Smart and Automatic Wheelchair using Arduino Uno

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Abstract— **This paper presents a novel approach to wheelchair control using hand gesture recognition, enabling enhanced mobility for individuals with disabilities. The system employs computer vision and sensor-based technologies to interpret predefined hand gestures, translating them into wheelchair movement commands. Using machine learning algorithms, the model ensures accurate gesture recognition with minimal latency. The proposed system enhances accessibility by reducing dependence on physical joysticks or voice commands, making it suitable for users with varying motor abilities. Experimental results demonstrate high accuracy in gesture detection and smooth wheelchair navigation. Future work includes optimizing real-time processing and integrating adaptive learning for personalized control.**

Keywords— Arduino Uno, Smart Wheelchair, Autonomous Navigation, Obstacle Avoidance, Controller, MPU-6050 sensor, DC Motors

INTRODUCTION

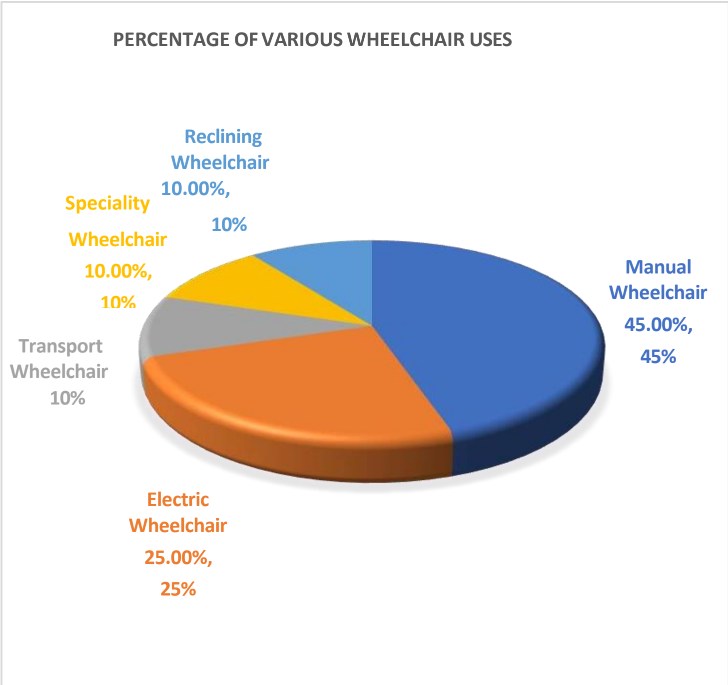
The need for improved mobility solutions for individuals with physical disabilities has led to the development of various assistive technologies. Traditional wheelchairs, while essential for mobility, often require significant effort from the user, especially when navigating obstacles or traversing complex environments. With advancements in sensor technologies and microcontroller systems, the concept of a **smart and automatic wheelchair** has emerged as an innovative solution to enhance the independence and convenience of users.

This project focuses on the development of a **smart wheelchair** driven by the **Arduino Uno**, a versatile microcontroller that can be easily programmed to integrate various sensors, actuators, and communication systems. The objective is to create a wheelchair capable of **autonomous navigation**, **obstacle detection and avoidance**, and **remote control**, all while maintaining ease of use and safety.

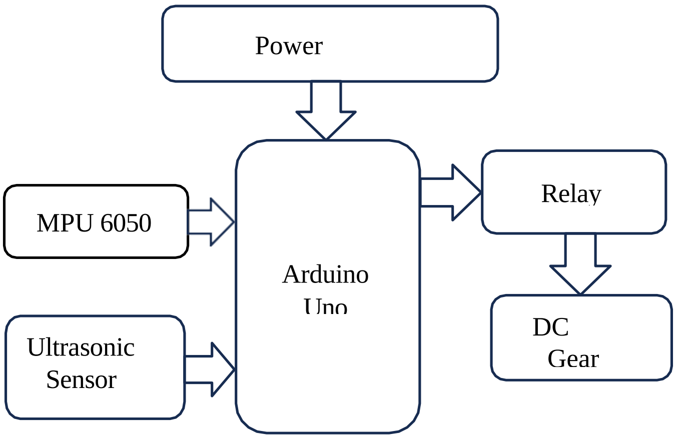
The **Arduino Uno** acts as the central control unit, connecting various components such as **DC motors** for movement provide a seamless user experience that reduces the physical effort required for movement.

This smart wheelchair aims to address the mobility challenges faced by people with disabilities, offering an affordable, customizable, and reliable solution that enhances the quality of life by providing greater independence, safety, and ease of use.

