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Voice Controlled Wheelchair using Embedded System for Assistive Mobility

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Abstract: ***The paper introduces the voice-controlled wheelchair using embedded systems for physically challenged individuals. The design makes use of ESP32 microcontroller, GSM, obstacle detector, and MPU6050 sensors to detect tilting or falling. Voice command is sent wirelessly from the android application to the wheelchair, providing a hand-free operation mode. Microcontroller senses command signals and translates them into various movements such as move forward, backwards, turn left, turn right, and stop. When a sudden tilt or unusual movement is sensed by the sensor, it starts the buzzer alarm along with sending an SMS signal to the mobile phone through GSM. The system also has an obstacle detection feature to ensure the safety of the user when any obstruction is detected by the system.***
Keywords: ESP32, GSM, Bluetooth Communication module, MPU6050, Ultrasonic sensor, Voice recognition module.

I. INTRODUCTION

Mobility is a basic need for independent living, but people with serious physical disabilities encounter difficulties in manoeuvring a traditional wheelchair. Manual wheelchairs rely on manual strength, and joystick-operated wheelchairs need hand dexterity, which is not an easy feat for people with restricted movement in the upper limbs. For this reason, smart technology systems have been invented that allow users to control the device using alternative techniques like voice and gesture control [3],[6].

In this category, systems that incorporate voice control offer an efficient approach. Voice commands do not require any physical manipulation on the part of the user and minimize effort, thus becoming very effective for users with motor disabilities. The emergence of embedded and wireless systems has made it possible to develop affordable smart mobility solutions [8].

II. METHODOLOGY

This project entails the creation of a Smart Wheelchair meant to aid Physically challenged persons and elderly individuals. The design will use the ESP32 device, which plays the role of the control unit for commands and controls of other devices [2].

The wheelchair is controlled by voice commands using an application on the phone, which is linked to the wheelchair through Bluetooth. Voice commands like go forward, go backward, go left, go right, and stop can be issued by the user. The commands are sent to the ESP32 and are controlled by the motors through the motor driver. For the purpose of safety, the system employs the use of an HC-SR04 Ultrasonic sensor to sense any presence of an obstacle in front of the wheelchair. In the event that there is anything close enough, the wheelchair will stop moving and a buzzer will sound. The system also has a fall detector which utilizes the MPU6050 sensor to sense any sudden tilting of the wheelchair. Should that occur, an emergency message will be sent to the specified mobile phone via the SIM800L GSM module. Therefore, this system enhances safety and mobility for the user by incorporating voice control, obstacle avoidance, and emergency alerts.

The figure 1 represents the block diagram of Voice controller wheelchair using embedded system.

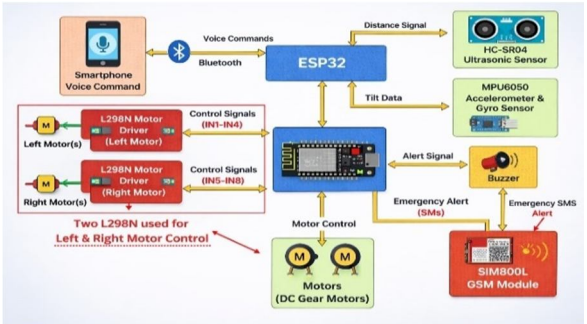

Fig. 1. Block diagram

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III. COMPONENTS

A. ESP32

Figure 2 represents the ESP32. The ESP32 is a highly efficient microcontroller that has inbuilt Wi-Fi and Bluetooth functionality. In this project, the ESP32 can be used for:

- Parsing voice commands
- Communicating with cell phones [2]

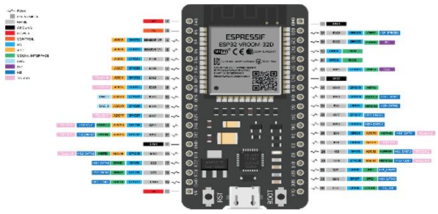

Fig. 2. Esp 32

B. Arduino IDE

Arduino IDE is an open-source software tool that allows you to write code and upload it into the Arduino board [1].

Fig 3. Arduino IDE

The above figure illustrates the Arduino IDE on ESP32.

C. L293D (Motor drivers)

Figure 4 demonstrates the L293D Motor Drivers. A motor driver acts as a link between the controller and the motor. L293D motor drivers are being used in this project.

