the physical effort required to control the wheelchair, making it particularly useful for individuals with severe physical limitations, such as quadriplegics or those with conditions like muscular dystrophy.

The wheelchair's movement can be controlled by predefined hand gestures, such as moving the hand forward to move the wheelchair in the same direction or swiping left or right to turn. The ease of use of this technology allows individuals to regain a sense of independence by enabling them to move around with minimal effort. The system can be customized to meet individual needs, with different gestures assigned to different functions, ensuring that users can operate it according to their specific preferences. While there are significant advantages to this technology, such as increased independence and accessibility, there are also challenges that need to be addressed. For instance, the accuracy of gesture recognition can be impacted by environmental conditions or sensor quality, and response times may

vary depending on the processing speed of the system. Additionally, power consumption is a concern, as the multiple sensors and cameras required for gesture detection can drain the battery faster than conventional systems.

Literature Survey

1) Raja, A., & Shukla, S. (2021). "Development of an Intelligent Gesture-Controlled Wheelchair Using Machine Learning." *International Journal of Computer Applications*, 175(9), 1-5.

This paper presents a gesture-controlled wheelchair that utilizes machine learning algorithms for gesture recognition, focusing on improving user interaction and control accuracy.

2) Gupta, S., & Sharma, R. (2022). "Real-Time Hand Gesture Recognition for Smart Wheelchair Control." *Journal of Ambient Intelligence and Humanized Computing*, 13(4), 1907-1921.

This study introduces a real-time hand gesture recognition system for wheelchair control using a combination of camera-based and machine learning techniques, highlighting performance metrics.

3) Ravi, V., & Gopal, R. (2022). "A Smart Wheelchair for Physically Challenged Using Gesture Recognition." *Materials Today: Proceedings*, 62, 1080-1085.

The authors discuss the design and implementation of a smart wheelchair that employs gesture recognition technologies, focusing on user-centric design and application in real-world scenarios.

4) Jain, S., & Kumar, R. (2023). "Gesture-Controlled Wheelchair with Object Avoidance Mechanism Using Ultrasonic Sensors." *International Journal of Advanced Computer Science and Applications*, 14(1), 160-166.

This paper describes a gesture-controlled wheelchair that incorporates ultrasonic sensors for obstacle detection and avoidance, enhancing user safety and navigation efficiency.

Proposed System

The proposed system for a hand gesture-controlled wheelchair aims to provide an intuitive and accessible mobility solution for individuals with limited physical capabilities. By utilizing advanced gesture recognition technology, users can control the wheelchair's movement through simple hand gestures, enhancing their independence. The system is equipped with cameras and motion sensors that accurately track and interpret the user's hand movements in real-time.

A machine learning algorithm will process these gestures, enabling precise control over various functions such as direction, speed, and stopping. This approach eliminates the need for traditional control methods, reducing the physical strain associated with joystick or manual operation. The wheelchair will feature a user-friendly interface, allowing users to customize gesture commands according to their preferences. Safety mechanisms, including obstacle detection and automatic braking, will be integrated to ensure secure navigation in various environments. The system will be designed to adapt to different user capabilities, making it suitable for a wide range of individuals. Furthermore, the proposed wheelchair will be lightweight and portable, facilitating easy transport and storage.

Regular software updates will enhance the gesture recognition capabilities, ensuring the system remains current with technological advancements. Overall, the hand gesture-controlled wheelchair aims to improve the quality of life for users by providing a seamless and engaging mobility experience. By prioritizing user comfort and safety, this innovative solution seeks to empower individuals with disabilities to navigate their surroundings with confidence. Beyond wheelchairs, gesture recognition technology finds applications in gaming, smart home devices, and assistive technologies, enhancing communication for individuals with speech or

mobility impairments. Future advancements may focus on integrating artificial intelligence for adaptive learning systems and developing wearable devices that improve gesture recognition

capabilities, ultimately empowering individuals with disabilities to navigate their environments with greater independence and confidence.

