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Head Gesture Controlled Wheelchair with Voice-Based Home Automation

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ABSTRACT:
This project presents the design and development of a smart assistive system that combines a head gesture-controlled wheelchair with voice-based home automation. The system is developed to enhance mobility and independence for physically challenged individuals by providing an intuitive and hands-free control mechanism.

The wheelchair movement is controlled using head gestures detected through sensors mounted on a wearable module, enabling directional navigation such as forward, backward, left, and right. In addition to gesture control, voice commands are integrated to operate the wheelchair driver, offering an alternative and flexible mode of control.

Furthermore, the system incorporates voice-based home automation to control three electrical appliances, such as lights and fans. Users can operate these appliances through simple voice commands, making the environment more accessible and user-friendly.

The integration of gesture recognition and voice control into a single system improves usability, safety, and convenience. This project demonstrates an effective approach toward assistive technology and smart home integration, contributing to improved quality of life for users with physical disabilities.

KEYWORDS: Head Gesture Control, Smart Wheelchair, Voice Recognition, Home Automation, Assistive Technology, IoT, ESP8266, Sensor-Based Control, Voice Commands

I. INTRODUCTION

In recent years, assistive technologies have gained significant importance in improving the quality of life for individuals with physical disabilities. Traditional wheelchairs require manual effort or joystick-based control, which may not be convenient or usable for people with severe mobility limitations.

To address this challenge, intelligent control systems using gestures and voice recognition have emerged as effective solutions.

This project focuses on the development of a head gesture-controlled wheelchair integrated with voice-based home automation. The system enables users to control wheelchair movements through simple head gestures, detected using sensors mounted on a wearable device. This approach provides a hands-free and intuitive method of navigation, making it suitable for users with limited hand mobility.

In addition to gesture control, the system incorporates voice recognition technology to operate both the wheelchair and home appliances. Users can control essential devices such as lights and fans using voice commands, enhancing convenience and independence in daily activities. The integration of these features creates a unified system that bridges mobility assistance and smart home control.

By combining gesture-based navigation with voice-enabled automation, this project aims to deliver a cost-effective, user-friendly, and efficient assistive solution. It contributes to the advancement of smart healthcare technologies and supports the goal of enabling independent living for individuals with disabilities

II. EXISTING SYSTEM

The existing system consists of a head motion-controlled wheelchair designed for physically disabled individuals who are unable to use their hands. It operates by detecting the tilt movements of the user's head (forward, backward, left, and right) using an MPU6050 accelerometer sensor. These signals are processed by a microcontroller (Arduino) and transmitted wirelessly via Bluetooth to control the movement of the wheelchair.

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The system is divided into two sections: a transmitter unit mounted on the user's headgear to capture gestures, and a receiver unit mounted on the wheelchair that drives the motors through a motor driver. Additionally, it includes ultrasonic sensors for obstacle detection and health monitoring features such as pulse and vibration sensors, which can send alerts using a GSM module. Overall, the system enables basic mobility and safety for users through gesture-based control.

III. PROPOSED SYSTEM

The proposed system combines a head gesture-controlled wheelchair with voice-based home automation to assist physically challenged individuals. Wheelchair movement is controlled using head gestures detected by sensors, enabling directions like forward, backward, left, and right.

In addition, voice commands are used to control both the wheelchair and home appliances such as lights and fans. A microcontroller (ESP8266) processes the inputs and controls the motor driver and relay modules.

This integrated system provides a simple, hands-free, and efficient solution for mobility and home appliance control.

The system works by combining head gesture detection and voice command recognition to control the wheelchair and home appliances. Motion sensors mounted on a cap detect head movements and send signals to the microcontroller, which interprets them to control the direction of the wheelchair through a motor driver.

At the same time, voice commands are processed by a voice recognition module or IoT platform, allowing the user to control wheelchair movement and switch ON/OFF appliances like lights and fans. The microcontroller then activates the corresponding motors or relays based on the received commands.

Thus, the system provides a hands-free and efficient way to control both mobility and home appliances.

BLOCK DIAGRAM:

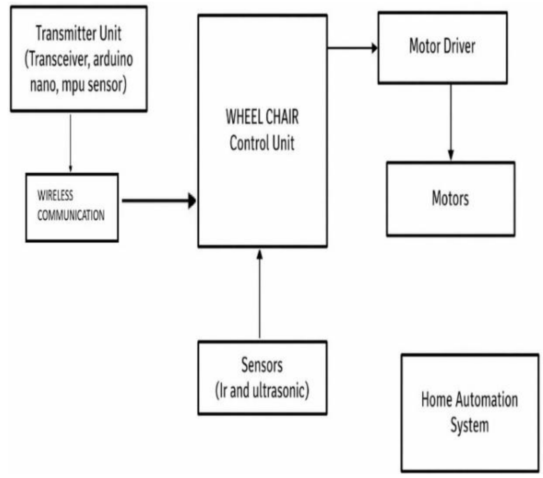

Fig1: Block Diagram of the System Prototype

BLOCK DIAGRAM EXPLANATION:

1. Transmitter Unit :

(Transceiver, Arduino Nano, MPU sensor) This is the user-side control unit .Arduino Nano: Acts as the microcontroller that processes input data. MPU Sensor (e.g., accelerometer/gyroscope) Detect head tilt movement and the transceiver sends the processed control signals wirelessly to the wheelchair using nRF24L01 with Adapter Module. The nRF24L01 is a low-power 2.4 GHz wireless transceiver module used for short-range communication between microcontrollers. The nRF24L01 can operate in both transmitter and receiver modes and supports multiple channels and addresses, enabling communication between multiple devices. the nRF24L01 with adapter is used to establish wireless communication between the control unit and the wheelchair system, ensuring smooth and real-time transfer of control signals without physical connetions.