Functions:

- Motor's rotation control
- Two motors' operation control at a time
- Supplies enough current to run the motors [4],[7]

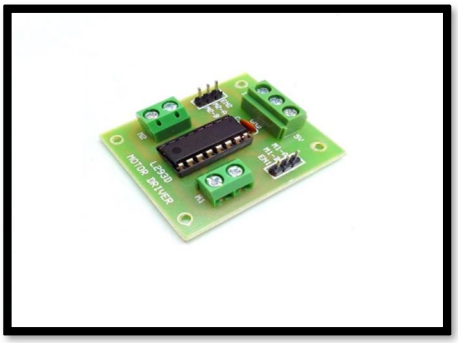

Fig 4. L293D

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D. ATMEGA328

ATmega328 is an 8-bit microcontroller. The device receives inputs from the voice module and sensors, and then executes commands. The controller sends control signals to the motor driver [7].

The below figure shows that the Atmega328 pin diagram.

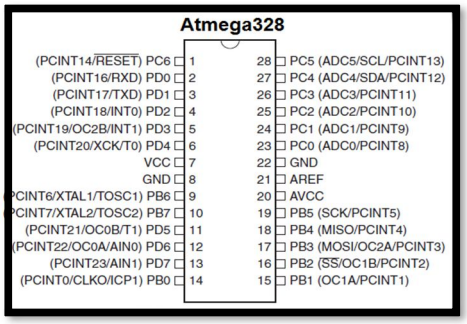

Fig 5. Atmega328

E. Ultrasonic Sensor

Ultrasonic sensors are used to detect obstacles. Ultrasonic sensors function on the principle of generation of sound waves of frequencies higher than what humans can hear. They then reflect sound waves and calculate.

The sensors will be used to detect any barriers in front of the wheelchair and hence prevent it from colliding and causing injury.

Distance = time multiplied by speed of sound in air (340 m/s)/2

Below is the illustration of how ultrasonic sensors detect any object that is within a specific range [5],[10].

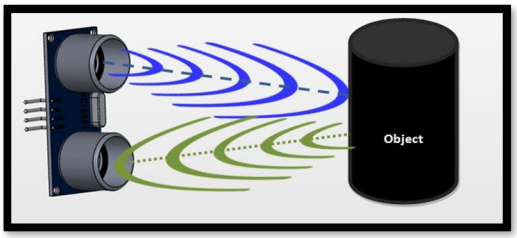

Fig.6. Ultrasonic sensor

F. GSM

The GSM module has very important functions regarding the connectivity of the device and the GSM network. This device establishes the link between the mobile device and the GSM network. In addition, the GSM modules encrypt and decrypt data during communication.

The below figure shows the SIM800L GSM.

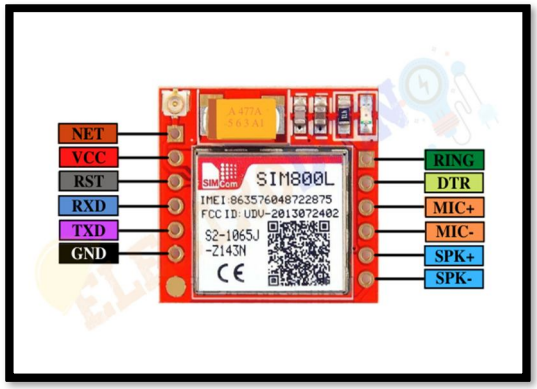

Fig. 7. SIM800L GSM

G. MEMS

MEMS accelerometers (Micro Electro Mechanical System) are highly miniaturized sensors made of silicon, which measures linear acceleration, vibration, and tilting. These sensors work through detecting the motion of a proof mass inside the sensor due to electric current. Capacitance-based and piezoresistive based sensors are some common types of MEMS accelerometers.
Figure 8 represents the MEMS sensor.

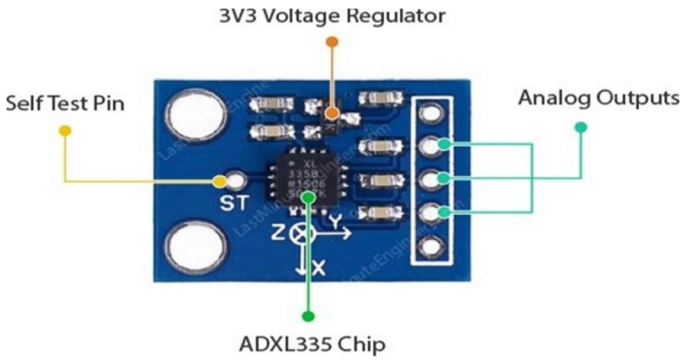

Fig 8. MEMS

H. DC motors

The DC motor is applied to produce motion in the wheelchair. The motor uses electricity to produce mechanical motion. The operation of DC motors relies on the control signals received. The DC motor motions may be forwards, backwards, left, right, or stopping [9].
1) Types of DC motors
a) Brushed DC motors
b) Brushless DC motors
c) Coreless DC motors