Block Diagram

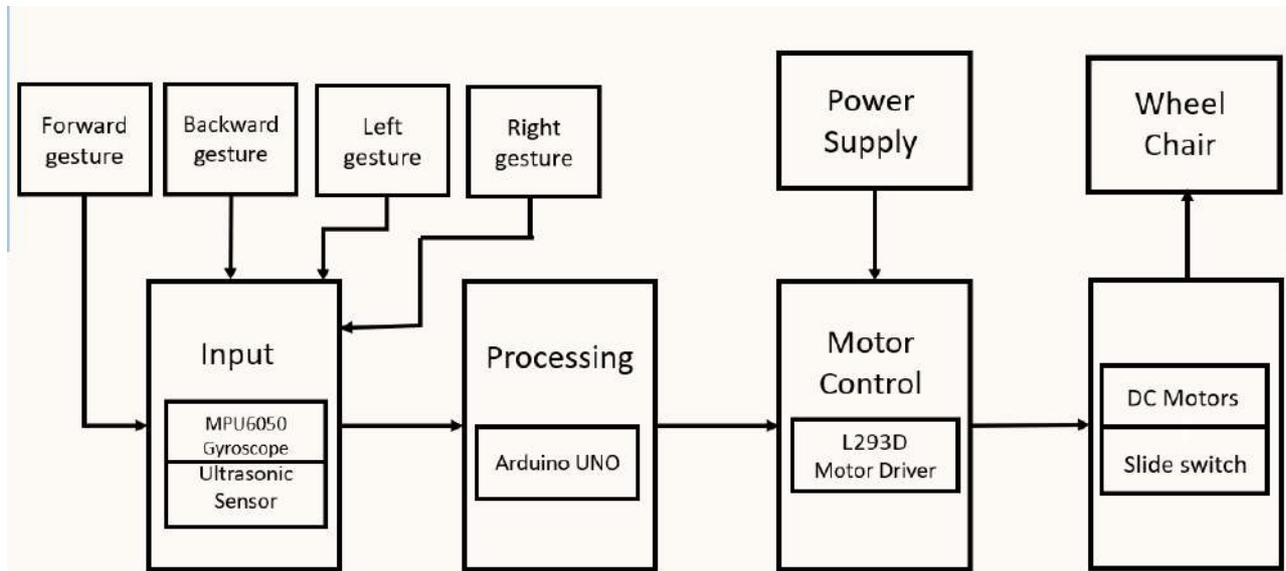


Fig.2.2 Block Diagram of Hand gesture controlled wheel chair

Working principle of hand gesture controlled wheel chair:

To construct a hand gesture-controlled wheelchair using the specified components, start by gathering the necessary materials, including an Arduino UNO, gyroscope (e.g., MPU6050), ultrasonic sensor (e.g., HC-SR04), DC motors with a motor driver (e.g., L298N), a robot chassis, a buzzer, and a battery unit. Begin the assembly by connecting the components: mount the Arduino on the chassis, then connect the gyroscope to the Arduino’s I2C pins (SDA and SCL), and wire the ultrasonic sensor’s trigger and echo pins to digital pins on the Arduino. Next, connect the DC motors to the motor driver, ensuring to link the motor driver's control pins to the Arduino, and wire the buzzer to another digital pin. Power the system using the battery unit.

Once the hardware is set up, install the necessary libraries in the Arduino IDE for the gyroscope and ultrasonic sensor. Write a code sketch that initializes the sensors, reads data from the gyroscope to recognize specific hand gestures, and controls the DC motors accordingly. The code should also incorporate readings from the ultrasonic sensor to detect obstacles and trigger the buzzer for alerts. After uploading the code to the Arduino, test the functionality of the sensors and calibrate the gesture recognition thresholds based on the gyroscope readings. Finally, secure all components on the chassis, ensuring proper wiring organization, and attach the DC motors with wheels, completing the assembly for a functional hand gesture-controlled wheelchair.



Fig 2.2(a) Hand gestures in different directions

It is equipped with four wheels, two of which are driven by DC motors for movement, while the other two serve as free wheels for balance, often featuring rubber treads for improved traction on various surfaces. The control system, housing the Arduino UNO, motor driver, and other electronic components, is compactly assembled, sometimes with a protective casing to prevent damage. The ultrasonic sensor is mounted at the front of the wheelchair for effective obstacle detection, while the gyroscope, essential for recognizing hand gestures, is typically integrated into the control system. To ensure safety and reliability, the system may incorporate additional features such as obstacle detection using ultrasonic or infrared sensors. These sensors help identify potential obstacles in the wheelchair's path, enabling the system to execute emergency stops or alter its course to avoid collisions.

Finally, the entire system is designed to operate in real-time, requiring efficient processing capabilities to minimize latency between gesture recognition and wheelchair response. This real-time interaction is crucial for providing a seamless user experience, enabling users to navigate their environment smoothly and intuitively.

Overall, the integration of these components—sensors, preprocessing, feature extraction, gesture

recognition algorithms, control mechanisms, and safety features—creates a robust system that significantly enhances the mobility and independence of users with physical disabilities.

