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Design and Fabrication of Hand Gesture Controlled Wheelchair

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ABSTRACT –

This Project presents the design and development of a hand gesture-based wheelchair motion system utilizing ESP32 microcontroller and wiper motors. The system enables individuals with limited mobility to control the wheelchair's movement through intuitive hand gestures detected by a sensor-equipped glove. By leveraging the ESP32's capabilities for wireless communication and motor control, the wheelchair responds to specific gestures, translating them into corresponding movements. This innovative approach enhances accessibility and independence for users, offering a seamless and intuitive interface for navigating their surroundings with ease.

Key Words – Hand Gesture, Wheelchair, Wiper Motor, ESP32, Wireless

I. INTRODUCTION

In an era of advancing technology, ensuring accessibility and independence for individuals with limited mobility is paramount. This paper introduces a groundbreaking approach to wheelchair navigation through the design and development of a hand gesture-based control system. Leveraging the versatility of the ESP32 microcontroller, ADXL345 Sensor and the reliability of wiper motors, this system empowers users to maneuver their wheelchairs effortlessly using intuitive hand gestures detected by a specially designed glove. By eliminating the need for traditional joystick controls, this innovation not only enhances accessibility but also fosters a sense of autonomy for users. Through a seamless integration of hardware and software, this project aims to redefine mobility assistance by providing a user-friendly and efficient means of navigating environments with precision and ease.

II. NEED FOR INNOVATION

The necessity for innovation in mobility assistance technologies has never been more evident. Traditional wheelchair control mechanisms often pose challenges for individuals with limited dexterity or mobility, hindering their ability to navigate independently and comfortably. The emergence of gesture-based control systems presents a promising solution to this longstanding issue. By harnessing the capabilities of the ESP32 microcontroller, ADXL345 Sensor and wiper motors, this project seeks to address the need for intuitive and accessible wheelchair navigation. The integration of hand gestures, detected through a specialized glove, offers users a natural and efficient means of controlling their mobility devices. This innovation not only enhances the quality of life for individuals with disabilities but also promotes inclusivity and autonomy in their daily activities. Furthermore, by leveraging cutting-edge technology, this endeavor strives to push the boundaries of assistive technology, setting a new standard for accessibility and empowerment in the field of mobility assistance.

III. LITERATURE REVIEW

[1] Jesse Leaman, and Hung M. La, Senior Member, IEEE "A Comprehensive Review of Smart Wheelchairs": A smart wheelchair (SW) is a power wheelchair (PW) to which computers, sensors, and assistive technology are attached. In the past decade, there has been little effort to provide a systematic review of SW research. This paper aims to provide a complete state-of-the-art overview of SW research trends. We expect that the information gathered in this study will enhance awareness of the status of contemporary PW as well as SW technology, and increase the functional mobility of people who use PWs. We systematically present the international SW research effort, starting with an introduction to power wheelchairs and the communities they serve. Then we discuss in detail the SW and associated technological innovations with an emphasis on the most researched areas, generating the most interest for future research and development. We conclude with our vision for the future of SW research and how to best serve people with all types of disabilities.

People with cognitive/motor/sensory impairment, whether it is due to disability or disease, rely on power wheelchairs (PW) for their mobility needs. Since some people with disabilities cannot use a traditional joystick to navigate their PW they use alternative control systems like head joysticks, chin

joysticks, sip-n-puff, and thought control. To accommodate the population of individuals who find it difficult or impossible to operate a PW, several researchers have used technologies originally developed for mobile robots to create smart wheelchairs. A smart wheelchair (SW) typically consists of either a standard PW base to which a computer and a collection of sensors have been added, or a mobile robot base to which a seat has been attached. Pineal et al. 2011 argue that the transition to wheelchairs that cooperate with the user is at least as important as that from manual to powered wheelchairs, possibly even more important since this would mark a paradigmatic rather than merely a technological shift.

