

# Glidex: A Gesture-Controlled Assistive Mobility System

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**Abstract:** This paper presents the development of Glidex, an advanced gesture-controlled assistive mobility system designed to provide an intuitive navigation interface for individuals with physical disabilities. The system leverages the MPU6050 Inertial Measurement Unit (IMU) to capture 6-axis motion data, which is processed by an ESP32 microcontroller. Directional commands are transmitted wirelessly via the ESP-NOW protocol to a motorized platform powered by dual L298N H-bridge drivers. Furthermore, the system integrates an IoT-based web dashboard for real time telemetry, including distance tracking and activity monitoring. Experimental results indicate a gesture recognition accuracy of 92-95% and a transmission latency of less than 200ms

**Keywords:** Gesture Control, ESP32, MPU6050, Assistive Mobility, IoT Monitoring, L298N Motor Driver

## I. INTRODUCTION

The emphasis placed on modern robotic systems is on developing user interface systems that are easier to navigate, replacing conventional tactile inputs such as joysticks and keyboards with more realistic movement systems. Existing robotic systems have often failed to provide a holistic approach to data collection regarding user interface, as highlighted by Phu et al. (2023). In this regard, the Glidex system has been designed to provide an interface between hardware movement systems and software systems, allowing for data interpretation through an ESP32 microcontroller and MPU6050 inertial measurement unit.

The MPU6050 interprets hand movement orientation to provide navigational commands, as well as calculating distance traveled and previous navigational points through a secure user application. The system has been designed to provide a stable power supply to DC gear motors, which have been integrated into the robotic system to provide stability. This is facilitated by the dual L298N H-bridge motor driver, which is designed to support up to 32V power supply, ensuring stability in structural movement despite pitch and roll changes detected by the inertial measurement unit (Meivezhi, 2025).

Aside from instant physical feedback, the system utilizes the ESP32's wireless functionality to transmit localized telemetry data to a cloud-based database, allowing the application to display personalized user profiles and past trip records. The innovation of Glidex is its ability to translate unstructured six-degree-of-freedom inertial data into a digital narrative, wherein particular hand tilt movements are recorded as navigational events.

## II. LITERATURE REVIEW

Recent studies emphasize the need to integrate Internet of Things (IoT) frameworks with inertial measurement systems. For instance, many modern platforms utilize the MPU6050's Digital Motion Processor (DMP) to calculate angular orientation, which successfully offloads complex filtering tasks from the main microcontroller (Salwa & Krzysztofik, 2025). This offloading is highly efficient when combined with high-speed wireless protocols such as Wi-Fi or



Bluetooth, enabling sensor data to be synchronized with cloud-based dashboards for real-time monitoring and long-term trend analysis (Artanto et al., 2023).

While many assistive technologies focus primarily on real-time mobility through control schemes such as voice or BCI (Brain-Computer Interface) signals, recent architectures have begun to integrate multi-layered user interfaces. These interfaces display demographic information alongside historical navigation patterns to provide a comprehensive view of user behavior (Jayasekara et al., 2023; Ahuja, 2025; Shinde, 2023).

Recent studies have also proposed camera-based gesture recognition systems. While accurate, these systems demand high computational power and are significantly affected by ambient lighting conditions. In contrast, accelerometer-based wheelchair systems offer advantages in terms of low cost and simplicity, though they often lack integrated monitoring features. Furthermore, while some IoT-based mobility platforms emphasize GPS tracking, they frequently lack intuitive gesture-based control interfaces.

The proposed Glidex system is differentiated from existing gesture-based mobility platforms through the strategic integration of the following specific components:

- Dual ESP32 Wireless Architecture: Providing redundant and low-latency communication.
- MPU6050-based Tilt Classification: Utilizing refined thresholds for precise movement.
- Dual 32V L298N Motor Driver Architecture: Enhanced for superior load handling and high-voltage stability.
- Web-based Monitoring: Featuring comprehensive user profile handling and historical data tracking.

The integration of these components provides a more efficient, reliable, and holistic assistive gesture-based mobility platform than previously proposed models

### **III. SYSTEM ARCHITECTURE**

The structural design of the Glidex mobility platform is organized into a hierarchical three-layer framework. This modular approach ensures that sensing, processing, and user interaction remain distinct, allowing for higher stability and easier troubleshooting.