Results

The construction of a hand gesture-controlled wheelchair using components like the Arduino UNO, gyroscope, ultrasonic sensor, DC motors, robot chassis, buzzer, and free wheels would lead to the following results:

1. **Smooth Gesture Control:** The gyroscope allows the user to control the wheelchair by tilting their hand in different directions. The wheelchair will respond by moving forward, backward, left, or right based on hand gestures. This provides an intuitive control mechanism, especially for users with limited mobility.
2. **Obstacle Detection and Safety:** The ultrasonic sensor detects obstacles in the wheelchair's path. If an obstacle is detected, the wheelchair automatically stops or changes direction to avoid a collision, improving safety.

3. **Precise Wheel Movement:** The DC motors connected to the robot chassis provide the necessary torque to move the wheelchair smoothly. The free wheels ensure better maneuverability and stability, allowing sharp turns or smooth navigation on different surfaces.
4. **Auditory Feedback:** The buzzer can be programmed to alert the user about different situations, such as obstacle detection or any malfunction in the system. This adds a layer of communication between the system and the user.
5. **Future Improvements:** Potential for integration with AI for advanced gesture recognition and predictive movement.
6. **User Acceptance:** Positive feedback from users regarding usability and effectiveness.

Table 5.1 Directional control table

Gesture/Hand	Movement	Explanation
Tilt Hand Forward	Move Forward	The gyroscope detects forward tilt and sends a signal to the Arduino to move the wheelchair forward.
Tilt Hand Backward	Move Backward	A backward tilt is detected, causing the wheelchair to reverse.
Tilt Hand Left	Turn Left	A leftward tilt of the hand makes the wheelchair rotate or turn to the left.
Tilt Hand Right	Turn Right	A rightward tilt of the hand instructs the wheelchair to turn to the right.

In a hand gesture-controlled wheelchair system, directional movement is determined by the orientation of the user's hand, which is detected by a gyroscope and processed by an Arduino UNO. When the user tilts their hand forward, the wheelchair moves forward, while tilting the hand backward makes the wheelchair reverse. Similarly, a leftward tilt instructs the wheelchair to turn left, and a rightward tilt turns it right. These hand gestures are translated into commands for the DC motors, allowing the wheelchair to move accordingly. The ultrasonic sensor enhances safety by detecting

obstacles, causing the wheelchair to stop or avoid collisions during movement. This gesture-based control system offers an intuitive, hands-free way for users to navigate their environment.

In a hand gesture-controlled wheelchair, sensor data processing and safety mechanisms play a critical role in ensuring smooth and secure operation. The ultrasonic sensor continuously monitors the distance between the wheelchair and any obstacles. When no objects are detected within a certain threshold, the wheelchair moves as commanded based on hand gestures. However, if the sensor detects an object

within the predefined safe distance, it sends a signal to the Arduino, prompting the wheelchair to stop or change direction to avoid a collision. In the case of a critical obstacle, where the object is extremely close (less than 10 cm), the wheelchair not only halts immediately but also triggers the buzzer to alert the user. This combination of real-time sensor data and safety responses ensures that the wheelchair operates effectively while protecting the user from potential hazards.

Table.5.2 Sensor Data Processing and Safety Mechanisms

After the construction of a gesture-controlled wheelchair, its appearance will resemble a typical motorized wheelchair but with additional components integrated to allow for gesture control. The robot chassis will support the main frame, which houses the DC motors connected to the wheels for mobility. Mounted on the armrest or handlebars will be the gyroscope sensor, which detects the user's hand gestures. This is typically a small, lightweight component that doesn't take up much space.

Sensor (Ultrasonic)	Detected Object Distance	Action
No Object	Distance > Safe Threshold	Continue Movement
Object Detected	Distance < Safe Threshold	Stop or Change Direction
Critical Obstacle	Distance Very Close (< 10 cm)	Emergency Stop and Trigger Buzzer Alert