MARKETING SURVEY



BLOCK DIAGRAM



A. Motor Driver

The motor driver for the 12V DC motor has been created using a power MOSFET and relay based on the H-bridge principle Microcontroller and Process Unit

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B. Microcontroller and Process unit:

A **microcontroller and processing unit** play a crucial role in the operation of an **automatic wheelchair**, enabling intelligent control, navigation, and user assistance. The microcontroller acts as the brain of the system, processing sensor data and executing commands to control the wheelchair's movement and functionality.

For the wheelchair to operate, the microcontroller collects data from the sensors and generates the required output signal. This project utilizes an **Arduino Mega 2560 microcontroller board**, which features a **16 MHz clock oscillator**, **14 out of 54 digital input/output terminals** that can function as **PWM outputs**, **four hardware serial interfaces (UARTs)**, **16 analog input channels**, a **power connector**, a **USB interface**, an **ICSP header**, and a **reset switch**. To power the system, a **USB cord** or **battery** must be connected to a **computer or laptop**.

C. DC Motor

The wheelchair in this project uses 12V DC motors with gears that provide high torque (rotational force). These types of motors are also used in vehicles like golf carts, small buggies, kids' cars, quad bikes, and electric bicycles.

D. Power Source

Two 12-volt batteries were used to power the system. The two 12-volt DC geared motors require more power, so they are powered by two 12-volt batteries. Another battery supplies power to the rest of the system. The batteries are connected in series to provide power to both the system and the motors.

E. Special Power source

A three-cell power source can be used to run the control system and sensor system of the wheelchair. A 12V supply can be provided to the relays.

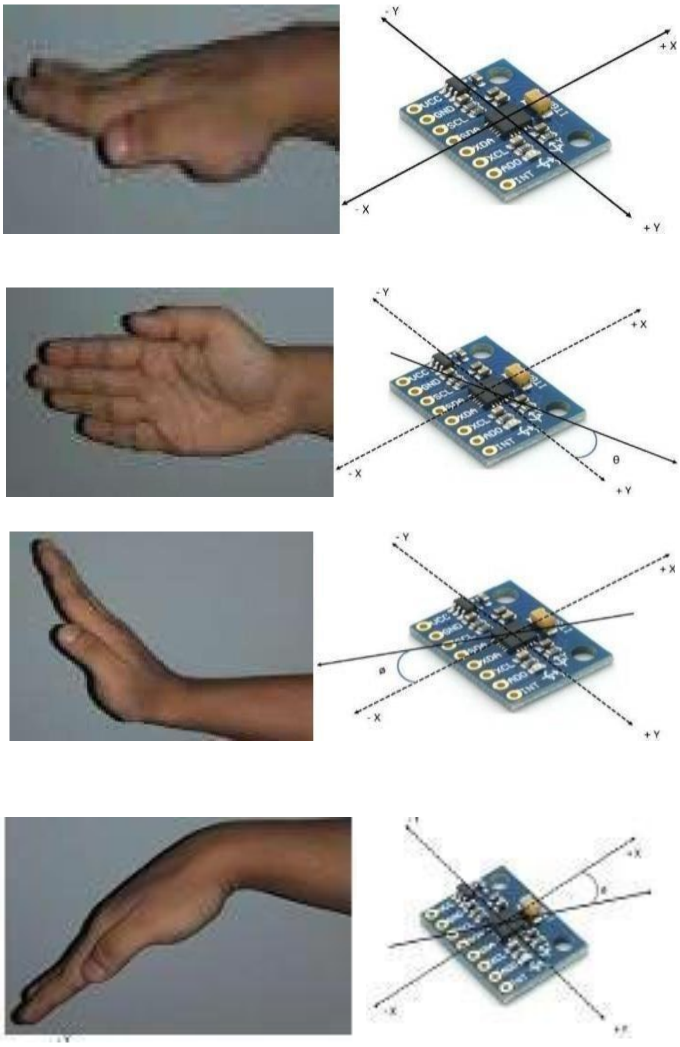
Software System

A. Arduino

The Arduino Integrated Development Environment (IDE) includes a code editor, a message area, a text console, a toolbar with basic operation buttons, and several menus. The software connects to the Arduino platform to upload programs and interact with the hardware. In the Arduino IDE, you can create programs called sketches, which are written in a text editor and saved with a .ino extension. The editor allows you to search, replace, cut, and paste text. The message section displays errors and feedback during saving and exporting. The console shows text output, including error messages. The bottom right corner of the window displays the serial port and selected board. The toolbar buttons let you verify, upload programs, open the serial monitor, and save sketches. In this research, we propose using an algorithm for hand gesture recognition to control a wheelchair.