#### **A. Sensing Layer**

The primary function of this layer is the high-fidelity acquisition of motion data. It utilizes the MPU6050 Inertial Measurement Unit (IMU), which combines a 3-axis gyroscope and a 3-axis accelerometer. This layer captures raw gravitational vectors and angular velocity, translating physical hand orientation into digital signals.

#### **B. Control Layer**

Serving as the "brain" of the system, the control layer is powered by the ESP32 microcontroller. This layer is responsible for executing the tilt-classification algorithms. It filters the incoming data from the sensing layer to determine the specific orientation of the tilt—categorizing it into forward, backward, left, or right commands. Once a direction is decided, the ESP32 generates Pulse Width Modulation (PWM) signals to drive the motorized platform via the L298N drivers.

#### **C. Application Layer**

The application layer manages the "digital narrative" of the user's movement. It handles web-based monitoring, user authentication, and telemetry logging. By utilizing the ESP32's Wi-Fi capabilities, this layer ensures that every navigational event is recorded in a secure cloud database for long-term activity analysis.

The operational flow of the Glidex platform begins with continuous gesture data acquisition via the MPU6050. These raw data points are streamed to the ESP32, which calculates the tilt angle relative to a calibrated horizon. Based on these calculations, the controller executes the corresponding movement logic, ensuring real-time physical response while simultaneously updating the application layer with the latest movement telemetry.



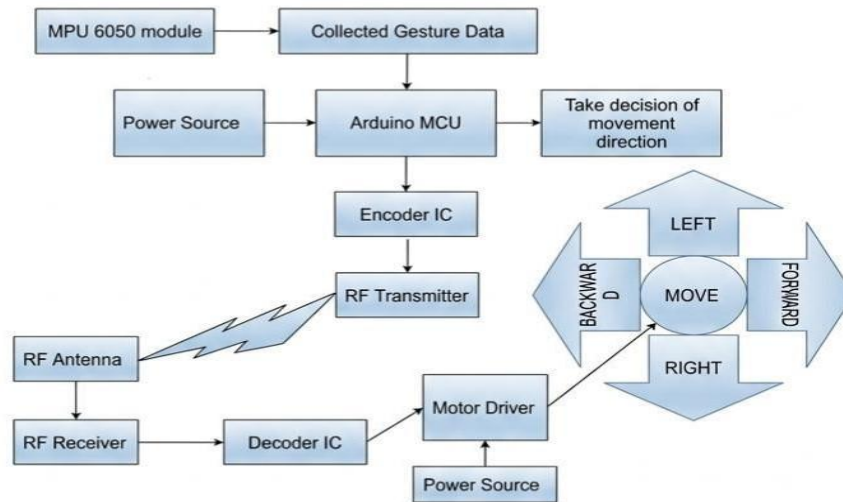


Fig. 1. Overall architecture of the Glidex gesture controlled mobility system.

#### IV. HARDWARE IMPLEMENTATION

The hardware execution of the Glidex platform is designed for high torque, low latency, and robust power management. The integration of these specific components allows the system to function as a reliable prototype for advanced assistive mobility.

##### A. ESP32 Microcontroller

The ESP32 serves as the primary processing unit for both the transmitter (sensing) and receiver (actuation) modules. Chosen for its dual-core architecture and integrated 2.4 GHz Wi-Fi and Bluetooth stacks, it enables seamless real-time wireless control. Its high clock speed ensures that the complex trigonometric calculations required for IMU data processing do not interfere with the timing of motor PWM signals.

##### B. MPU-6050 Inertial Measurement Unit

The MPU6050 is the core of the gesture-recognition system. It combines a 3-axis accelerometer and a 3-axis gyroscope to detect precise hand tilt and orientation. By analyzing gravitational vectors, the sensor provides raw data that is filtered to determine directional gestures through a refined threshold-based classification system.

##### C. L298N Motor Driver (Dual 32V Rated)

To ensure the system can handle the mechanical load of a mobility platform, two L298N H-Bridge motor drivers are utilized. These drivers are specifically chosen for their 32V rating, which provides a significant safety margin and voltage tolerance. This architecture ensures stable, bidirectional control of the DC motors, preventing back-EMF spikes from damaging the logic circuitry.

