International Journal on Science and Technology (IJSAT)

E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

Gesture-Controlled wheelchair

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Abstract

Assistive technologies are at the forefront of enhancing the quality of life among individuals with physical disabilities. Traditional wheelchairs, although effective, are often challenging for individuals who possess limited hand strength or mobility. This review of literature focuses on gesture-controlled wheelchairs, an emerging class of intelligent mobility devices that implement hand or body gestures to aid in control. These systems generally utilize sensors such as accelerometers, gyroscopes, or vision modules to detect user gestures and transform them into direction commands for navigation. The survey explores various methodologies, which include sensor fusion, machine learning gesture recognition algorithms, and real-time signal processing techniques. Moreover, the review also explores system architectures, control accuracy, flexibility of users, and safety aspects. By comparative analysis of the literature at hand, this paper establishes the existing limitations—e.g., gesture misclassification, latency, and environmental sensitivity—and outlines future directions like integration with IoT, adaptive learning systems, and enhanced user interfaces. Gesture-controlled wheelchairs are a potentially useful technology for hands-free mobility, particularly for individuals with severe motor impairment.

Keywords: Gesture-control , accelerometer , signal processing ,directional commands

1. Introduction

Mobility is an integral aspect of human autonomy and well-being. For individuals with physical disabilities, especially those suffering from disorders such as quadriplegia, muscular dystrophy, or extreme paralysis, traditional wheelchairs may be less accessible since it requires manual or joystick-assisted control. Gesture-operated wheelchairs over the last couple of years have emerged as the futuristic answer to this issue by enabling users to control wheelchairs using basic hand or body gestures.

Gesture-controlled systems use sensor technologies such as accelerometer, gyroscopes, or computer vision to identify and understand user gestures in real-time. The gestures are then translated into individual wheelchair movement, allowing users to navigate their space using a method independent of conventional controls. Such interaction not only enhances independence but also significantly reduces physical effort associated with operation.

The development of gesture-based interfaces relies on research in artificial intelligence, signal processing, and embedded systems. By incorporating microcontroller like Arduino or Raspberry Pi and wireless communication modules, the systems are becoming low-cost, compact, and user-friendly.

2. Literature Review

2.1: Principal and gesture recognition

- The hand-gesture wheelchair system operates based on motion detection and gesture recognition that convert certain hand gestures into corresponding directional commands for the wheelchair. In the center of the system is an accelerometer or a gyroscope sensor usually attached to the user's hand that detects the change in orientation and movement.

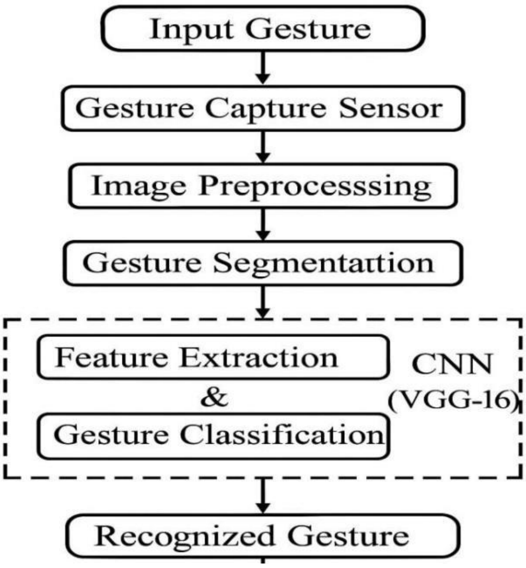
[13] IoT technology is used to enable remote alerting and monitoring with the aid of networked devices to enhance real-time response in situations of emergency.

The sensors pick up acceleration and angular velocity, which are processed by a microcontroller such as an Arduino or. Upon the user's gesture—forward bending of the hand, backward bending, left, or right—the sensor picks up the movement and sends data signals to the microcontroller. This device interprets the gestures based on per-programmed thresholds and outputs corresponding signals to the motor driver circuits. The motor drivers control the wheelchair's motion—moving it in one direction, reversing, or rotating based on the perceived gesture.

3. Methodology

- Hand-gestured wheelchairs utilize a combination of computer vision, machine learning, and embedded systems in order to interpret user gestures as navigation commands. As described in [2]. A vision-based approach utilizing YOLOv8n and MediaPipe achieves real-time gesture detection with high accuracy, with the system interpreting camera feed to distinguish gestures and navigate. Similarly, [1] utilizes sensor-based approaches that capture hand movement data via accelerometers and flex sensors, which get translated into direction inputs. The approaches emphasize low cost, low latency, and simplicity so that the technology is cheap and fast enough for real-world use.[13]The application of gesture control with IoT makes the design flexible and scalable for possible integrations such as GPS tracking or voice commands. In [7], writers present an IoT-based wheelchair system that seeks to enhance user safety through embedded fall detection and control capabilities. The system incorporates a variety of sensors such as accelerometer and gyroscopes to monitor movement and identify falls in real time.The plan of accomplishment by the end of the project is that to have a full working omnidirectional hand gestured wheelchair and with additional features such as motion detection in real time.

Figure 1: Methodologies of Hand gestured wheelchair



5. Conclusion and Future Work

• The integration of hand gesture recognition technology into wheelchair systems is a revolutionary move towards enabling individuals with mobility impairments. Through cheap sensors and intelligent algorithms, users can now operate wheelchairs through basic hand gestures, promoting their independence and quality of life. Authors such as [1] and [2] demonstrate the effectiveness of gesture-based interfaces, with [2] showcasing a 99.3% recognition accuracy high-accuracy real-time system based on YOLOv8n and MediaPipe. Despite these advancements, some concerns such as ambient light interference, limited gesture vocabularies, and flexibility with user-specific motion persist.[13]The study details the pragmatic viability of combining gesture recognition and IoT in aiding assistive mobility technology.[8]The merging of hand gesture control can quite readily add to the ease of use for persons with limited mobility, being more of a natural control system than joystick-controlled wheelchairs. The system allows greater autonomy for users of wheelchairs by reducing the reliance upon continuous caregiver involvement, specifically in indoor environments. Future studies can focus on the incorporation of multimodal inputs such as eye-gaze or voice for hybrid control systems, enhancing robustness in dynamic environments, and utilization of machine learning for personalized gesture mapping.

[15] The suggested system successfully identifies real-time falls through IoT sensors, with timely detection of key incidents pertaining to individuals or wheelchairs.Additionally, the integration of advanced fall detection and IoT capabilities can enhance user autonomy and safety.

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