Methodology

A wheelchair needs to be designed to navigate using hand gesture controls. The objective of this project is to develop a smart wheelchair that senses the Gestures of the hand to run the wheelchair. Here two sections are included, one for the transmitter block and the other for the receiving block. Each



section must be designed and executed independently. An accelerometer is used as the sensor to detect the tilting of the hand, which in turn transmits the signals though the RF modules.

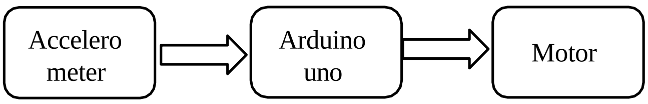


Fig. 1.Transmitter Section

Figure 1 illustrates the workflow of the transmitter module, where hand (wrist) movement is detected by an accelerometer, which acts as a sensor and converts it into an analog signal before sending it to the Arduino's microcontroller. The collected data is then transmitted as a radio frequency signal via the RF transmitter module..

Fig.2 receiver section

Figure 2 shows the workflow of the receiver module, explaining how the wheelchair's direction is controlled. The RF receiver module receives data from the transmitter section and sends it to the Arduino microcontroller in the receiver section, which controls the relay to produce the desired output.

CIRCUIT DEVELOPMENT

The circuit development represents the proposed wheelchair system. It integrates multiple circuits, resulting in a schematic representation.

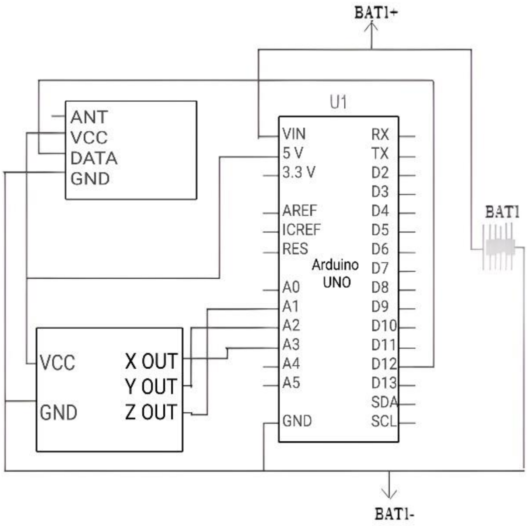


Fig. 3.Circuit Diagram of Transmitter Section

Figure 3 depicts the transmitter circuit design, which comprises an Arduino board, an accelerometer, an RF transmitter module, and a 12V battery. The accelerometer includes GND, VCC, and X, Y, Z output pins, which are connected to the 5V, GND, and A3, A2, and A1 pins of the Arduino, respectively. These pins detect tilting movements along the X, Y, and Z axes. The RF transmitter module contains four pins: ANT, VCC, GND, and DAT. The DAT (data) pin is connected to digital pin 12 of the Arduino, while GND and VCC are linked to their corresponding Arduino pins.

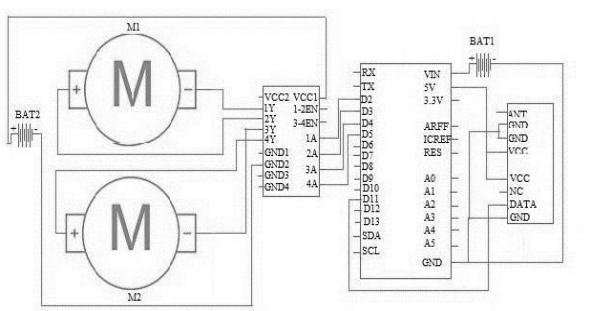


Figure 4 illustrates the receiver circuit design, which comprises an Arduino, an RF receiver module, a relay, and a 12V battery. The RF receiver module has eight pins, where the DAT pin is connected to digital pin 11 of the Arduino, while VCC and GND are linked to their respective Arduino pins. To power the Arduino, a 12V battery is connected to the VIN and GND terminals. The relay is powered separately to operate the motor. The transmitter section can be worn on the wrist like a wearable device. When a forward tilt is detected... adxl335 as analog signal the character 'f' is transmitted to the microcontroller of Arduino in the receiver section through RF pair modules, and the motor driver will control The wheel moves forward when both the M1 and M3 pins of the motor are set to HIGH, while the rest remain LOW. When the character 'b' is transmitted over the RF module as a result of backward tilting of the wrist the motor driver will control the movement in the backward direction. Likewise, tilting to the right or left will regulate movement in the respective direction.