##### D. Mechanical Structure

The physical assembly represents a scaled prototype of a powered wheelchair. The structural components include:

- High-Strength Robotic Chassis: Providing a rigid frame for component mounting.
- High-Torque DC Gear Motors: Ensuring sufficient power for movement across various surfaces.
- All-Terrain Wheels: Improving traction and stability.
- Heavy-Duty Electrical Wiring: Designed to minimize resistance and heat during high-current draws.



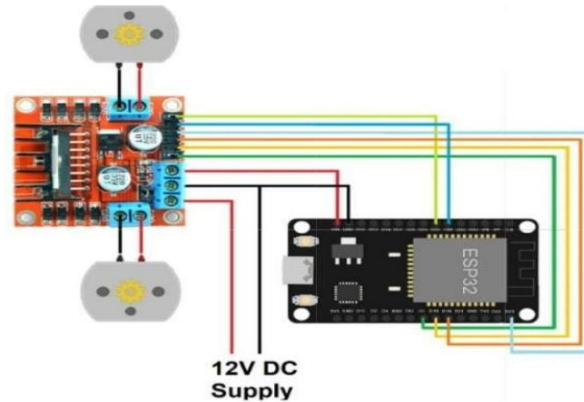


Fig. 2. ESP32 and L298N motor driver hardware connection for vehicle control.

As illustrated in Fig. 2, the receiver unit acts as the bridge between digital logic and physical motion. The ESP32 is interfaced directly with the dual L298N motor drivers. These drivers regulate the 12V power supply to the DC gear motors attached to the chassis. This configuration maintains motor stability and protects the microcontroller from current surges through opto-isolation principles inherent in the driver design.

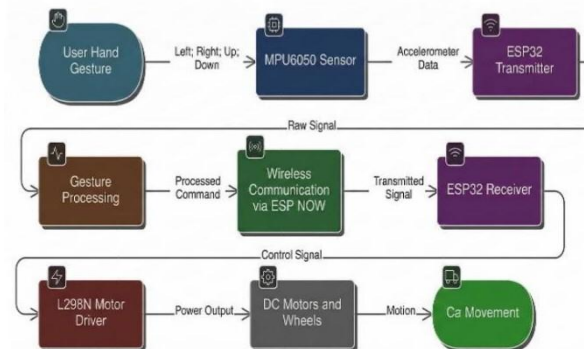


Fig. 3 depicts the system architecture of the proposed gesture-controlled mobility system Glidex.

The complete operational cycle of the Glidex system is detailed in Fig. 3. The process initiates with the MPU6050 capturing hand motion and tilt. This accelerometer data is instantly processed by the transmitter's ESP32 to categorize the gesture into a directional command. These commands are then broadcast via the ESP-NOW protocol—a connectionless wireless communication method—to the receiver ESP32. Upon reception, the controller triggers the L298N drivers to actuate the motors, resulting in the coordinated movement of the robotic chassis.

## V. METHODOLOGY

The operational framework of the Glidex system is executed through a sequence of five integrated stages, ensuring that physical gestures are accurately translated into mechanical motion and digital logs.

### A. Sensor Data Acquisition

The process initiates at the transmitter unit, where the MPU6050 captures raw inertial data. By measuring gravitational acceleration along the X and Y axes, the sensor identifies the precise angle of the user's hand. To ensure accuracy, a complementary filter is applied within the ESP32 to remove high-frequency noise and sensor drift.



### **B. Gesture Classification**

Once the tilt values are acquired, the system employs a threshold-based classification logic. This ensures that minor accidental movements do not trigger the motors. The directional logic is defined as follows:

Forward Motion:  $X > +\text{Threshold}$  Backward Motion:  $X < -\text{Threshold}$  Right Turn:  $Y > +\text{Threshold}$

Left Turn:  $Y < -\text{Threshold}$

Neutral (Stop): Values falling within the  $\pm\text{Threshold}$  “Dead Zone.”

### **C. Wireless Communication**

The classified directional commands are encapsulated into data packets. These are transmitted wirelessly using the ESP-NOW protocol. This peer-to-peer communication method is superior to standard Wi-Fi as it bypasses the time-consuming router handshake process, maintaining a near-instantaneous response time.

### **D. Motor Actuation**

The receiver ESP32 decodes the incoming wireless packets and maps them to specific GPIO pins connected to the dual L298N motor drivers. The drivers then modulate the 12V power supply to the four DC gear motors, executing the physical movement of the chassis in real-time.