[2] Prof. R. S. Nipanikar, Vinay Gaikwad "A Smart and Sensitive Wheel Chair for Physically Challenged":

This project is on automatic wheelchair for physically disabled people. A dependent user recognition voice system and ultrasonic and infrared sensor systems has been integrated in this wheelchair. In this way we have obtained an automatic wheelchair which can be driven using voice commands and with the possibility of avoiding obstacles by using infrared sensors and down stairs or hole detection by using ultrasonic sensors. The wheelchair has also been developed to work on movement of accelerometer which will help for the person whose limbs are not working. Accelerometer can be attached to any part of body of physically disabled person which he can easily move like head, hand etc. It has also provision of joystick for disabled person who can easily move his/her hand. Electronic system configuration, a sensor system, a mechanical model, voice recognition control, accelerometer control and joystick control are considered.

Robotics Wheelchairs extend the capabilities of traditional powered devices by introducing control and navigational intelligence. These devices can ease the lives of many disabled people, particularly those with severe impairments by increasing their range of mobility. For handicapped people human found a wheel chair which can be moved by using hands for those who don't have legs. But the peoples who don't have legs as well as hands cannot move their wheel chair self. They need some other person to move their wheel chair. But sometimes such person faces so many problems if they did not get any person to move their wheel chair.

IV. PROBLEM STATEMENT

In the absence of hand gesture-based movement in wheelchairs, individuals with limited mobility face significant challenges in controlling their mobility devices effectively. Traditional control mechanisms, such as joysticks or buttons, may be difficult or impossible for users with severe motor impairments to operate, leading to a loss of independence and frustration. Moreover, these conventional controls often require precise hand movements or fine motor skills, which may be impaired due to conditions such as paralysis or arthritis. Consequently, users may experience limitations in navigating their environment, performing daily activities, and engaging in social interactions, resulting in a diminished quality of life. Additionally, reliance on caregivers or assistance for basic mobility tasks may lead to feelings of dependency and loss of dignity for wheelchair users. Thus, the lack of hand gesture-based movement in wheelchairs underscores the urgent need for innovative solutions to enhance accessibility and empower individuals with mobility impairments to lead fulfilling and independent lives.

V. OBJECTIVE

To design and develop a hand gesture-controlled wheelchair system using readily available components such as the ESP32 microcontroller, HC-05 Bluetooth module, ADXL345 accelerometer sensor, relay module, wiper motors, and a rechargeable battery. The goal is to create a user-friendly interface where individuals with limited mobility can operate the wheelchair by simple hand gestures detected by the accelerometer sensor. This project aims to provide a cost-effective and accessible solution for enhancing the mobility and independence of users with physical disabilities.

VII. WORKING PRINCIPLE

The ADXL345 sensor is attached to the user's hand or wrist to detect hand gestures. The accelerometer data from ADXL345 is read by the ESP32 to determine the direction and speed of the hand movement. The ESP32 processes the accelerometer data to recognize specific hand gestures. Based on the recognized gestures, the ESP32 decides the wheelchair's movement commands. The ESP32 sends the movement commands to the HC Bluetooth module via UART communication. The HC Bluetooth module wirelessly transmits these commands to the relay module, which in turn controls the wiper motor. The relay module acts as a switch to control the wiper motor's direction and speed. Depending on the movement commands received, the relay module adjusts the motor's operation to move the wheelchair in the desired direction and at the desired speed. The wheelchair's battery powers all the components, including the ESP32, ADXL345 sensor, Bluetooth module, relay module, and wiper motor.