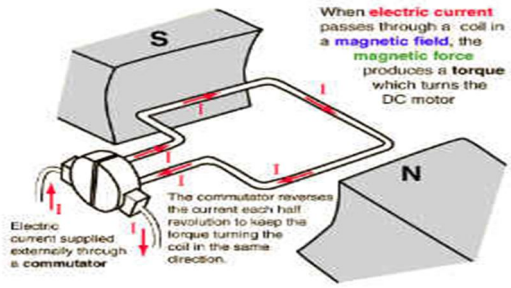

Fig. 9. DC motor

I. Buzzer

A buzzer is an electronic component that emits sounds through a mechanical process and can be either mechanical, electromagnetic, or piezoelectric. They are commonly found in devices like alarm clocks, security systems, and other appliances for alerts and alarms [3].
Figure 10 represents the diagram of a Buzzer.

Fig. 10. Buzzer

J. Battery

Batteries provide the main power for the entire wheelchair. Lithium-ion batteries are selected in this project because they can be charged and are efficient.

For instance, lithium-ion batteries are commonly replacing lead-acid batteries that were traditionally employed in golf carts and other utility vehicles [8],[9].

Functions:

- Powers all system parts
- Makes movement possible without using any wires
- Capable of sustaining operation of the motors and sensors
- Ensures efficient system performance

IV. CIRCUIT DIAGRAM

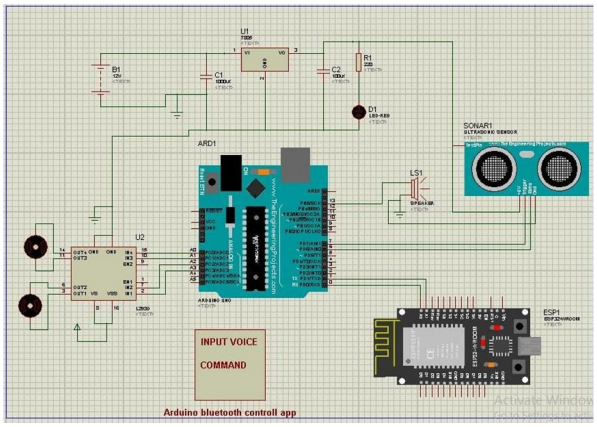

Fig. 11. Circuit diagram

The above figure illustrates the overall circuit diagram of this project.

V. WORKING

The system uses Bluetooth technology, sensing devices and microcontrollers for the functioning of the wheelchair. The main microcontroller in the system is ESP32 which coordinates the functioning of all the devices in the system.

In the first step, the user will give voice commands via a mobile app which is connected to the main controller ESP32 through Bluetooth. Upon receiving the command from the mobile phone, the ESP32 acts accordingly and controls the functioning of the wheelchair through its motor drive. The wheel chair will move based on the commands given by the user through the mobile app such as forward, backward, right, left or stop. Meanwhile, HC-SR04 Ultrasonic sensor will keep measuring the distance between the wheelchair and nearby objects. In case the sensor detects any object in a pre-defined distance, the ESP32 will turn off the motors and activate a buzzer.

The system keeps checking the tilt and acceleration of the wheelchair. If any unusual movement is observed, then the ESP32 sends an alert message. A message will be sent to an emergency contact using the SIM800L GSM module.

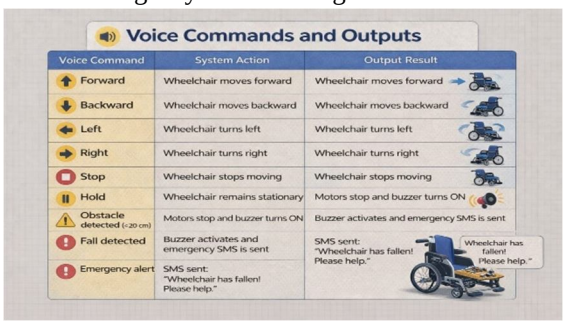

Fig. 12. Commands

VI. RESULTS

1) Voice Command Control:

The wheelchair is able to respond to voice commands transmitted from the smartphone application via Bluetooth. The command "Forward", "Backward", "Left", "Right" and "stop" controls the motion of the wheels using the motor driver.

The ESP32 interprets the command and moves the wheelchair according to the command.

2) Obstacle Detection:

The HC-SR04 Ultrasonic Sensor keeps measuring the distance from the wheelchair. If any object is detected at a distance of less than 40 cm, then the system will:

- stop the wheelchair.
- buzz to warn the user.

3) Fall Detection:

The MPU6050 accelerometer and gyroscope sense the tilt of the wheelchair. In case of any abnormal tilt or falling, the following action will be triggered:

- The buzzer will sound off.
- The system will send out emergency message through the GSM module to a specific phone number.

