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Smartphone Based Gesture Controlled Wheelchair

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Abstract :
This work introduces a gesture-controlled wheelchair system that enhances mobility for individuals with physical disabilities using a smartphone's built-in accelerometer. By detecting tilt gestures—such as forward, backward, left, and right—the smartphone sends motion commands wirelessly via Bluetooth to a microcontroller, which then controls the wheelchair's movement. This hands-free system eliminates the need for traditional input devices or additional sensors, making it both cost-effective and user-friendly. A mobile application serves as the user interface, capturing real-time motion data to provide intuitive and responsive control. The approach leverages widely available hardware to ensure affordability and scalability, especially in resource-limited settings. This integration of mobile technology and embedded systems offers a practical and accessible assistive solution that promotes independence for users with limited mobility.
Keywords: *Accessibility, Assistive Technology, Bluetooth Communication, Gesture Control, Wheelchair*

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I. Introduction

Mobility is essential not just for physical movement but also for independence and quality of life. For individuals with severe motor impairments, traditional wheelchairs—whether manual or joystick-controlled—often prove inadequate due to limited upper-body strength or dexterity. Over the years, researchers have explored gesture-controlled user interfaces as intuitive alternatives for human-computer interaction [1][2]. Such systems are especially promising for assistive mobility applications, offering hands-free control with minimal physical effort [4].

Advanced mobility solutions like brain-computer interfaces and eye-tracking systems exist but are often prohibitively expensive and technically complex, limiting their practical adoption in low-resource environments [3]. Moreover, existing joystick-operated powered wheelchairs still require fine motor control, which excludes many users with high-level physical disabilities [6].

With the widespread availability of smartphones equipped with motion sensors like accelerometers and gyroscopes, mobile-based gesture recognition has become an affordable and practical solution [5]. These sensors can detect tilt gestures and have been effectively implemented in various remote-control systems, including smart vehicles and robots [8].

This paper presents a low-cost, modular gesture-controlled wheelchair that uses a smartphone's motion sensors and Arduino-based embedded system to interpret directional gestures. The control signals are transmitted wirelessly via Bluetooth to move the wheelchair forward, backward, left, or right. The proposed system prioritizes affordability, simplicity, and usability, making it suitable for users with limited motor control.

II. Design Of Arduino Based Wheelchair

The gesture-controlled wheelchair system is designed as a low-cost, modular, and intuitive solution for individuals with physical disabilities who have limited motor control. At the core of this design is a smartphone, which serves as a gesture input device, detecting directional movements based on built-in motion sensors. These gestures are interpreted in real time and transmitted wirelessly to a control system based on the Arduino Uno microcontroller. The overall system includes the smartphone, Bluetooth communication, an Arduino Uno, a motor driver module (L298D), two BO geared DC motors, a castor wheel for stability, and auxiliary components like a piezo buzzer and an LED bulb for additional user interaction.

The block diagram of the system, shown in Fig. 2.1, outlines the core components and their interaction. The user interacts with a Bluetooth-based mobile application, which translates specific hand gestures into directional commands such as forward, backward, left, and right. These commands are transmitted via Bluetooth to the HC-05 module, which relays them to the Arduino Uno. Based on the received signal, the Arduino processes the input and activates the appropriate motor control logic. The L298D motor driver receives this control data and energizes the DC motors connected to the wheelchair's wheels, causing movement in the desired direction. The power supply is managed using a set of AA batteries, connected through a toggle switch, and all modules are linked using jumper wires for modularity.

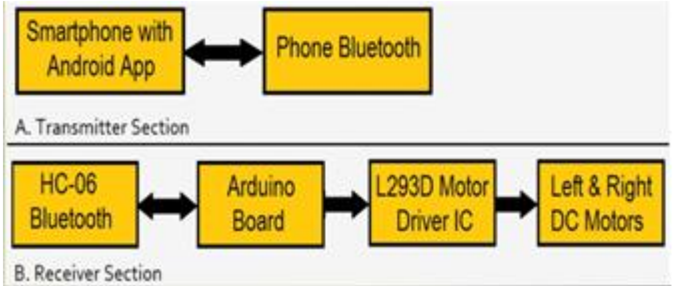

Fig 2.1: Block Diagram of Gesture-Controlled Wheelchair

A crucial feature of the system lies in the smartphone's internal sensors specifically, the accelerometer and the gyroscope. The accelerometer measures the linear acceleration along the X, Y, and Z axes, allowing detection of basic tilting actions. However, the gyroscope plays a more advanced role by measuring the angular velocity, making it possible to detect changes in the orientation of the phone. This combination allows for precise recognition of tilt gestures. As illustrated in Figure 2.2, the gyroscope detects rotation around three primary axes: pitch (forward and backward tilt), roll (side-to-side tilt), and yaw (twisting motion). The system maps these movements to commands that are interpreted by the Arduino to initiate the corresponding motion of the wheelchair.