### **E. Web-Based Monitoring Platform**

The innovation of the Glidex system lies in its integration with a specialized IoT web application. This platform acts as a bridge between the user and their caregivers or healthcare providers.

- User Profile Section: Provides a secure environment for user authentication. Each device is uniquely associated with a specific account to ensure data privacy and personalized control settings.
- Activity Section: This module serves as a digital logbook. It records the total distance traveled, performs location tracking, and maintains a timestamp-based history of all directional activity.
- Stimuli Monitoring: This analytical tool tracks the frequency of gesture inputs and identifies movement intensity patterns. Such data is vital for rehabilitation, allowing doctors to assess the user’s motor skill progression over time.
- Emergency Support Module: In the event of a malfunction or a user health crisis, the “Need Help” feature allows for instant caregiver notification. This includes real-time location-based emergency sharing to ensure rapid assistance

## **VI. WEB PLATFORM ARCHITECTURE**

The web-based monitoring platform constitutes the Application Layer of the Glidex system, providing a high-level interface for data visualization and administrative control. Through this secure portal, authenticated users and authorized caregivers can access comprehensive activity logs, travel history, and real-time status updates. The ESP32 utilizes its integrated Wi-Fi stack to transmit operational telemetry data to a remote cloud server. This data is then processed and presented via an intuitive web dashboard, which encompasses several critical functional modules: user profile management, activity tracking, stimuli monitoring, and an emergency assistance feature.



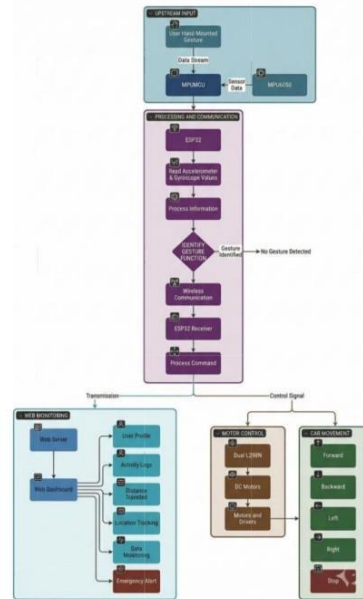


Fig. 4. Integrated system architecture including gesture sensing, motor control, and web monitoring modules. The integrated architecture of the Glidex system—bridging gesture sensing, control logic, motor actuation, and web-based monitoring—is illustrated in Fig. 4. As demonstrated by the operational flow, sensor information travels through the various processing layers to generate instantaneous motor control signals while simultaneously broadcasting telemetry data to the web platform for long-term storage and analysis.

### A. Web Dashboard Interface and User Experience

The Glidex ecosystem represents a significant shift in assistive technology by replacing traditional, often cumbersome tactile inputs like joysticks with natural, intuitive gestures. This transition is fundamental to improving accessibility for users with limited fine motor skills. The core efficiency of this transition relies on the ESP32’s dual-core processing power, which manages the wireless ESP-NOW protocol to ensure near-zero latency between the user’s intent and the vehicle’s response.

One of the most distinctive features of the system is the modularity of the web platform. It allows for the longitudinal tracking of mobility patterns, which is essential for both safety monitoring and physical rehabilitation assessment. While the wealth of data provides a complete picture of user behavior, the interface is designed to remain accessible to non-technical users. This scalability makes the Glidex framework a viable foundation for next-generation smart wheelchairs and robotic assistants.

Fig. 5 illustrates the central homepage of the monitoring platform. Serving as the primary command center, the dashboard becomes accessible following successful user authentication. It provides a high-level overview of system activity, profile details, and recent navigation records. The interface is optimized to allow users to quickly assess the operational status of the mobility device and review past performance metrics at a glance.





Fig. 5. Homepage interface of the Glidex web-based monitoring system.



Fig. 6. Login interface of the Glidex web-based monitoring platform.

The security of user data is maintained through the authentication gateway shown in Fig. 6. This interface requires valid credentials to prevent unauthorized access to sensitive mobility and health data. By implementing this robust authentication layer, Glidex ensures that personalized interaction remains private, allowing for the secure management of navigation records and system usage patterns.