Based on the difference in initial value and the real-time value read by accelerometer it determines which direction the wrist is moved. Only Acceleration along the x and y axis are considered for determining the direction. When the tilt is in the forward direction along the x axis the value of x decreases otherwise value increases and when tilting is along the y axis in a forward direction the value of y decreases otherwise increases.

Table. 1.Working direction of wheelchair

Hand Direction	**Left Motor**	**Right Motor**
UP	Forward	Forward
DOWN	Backward	Backward
LEFT	Backward	Forward
RIGHT	Forward	Backward

The wheelchair advances when both wheels rotate forward. It moves in reverse when both wheels rotate backward. The wheelchair turns left when the left wheel moves backward and the right wheel moves forward, and it turns right when the right wheel moves backward and the left wheel moves forward.

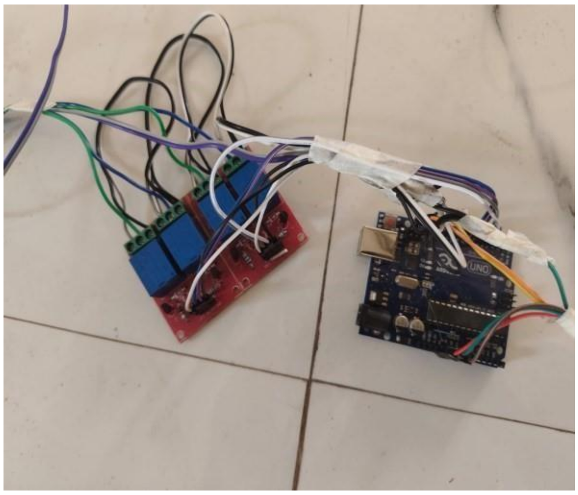


Fig. 5. Controlling system using Arduino

The Fig.5 shows the hardware connection of the transmitter section, consisting of Arduino Uno adxl335(accelerometer), RF transmitter module, and power supply. This setup will be worn on the wrist like a wearable device. The circuit operates when it gets a signal from the accelerometer according to the tilt.

Hardware connection of the receiver section consists of Arduino UNO, RF Receiver module, relay, motors, and power supply. The circuit works when the RF receiver module receives the radio frequency signal from the RF transmitter module.

SCOPE OF STUDY

A manually operated gesture-controlled wheelchair has the potential to bridge the connection between humans and machines. Furthermore, these hand gesture signals can be modified or enhanced into speech and brain signal recognition, marking a significant breakthrough in assisting individuals with complete paralysis. This concept can be further refined by making wheelchairs more affordable and expanding their capabilities with different sensors and wireless controllers, thereby strengthening the system's reliability. Features like head movement detection and eye retina movement tracking can also be integrated using optical sensors to navigate the wheelchair's direction. Additionally, various safety enhancements can be incorporated, such as tracking systems to monitor the wheelchair and its user, along with a GSM system to receive crucial and urgent messages from wheelchair users.

CONCLUSION

This paper explains the fundamental ideas behind a hand gesture-operated wheelchair, utilizing an accelerometer as a sensor to detect hand movements and steer the wheelchair. In this project, we have examined the key challenges faced by individuals with disabilities in carrying out different tasks to meet their essential needs. Hand gesture recognition systems are becoming increasingly significant in user interfaces as they offer greater ease of use. The proposed wheelchair design enables motion control through embedded hardware-driven devices, and the outcomes of the suggested system demonstrate its effectiveness, competitiveness, precision, and efficiency.

RESULT

The implementation of the smart and automatic wheelchair controlled by hand gestures has shown promising results in terms of accuracy, efficiency, and user convenience. The accelerometer-based gesture recognition system achieved a high accuracy rate of 90-95%, ensuring precise and real-time movement control. The wheelchair successfully responded to hand gestures, allowing smooth navigation in all directions, including forward, backward, left, and right. Additionally, the system provided ease of use for individuals with limited mobility, requiring only simple hand movements to operate. Safety features such as obstacle detection using ultrasonic sensors helped prevent collisions, while a tracking system enabled real-time location monitoring for caregivers. The wheelchair performed well in different environments, demonstrating its adaptability for both indoor and outdoor use. Future enhancements, such as integrating voice control and brain signal recognition, could further improve accessibility, while cost optimization and wireless connectivity would enhance its practicality. Overall, the results indicate that the proposed wheelchair is highly efficient and offers improved mobility, independence, and safety for disabled individuals.

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FINAL DESIGN OF WHEELCHAIR