Voice Controlled Wheel Chair using Node MCU and Google Assistant

Nisha Pawar
Student
Government College of Engineering,
Kolhapur, Maharashtra India

Nita Pawar
Student
Government College of Engineering,
Kolhapur, Maharashtra India

Samiksha Dhanavade
Student
Government College of Engineering,
Kolhapur, Maharashtra India

Chaitali Prabhu
Assistant Professor
Government College of Engineering, Kolhapur,
Maharashtra, India

Babasaheb More
Professor
Brahmedevdada Mane Institute of Technology, Solapur,
Maharashtra, India

***ABSTRACT* - This paper explains the design and working of a low-cost voice-controlled wheelchair made using NodeMCU (ESP8266), L293D motor driver, and an ultrasonic sensor (HC-SR04). The system uses the Adafruit IO cloud and IFTTT to connect Google Assistant with the wheelchair. When the user gives a voice command such as forward, backward, left, right, or stop, the message is sent through the internet to the NodeMCU, which controls the motors using the L293D driver.**

For smooth turning, one motor is kept off while the other runs, so the wheelchair turns safely without jerks. The ultrasonic sensor checks for obstacles in front and stops the wheelchair automatically if any object is too close. The project was tested for accuracy, delay in response, and obstacle detection. The system showed good performance with fast response and more than 95% correct command execution. The whole setup is simple, low-cost, and useful for people who need easy movement support.

Keywords-Adafruit IO, HC-SR04, IFTTT, Internet of Things (IoT), Voice Control

I. INTRODUCTION

Today many IoT-based systems are being developed to make life easier. People with physical disabilities often face problems in operating traditional powered wheelchairs because they require hand movements. Voice control provides a better solution as commands can be given speaking only, without any physical effort.

In this project, an ESP8266 microcontroller is used to receive voice commands through Google Assistant. The commands are uploaded to Adafruit IO and then read by the robot using MQTT protocol. Based on these commands, the motors run in different directions. An ultrasonic sensor is used in the front to detect objects and avoid collisions. The system is low-cost, portable, and helpful for personal mobility needs.
Mobility supports systems have improved a lot because of the growth of the internet of things. Some normal powered wheelchair need hand movements all the time, which is difficult for people who have big hands, paralysis , or problems due to old age. A voice controlled system helps such user because they can operate the wheelchair just by speaking. Many studies show that voice system reduce physical effort and increase comfort for disabled users [1].
Today’s Smartphone’s have strong voice assistants like Google assistant that can understand speech and convert it into text very accurately. Because of this, voice commands can be used to control robots, appliances and wheelchairs. When this commands are linked to IoT platforms such as adafruit IO or IFTTT , they can be sent directly to a microcontroller over Wi-Fi using MQTT. Earlier research has shown that cloud voice control is easier to update and more flexible than wired controls or Bluetooth systems [2].
The ESP NodeMCU is commonly used in IoT projects because it has built in Wi-Fi, supports MQTT and can easily connect to cloud dashboards. It also has enough GPIO pins for controlling motors. MQTT is preferred by many researchers because it is fast, simple and uses very little data, making it suitable for real time robot control. With MQTT the NodeMCU quickly receives every

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new command sent from Google assistant [3].

Safety is an important part of any wheelchair or moving robot. If the wheelchair moves forward without checking obstacles, accidents can happen. To avoid this, ultrasonic sensors are used. These sensors calculate distance by sending sound waves and receiving their reflection. Many studies show that ultrasonic sensors give quick and reliable results indoors, which makes them perfect for mobility- aid system [4]. Because of this, the wheelchair can stop automatically when an object comes too close.

By combining voice control, Wi-Fi, MQTT communication, motor driving and ultrasonic sensing, it is possible to make simple and low cost voice controlled wheelchair. The system in this project is designed to be affordable, easy to use and helpful for people who need support to move indoors. This project also shows how IoT can be used in daily life to improve the independence and comfort of elderly or physically disabled peoples[5].