By leveraging smartphone-based sensing and widely available electronic components, the design offers both simplicity and scalability. It avoids the need for costly gesture recognition equipment, ensuring that the wheelchair can be built and maintained affordably, even in resource-constrained settings. The use of open-source components such as the Arduino Uno and HC-05 Bluetooth module enhances the replicability of the system, while the inclusion of user feedback mechanisms like the buzzer and LED makes the system more interactive and user-friendly.

Fig 2.2: Gyroscope Sensor in Mobile Phone

III. Implementation Of The Proposed Design

The implementation of the gesture-controlled wheelchair system follows a logical and streamlined process. Initially, the mobile application captures motion data from the smartphone's accelerometer and gyroscope sensors. The application continuously monitors for changes in orientation and maps each recognized gesture to a predefined control character such as 'F' for forward, 'B' for backward, 'L' for left, and 'R' for right. These character commands are then sent via Bluetooth to the HC-05 Bluetooth module, which is interfaced with the Arduino Uno microcontroller.

The operational flow of the system is illustrated in the flowchart in Figure 3.1. Once the Bluetooth control app starts transmitting data, the Bluetooth module receives the specific character values and sends them to the Arduino. The microcontroller then checks the incoming signal and determines the appropriate response. Depending on the input, the Arduino sends control signals to the L298D motor driver module. For instance, when a forward tilt is detected and the command 'F' is received, the Arduino energizes both motors in the forward direction. If the tilt is to the right, one motor is slowed or stopped, allowing the wheelchair to turn smoothly.

All components are carefully mounted on a lightweight chassis, and the wiring is arranged for optimal signal integrity and ease of maintenance. The Arduino is programmed using the Arduino IDE with logic that ensures smooth transitions between different movement states. The PWM control provided to the L298D driver allows for efficient motor control and speed regulation. The buzzer and LED are also triggered through digital pins to provide acoustic and visual feedback respectively, enhancing user awareness. The entire system operates wirelessly and hands-free, making it suitable for individuals with minimal dexterity.

This implementation strategy, which blends simplicity with functionality, ensures that the prototype not only performs reliably but is also easy to replicate and maintain. The modular approach means that individual components can be replaced or upgraded without reengineering the entire system.

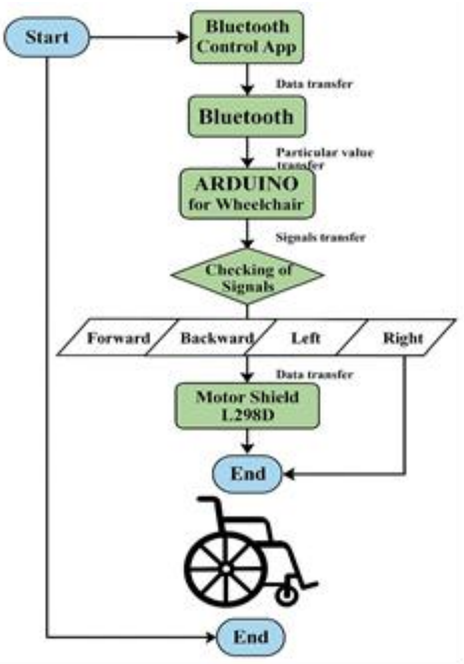

Fig 3.1: Flowchart of Gesture-controlled wheelchair

IV. Results

The prototype was tested in various conditions to evaluate its responsiveness, stability, and accuracy in translating gestures into motion commands. The results confirmed that the system is capable of reliably detecting directional tilts and executing the corresponding movement through the wheelchair's motors. The control commands transmitted from the smartphone were consistently received and interpreted correctly by the Arduino, with no noticeable delay or misinterpretation during testing.