VIII. DESIGN OF THE PROTOTYPE

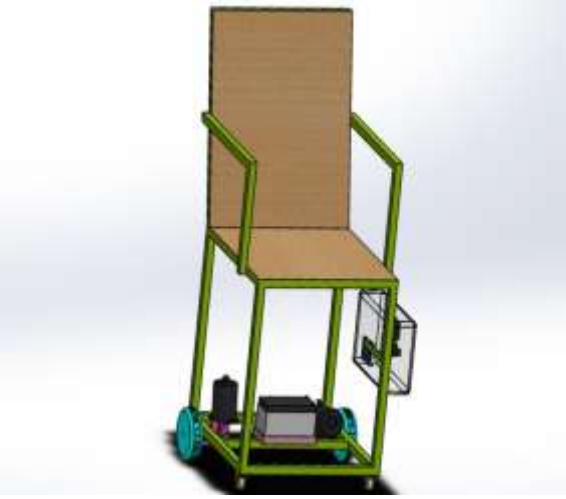

Figure 1 Prototype Design

IX. MAIN COMPONENTS OF HAND GESTURE CONTROLLED WHEELCHAIR

- **Caster wheel:**

A caster (or castor) is an undriven wheel that is designed to be attached to the bottom of a larger object (the "vehicle") to enable that object to be moved. Common inexpensive casters may include a brake feature, which prevents the wheel from turning. This is commonly achieved using a lever that presses a brake cam against the wheel. However, a swivel caster is still able to move around slightly, in a small circle rotating around offset distance between the vertical shaft and the centre of the locked wheel.

Figure 2 Caster wheel

- **Wiper Motor**

Wiper motors are electromechanical devices primarily used in automotive applications to drive windshield wipers for clearing rain, snow, or debris from the windshield of vehicles. These motors are designed to provide the necessary torque and motion required to move the wiper arms across the windshield efficiently. Typically, wiper motors consist of a motor unit, gearbox, and linkage mechanism. The motor unit converts electrical energy into mechanical motion, while the gearbox amplifies the torque output to ensure effective wiper operation. The linkage mechanism connects the motor to the wiper arms, transmitting the rotational motion generated by the motor to the wiper blades.

One of the key characteristics of wiper motors is their ability to operate at variable speeds and in both directions. This versatility allows for customizable wiper operation to suit changing weather conditions and driver preferences. Additionally, wiper motors are designed to withstand harsh environmental conditions, including exposure to moisture, temperature fluctuations, and mechanical stress, ensuring reliable performance in diverse operating environments.

Figure 3 Wiper Motor

- **ESP32 Node MCU:**

The ESP32 is a powerful microcontroller widely used in IoT (Internet of Things) applications. It combines Wi-Fi and Bluetooth connectivity, making it ideal for projects requiring wireless communication. With its dual-core processor and rich set of peripherals, the ESP32 can handle complex tasks efficiently. Its low power consumption and small form factor make it suitable for battery-powered devices. Overall, the ESP32 enables developers to create versatile, connected devices for various applications.

Figure 4 ESP32 Node MCU

- **ADXL 345 Accelerometer Sensor**

The ADXL345 is a compact 3-axis accelerometer that measures acceleration in three directions: up-down, left-right, and forward-backward. It offers high-resolution measurements and can detect movements up to 16 times the force of gravity. With its digital output, it can easily communicate with devices like microcontrollers. One of its advantages is low power consumption, making it suitable for battery-powered applications. The accelerometer also comes with built-in features such as tap detection, activity monitoring, and free-fall detection. It's found in mobile devices for screen rotation and gaming, wearable devices for tracking steps, industrial machines for vibration monitoring, and even in some healthcare devices to monitor patient movement. Integrating the ADXL345 is straightforward; you connect it to a device using SPI or I2C, configure its settings, and then read the acceleration data to understand how the device is moving.

Figure 5 ADXL 345 Accelerometer Sensor

- **Hc-05 Bluetooth Module**

To set up Wireless Serial Communication, HC-05 Bluetooth Module is most demanding and popular due to its low price and extremely high features.

This module can be used in Master or Slave Mode and easily switchable between these two modes, by default Slave mode is configured.

Modes can be changed using AT Commands.

The slave mode in HC-05 cannot initiate a connection to another Bluetooth device but can accept connections. Master mode can initiate a connection to other devices.

Figure 6 Hc -05 Bluetooth module

Specification

1. Profiles: Bluetooth serial port Profile
2. Bluetooth protocol: Bluetooth Specification v2.0+EDR
3. Frequency: 2.4GHz ISM band
4. Modulation: GFSK (Gaussian Frequency Shift Keying)
5. Speed: Asynchronous: 2.1Mbps (Max) / 160 kbps, Synchronous: 1Mbps/1Mbps
6. Power supply: +3.3VDC 50mA
7. Working temperature: -20 ~ +75Centigrade
8. Dimension: 26.9mm x 13mm x 2.2 mm

- **Battery**

The sealed Lead Calcium Maintenance-Free Battery is an advanced and economical rechargeable battery. It has several properties different from other types of batteries maintenance Free - As it is valve-regulated, sealed and glass-mat is utilized, acid is trapped inside. So, refilling is not needed and is leakproof. Charging at constant voltage is the most suitable and commonly used method for charging batteries. The charger voltage must be stabilized in a narrow range and with a device to suppress the initial current to less than 0.3C. The initial current limitation can be accomplished by a constant-current regulator, a properly designed output voltage from the power transformer, or by creating the overall impedance of the circuit (such as using a current regulating resistor). During the final stage of charge, the current decreases automatically.