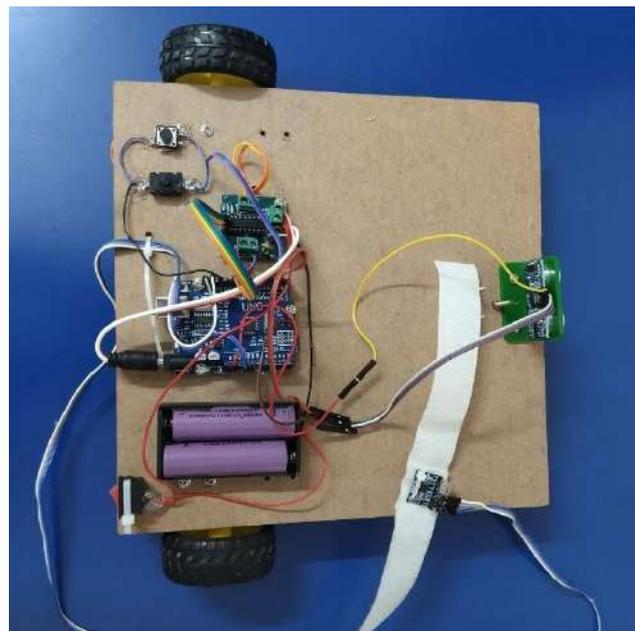


Fig 5.1 Internal structure with hardware components

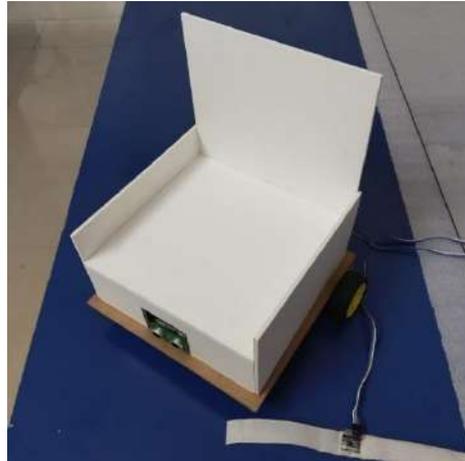


Fig.5.2 Outlook of hand gesture controlled wheel chair

Overall, the wheelchair would look like a standard motorized wheelchair with additional technology that enhances its functionality but without significant

bulkiness, maintaining its practical and accessible design for the user.

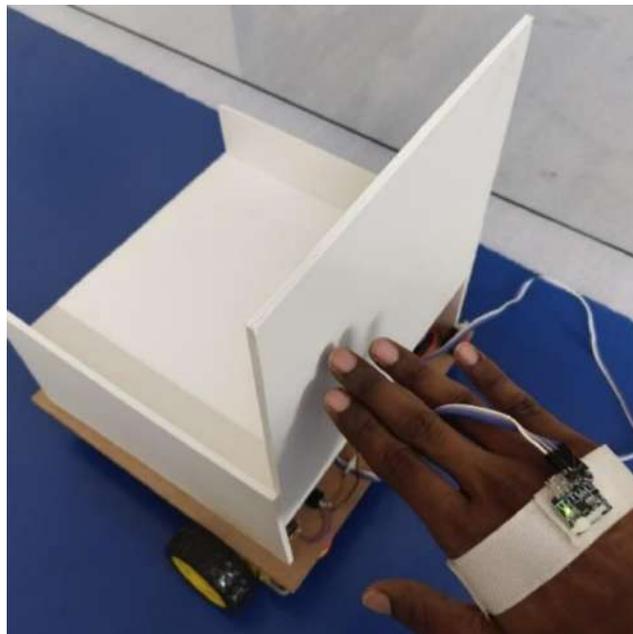


Fig.5.3 Movement in forward direction

Conclusion

Hand gesture-controlled wheelchairs offer a transformative solution for individuals with mobility impairments, enabling users to control their movement through simple, intuitive gestures. These wheelchairs provide greater independence, particularly for those who struggle with traditional control methods, such as joysticks or manual inputs. By leveraging advanced sensors and technology, they offer an accessible and user-friendly experience, especially when combined with smart home integration and adaptive features. However, challenges like high costs, gesture recognition errors, and the need for regular maintenance can limit their widespread adoption. Furthermore, environmental factors, battery life, and the complexity of setup pose additional barriers. Despite these drawbacks, continuous advancements in technology and potential for customization ensure that hand gesture-controlled wheelchairs will play a crucial role in improving mobility solutions, enhancing the quality of life for users by offering greater freedom and autonomy.

Future Scope:

The future of hand gesture-controlled wheelchairs holds great promise, particularly with advancements in gesture recognition technology powered by artificial intelligence and machine learning. These innovations will enhance accuracy and responsiveness, allowing for a broader range of gestures to accommodate users with varying mobility levels. As production costs decrease, these wheelchairs are expected to become more affordable and accessible, particularly in underserved regions. Furthermore, integrating gesture controls with other assistive technologies—such as voice recognition and smart home systems—will create a seamless multimodal experience for users. Enhancements in battery life and sensor reliability will enable better performance in diverse environments, from crowded

public spaces to outdoor settings. Additionally, continuous feedback from users will drive further customization and improvements, ensuring that gesture-controlled wheelchairs evolve to meet the dynamic needs of individuals with disabilities. Overall, these advancements will significantly enhance mobility, independence, and quality of life for users in the years to come.

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