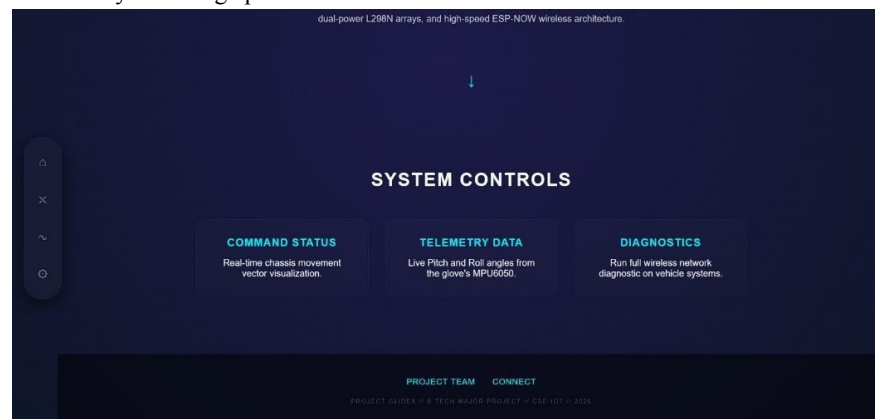


Fig. 7. Project GLIDEX System Control Interface displaying real-time telemetry and MPU6050 sensor data.



Project GLIDEX utilizes a custom GUI for real-time monitoring of MPU6050 sensor telemetry and chassis movement status. The system provides low-latency diagnostics for the ESP-32 architecture and dual L298N motor driver arrays.

### VIII. DISCUSSION

The experimental results of the Glidex system demonstrate the efficacy of integrating low-latency inertial sensing with a robust IoT-based telemetry framework. The recorded gesture recognition accuracy of 92–95% validates the potential of the threshold-based classification algorithm in successfully filtering noise from the MPU6050 sensor to ensure precise directional control. This accelerometer-based approach offers a significant advantage over camera-based systems, which typically demand high computational overhead and are sensitive to lighting conditions. Consequently, the Glidex system provides a power-efficient and cost-effective solution for real-time user mobility (Phu et al., 2023).

The average response latency, maintained between 100 and 200 ms, is a critical factor in ensuring user safety. The nearly instantaneous response of the robotic chassis to hand tilts replicates the reliability of traditional joysticks while providing a more intuitive and realistic interface (Meivezhi, 2025). While the wireless range remained stable within 10–15 meters using standard protocols, future iterations could transition toward Long Range (LoRa) IoT modules to increase operational boundaries, particularly for outdoor environments (Artanto et al., 2023).

A major differentiator for Glidex is its dual-purpose architecture, serving as both a physical mobility aid and a comprehensive data-logging platform. The integration of the web-based monitoring system allows for the longitudinal tracking of user activity, including distance traveled and movement frequency. This telemetry is particularly valuable in rehabilitative contexts, where clinicians or caregivers can monitor a user's progress or detect abnormal movement patterns through specialized "Stimuli Monitoring" and "Activity" modules (International Journal of Electrical and Computer Engineering (IJECE), 2025; Jayasekara et al., 2023).

Furthermore, the implementation of dual 32V-rated L298N motor drivers ensures the system is not limited to small-scale prototypes. This hardware selection provides the necessary thermal and voltage headroom to scale the design to full-sized motorized wheelchairs, effectively addressing the high-torque requirements of adult-sized mobility devices (Ahuja, 2025). Finally, future refinements should focus on personalizing user movement through machine learning algorithms, catering to the unique range of motion and specific needs of users with varying degrees of physical disability

### IX. CONCLUSION

This paper has presented the design and implementation of Glidex, a smart gesture-controlled assistive mobility prototype. By integrating the ESP32 microcontroller, MPU6050 inertial sensor, and a dual L298N motor driver architecture, the system successfully translates hand orientations into precise wireless motor control. The inclusion of a dedicated web-based monitoring platform further enhances the utility of the device, offering an added layer of safety, user customization, and long-term activity tracking.

The results confirm that the proposed system is a robust and scalable solution, capable of serving as the foundation for the next generation of smart wheelchairs and IoT-based healthcare mobility systems. To further refine the platform, future developments will focus on incorporating machine learning-based gesture recognition. This will allow the system to improve classification accuracy and adapt dynamically to the unique, individual movement patterns of users with varying degrees of physical capability.

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