4) Emergency Alert System:

In the event that the chair falls, the following message would be sent by the SIM800L GSM module:

- "The wheelchair has fallen. Assistance required."
- This guarantees the timely response from the carers and family.

5) Performance of the Entire System:

This system has been designed for safe and intelligent wheelchair operation.

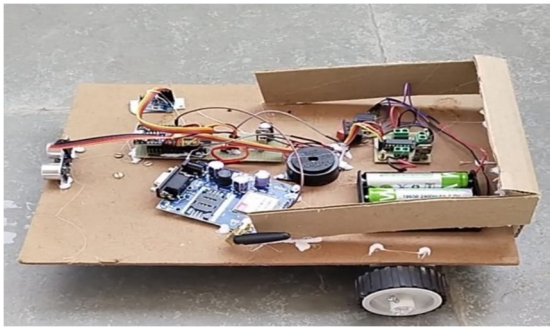

Fig.13. Voice-controlled wheelchair

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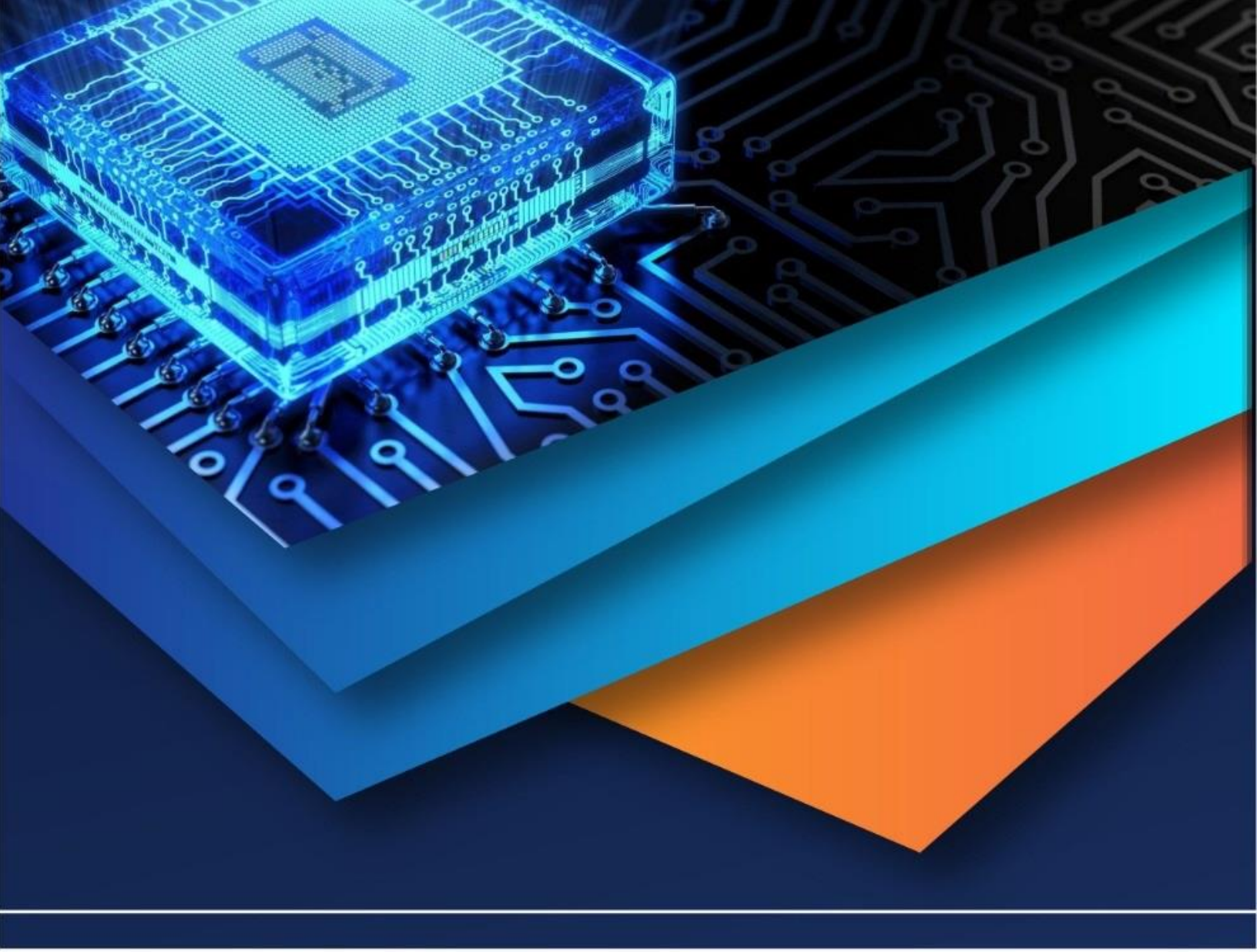

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