To better illustrate how the input gestures correlate with motor control logic, Table 1 shows the observed relationship between tilt direction, logic signals at the motor control pins (IP1 and IP2), and the resulting wheelchair movement. This table summarizes the expected behavior for each gesture input.

Table 1: Tilt Gestures and Corresponding Wheelchair Movements

TILT	IP1	IP2	DIRECTION
Steady state	Low	Low	Stop
Tilt Forward	High	High	Forward
Tilt Backward	High	High	Backward
Tilt Right	Low	High	Right
Tilt Left	High	Low	Left

The mobile application Fig 4.1 implements a sophisticated gesture control interface that translates natural hand movements into wheelchair navigation commands. The gesture control system utilizes the smartphone's built-in accelerometer and gyroscope sensors to detect device orientation and movement patterns.

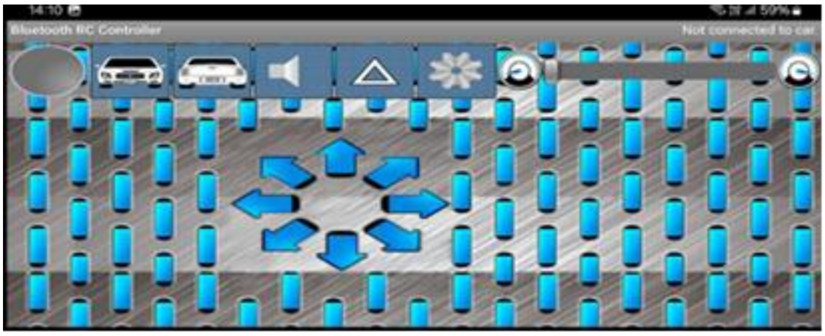

Fig 4.1: Controller interface on the Mobile Device

Developed smart phone based gesture-controlled wheelchair shown in Fig 4.2 is powered by an Arduino Uno.It uses an L298N motor driver to control two DC geared motors for movement.Gesture inputs from a glove sensor are transmitted via Bluetooth using the HC-05 module. A battery pack powers the entire system, with a toggle switch for control.The setup also includes LEDs and a buzzer for feedback during operation.

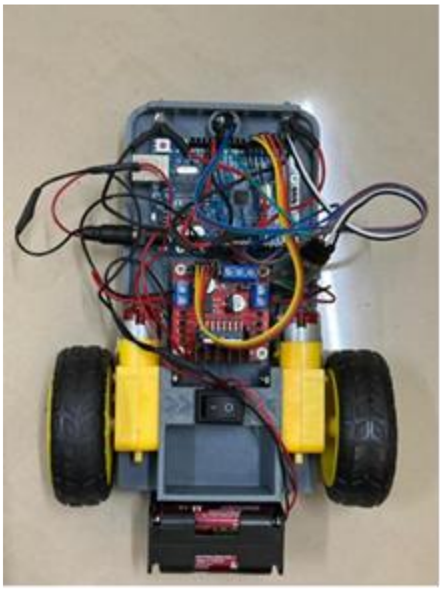

Fig 4.2: Top View of the Prototype

The results indicate that the system interprets and processes tilt-based gestures accurately. The Bluetooth communication between the smartphone and Arduino remained stable within a typical indoor range, and the control delay was minimal, making the system feel responsive and easy to use. The buzzer and LED indicators functioned correctly, providing the user with real-time feedback. The use of the gyroscope and accelerometer in tandem improved the precision of gesture recognition, reducing false commands and enhancing the reliability of movement control.

V. Conclusion

The Gesture Controlled Wheelchair successfully demonstrates how smartphone-based motion sensing can be effectively used to aid individuals with mobility challenges. By utilizing the accelerometer sensor embedded in modern smartphones, combined with the wireless communication capabilities of the HC-05 Bluetooth module and the control logic implemented through Arduino, a low-cost, user-friendly, and hands-free wheelchair control system was developed.

This system allows users to navigate the wheelchair intuitively through simple hand or phone gestures, enhancing their independence and quality of life. The incorporation of additional features like buzzer alerts and LED indicators further contributes to safety and usability. The project not only highlights the practical application of embedded systems and IoT in assistive technology but also opens up possibilities for future improvements, such as obstacle detection, voice control, or integration with mobile apps for more advanced functionality.

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