Figure 7 12V Battery

X. CIRCUIT DIAGRAM

10.1 Transmitter Circuit

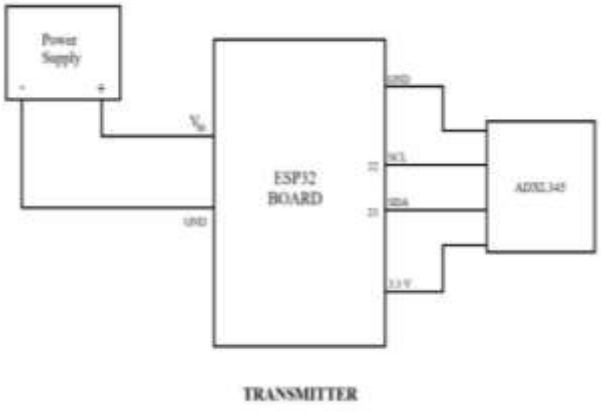

Figure 8 Transmitter Circuit

10.2 Receiver Circuit

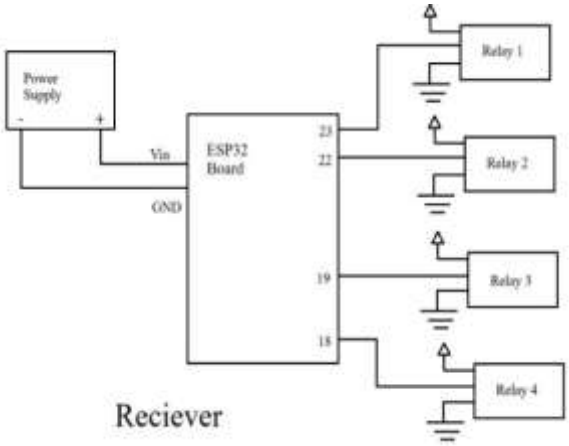

Figure 9 Receiver Circuit

XI. FUTURE SCOPE

The future scope for the design and development of the hand gesture-based wheelchair motion system using ESP32 microcontroller, ADXL345 Sensor and wiper motors, along with a hand gesture-detecting glove, holds immense potential for further advancements and applications. One avenue for future exploration involves enhancing the system's gesture recognition capabilities through machine learning algorithms, enabling it to adapt and recognize a wider range of gestures with greater accuracy. Additionally, incorporating additional sensors and feedback mechanisms could further improve the system's responsiveness and safety features. Moreover, exploring the integration of other assistive technologies, such as obstacle detection and navigation aids, could broaden the system's utility and address additional needs of individuals with disabilities. Overall, the future scope entails continuous innovation and refinement to further enhance the functionality, accessibility, and effectiveness of the hand gesture-based wheelchair motion system, ultimately improving the quality of life for users.

XII. CONCLUSION

In conclusion, the design and development of the hand gesture-based wheelchair motion system using ESP32 microcontroller and wiper motors, in conjunction with a hand gesture motion module for ESP32 with a glove, represents a significant leap forward in mobility assistance technology. By seamlessly integrating cutting-edge hardware and sophisticated algorithms, this system offers individuals with disabilities an intuitive and accessible means of controlling their wheelchairs through natural hand gestures. The ESP32 microcontroller serves as the central hub, orchestrating communication between components and enabling precise wheelchair motion control. Coupled with wiper motors for propulsion and a hand gesture detection module for

intuitive interaction, the system empowers users to navigate their surroundings with confidence and independence. Moving forward, further research and development in this field hold promise for even greater advancements in mobility assistance, ultimately improving the quality of life for users and promoting equality and accessibility for all.

Figure 10 Final Prototype

XIII. REFERENCES

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