2. Wheelchair Control Unit :

This is the brain of the wheelchair. Receives signals from the transmitter. Interprets the commands .Makes decisions based on sensor inputs like obstacle detection and voice commands.

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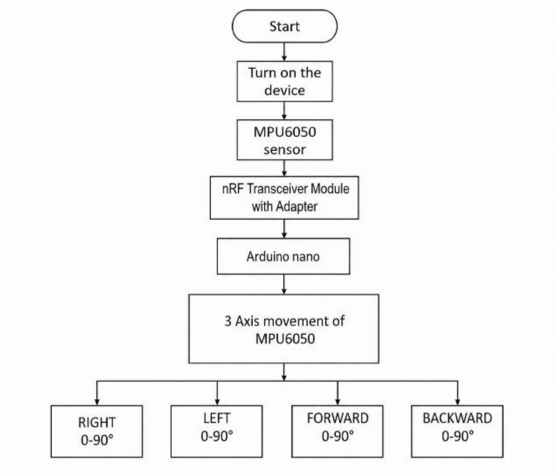

Fig.2 Flowchart of Transmitter Section

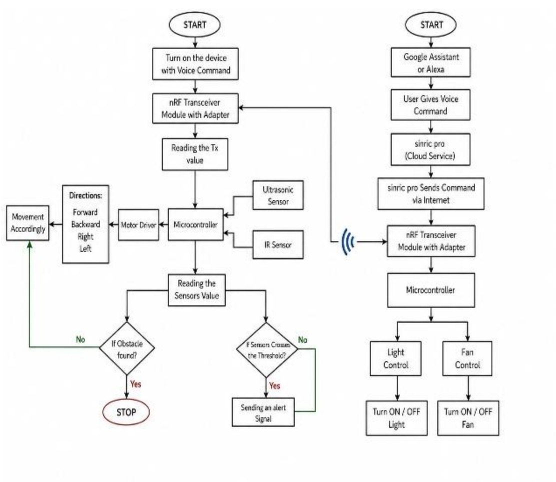

Fig.3. Flowchart of Receiver Section with Home automation

2.1 Motor Driver:

BTS 7960 Motor Driver, this acts as an interface between the control unit and motors. Microcontrollers cannot supply enough current to drive motors directly. The motor driver amplifies signals from the control unit. the BTS7960 is used to control the wheelchair motors based on signals received from the microcontroller (Arduino Nano). It supports both direction and speed control of motors. The direction is controlled using logic input pins, while speed is controlled using PWM (Pulse Width Modulation) signals

2.2 Motors:

These are the actuators that physically move the wheelchair .Typically DC motors connected to wheels. Controlled in direction and speed.

2.3 Sensors (IR and Ultrasonic):

An IR Obstacle Sensor is an electronic device used to detect obstacles in front of it using infrared (IR) light. An Ultrasonic Sensor is a device used to measure distance by using ultrasonic sound waves. It works on the principle of SONAR (Sound Navigation and Ranging). The sensor has two main parts: a transmitter and a receiver. The transmitter emits high-frequency sound waves (usually around 40 kHz), which travel through the air. When these waves hit an object, they bounce back toward the receiver.
These provide environment awareness.IR Sensors: detect the edges like staircase and helps as anti-fall system and Ultrasonic Sensors Measure distance to objects using sound waves.

3. Home Automation System:

This extends functionality beyond mobility. Allows the wheelchair system to control home appliances (light, fan, TV etc.) Can be controlled by his/her voice through his/her mobile assistance (like google, Alexa etc...,) Relay modules are widely used in home automation, industrial control systems, motor control, and IoT projects and in this project, Sinric Pro is used to implement voice-based home automation and wheelchair control. The ESP8266 connects to Wi-Fi and communicates with the Sinric Pro cloud. When the user gives a voice command (e.g., “Turn on light” or “Move ”), the command is processed by Alexa or Google Assistant and sent to the Sinric Pro server

SCHEMATIC DIAGRAM:

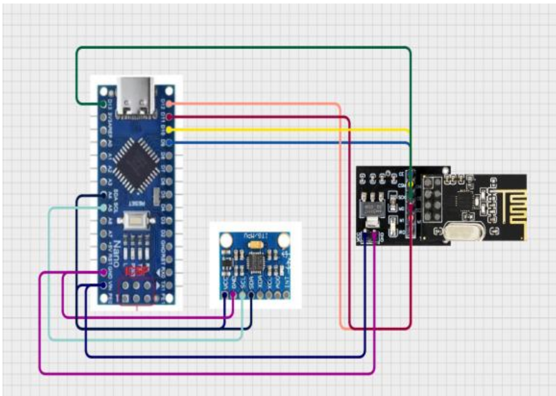

Fig.2 Transmitter circuit.

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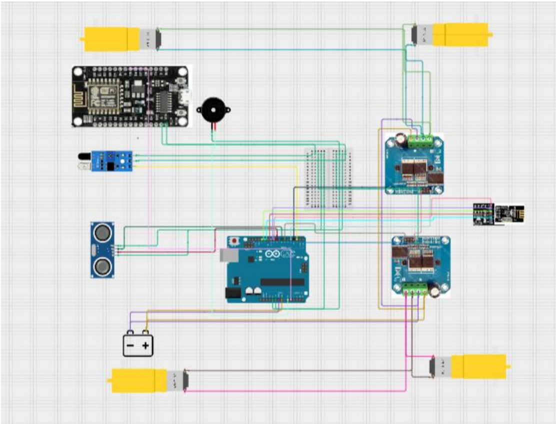

Fig.3 Receiver circuit

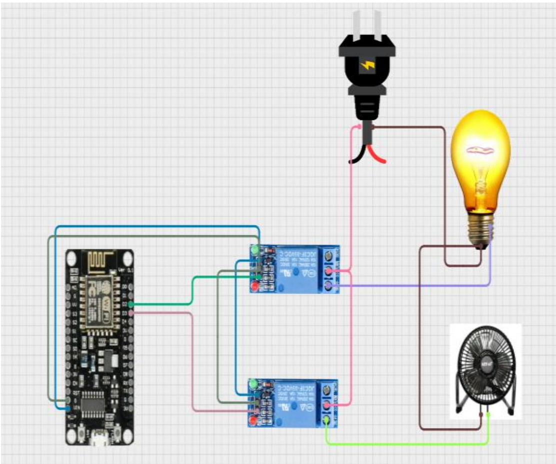

Fig.4 Home Automation circuit.

IV . RESULTS

The voice recognition module effectively identified predefined commands to control both the wheelchair and home appliances like light and fan. The appliances were switched ON/OFF reliably through relay modules, demonstrating proper integration of home automation with the assistive system.

During testing, the system performed well in indoor environments with minimal noise interference. However, slight delays or inaccuracies were observed in voice recognition under noisy conditions. The gesture control was found to be consistent, but required proper calibration of sensors for accurate performance.

Overall, the system proved to be efficient, user-friendly, and reliable. The integration of gesture and voice control enhanced flexibility and usability, making it a practical solution for assistive mobility and smart home automation.

Fig.5

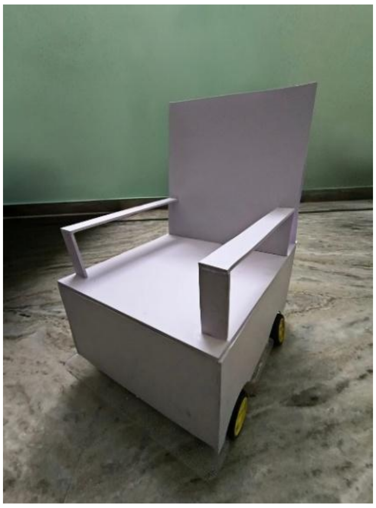

Fig.6

Fig 5, 6: Prototype of wheelchair

Fig 7: Transmitting section

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Fig.8 Receiving section

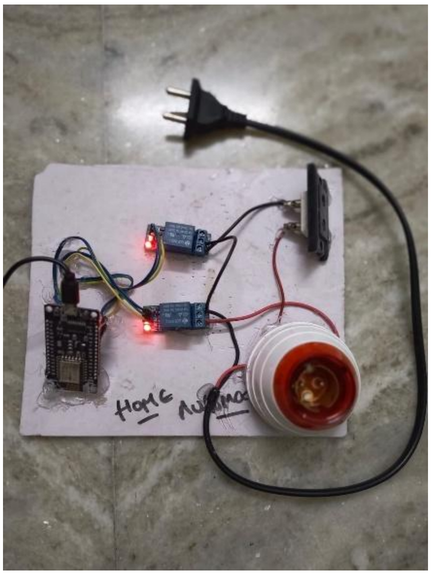

Fig.8.Home automation

V . CONCLUSION

The proposed system successfully integrates head gesture control and voice recognition to operate a wheelchair and home appliances. It provides a hands-free, user-friendly solution that enhances mobility and independence for physically challenged individuals. By combining assistive technology with home automation, the system improves convenience, safety, and overall quality of life.

The system can be further enhanced by improving voice recognition accuracy using AI-based models and adding obstacle detection for better safety. It can be expanded to control more home appliances and integrated with mobile applications for remote monitoring. Additionally, features like GPS tracking, health monitoring, and automation based on user behaviour can be implemented to make the system more advanced and reliable.

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