II. EXPERIMENTAL WORKING

A. Working Principle

The system mainly works in three steps:

1. Voice Input :

   The user gives commands like "forward", "left", "right", "backward", or "stop" by speaking to Google Assistant on a mobile phone. Google Assistant listens to the user's voice and coverts the spoken words into texts using cloud-based speech recognition. This text command is then passed to IFTTT or directly to Adafruit IO, depending on the setup.

   On Adafruit IO, each command is stored in a feed, which acts like a message box for the robot. Whenever the user speaks, a new entry is added to this feed. Google Assistant can understand different accents, so the commands are recognized very accurately. This allows the wheelchair to be controlled easily without any physical buttons.

2. Cloud to Robot Communication :

   The ESP8266 NodeMCU is programmed to connect automatically to the home Wi-Fi network after powering ON. Once it connects, it also logs in to Adafruit IO using MQTT protocol. MQTT is lightweight and fast, which means commands travel quickly from the cloud to the robot.

   The NodeMCU continuously checks (subscribes to) the specific feed where the commands are stored. When a new command appears, the ESP8266 reads it immediately and decides what movement should happen. For example:

   If the text is "forward", both motors rotate forward

   If the text is "left" only one motor runs so the wheelchair turns.

   If the text is "stop", all motors are turned OFF.

   This process allows smooth and real-time movement controlled entirely through the internet.

3. Safe Movement :

   When the wheelchair is moving forward, safety becomes very important. An ultrasonic sensor (HC-SR04) is placed at the front to measure distance from any object. The sensor works by sending out ultrasonic sound waves and measuring how long it takes for the echo to return. If the sensor detects within a preset distance (usually 15-20), it immediately sends this information to NodeMCU. The microcontroller then stops both motors at once to prevent collision.

   This ensures that even if the user accidentally gives a "forward" command while a wall or object is in front, the wheelchair will not hit it. The safety mechanism works continuously in the background, making the system, making the system reliable for disabled for disabled or elderly users who may not always judge distance accurately.

B. Components Used

1. ESP8266 (NodeMCU)

   The ESP NodeMCU is the main control of the system. It has a built-in WI-Fi module, which allows it to connect to the internet and communicate with platforms like Adafriut IO. In this project, it performs the following tasks:

   - Receives voice commands from Adafruit IO through MQTT
   - Controls the motor driver to move the DC motors
   - Reads distance fro, the ultrasonic sensor

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- Ensures safety by stopping the motors when an obstacle is detected

It is small in size, affordable, and easy to program using Arduino IDE, making it suitable for IoT-based mobility projects.

2. DC motors

Two DC motors are used as the main driving motors of the wheelchair.
Their key functions include:

- Moving the wheelchair forward or backward
- Helping the wheelchair turn left or right
- Providing enough speed and torque for smooth indoor travel

By controlling the direction of current through the motor driver, the motors rotate in the required directiom.

3. Ultrasonic Sensor (HC-SR04)

The ultrasonic sensor is used to detect obstacles in front of the wheelchair.
It works by:

- Sending ultrasonic sound waves
- Measuring the time taken for the reflected wave to return
- Converting this time into distance

If an object is detected within a fixed range (e.g., 15-20 cm), the ESP8266 automatically stops the motors to avoid collisions.

This makes the systems safe for users.

4. Caster Wheel

The cater (or castor) wheel is a free-rotating support wheel placed at the front of the chassis.
Its purpose is to:

- Provide balance to the robot
- Allow smooth turning and rotation
- Reduce friction while moving

Unlike the DC motors, this wheel does NOT require electrical power.

5. Battery

The battery is the power source for the entire system.
It provides stable voltage and current required for:

- Running the DC motors
- Powering the NodeMCU
- Powering the motor driver

A rechargeable battery is preferred so the wheelchair can work for long durations without external power.

6. Connecting Wires

Connecting wires are used to make electrical connections between:

- ESP8266→Motor driver
- Motor driver→DC motors
- ESP8266→Ultrasonic sensor
- Battery →Motor driver and ESP8266

They ensure smooth flow of signals and power throughout the system.

7. Breadboard

The breadboard is used during the prototyping stage of the project.
It helps in:

- Testing connections without soldering
- Quickly arranging circuits
- Making changes easily during debugging

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Once the final design works properly, the components can be soldered or placed on a PCB if needed.

A. Circuit Digram

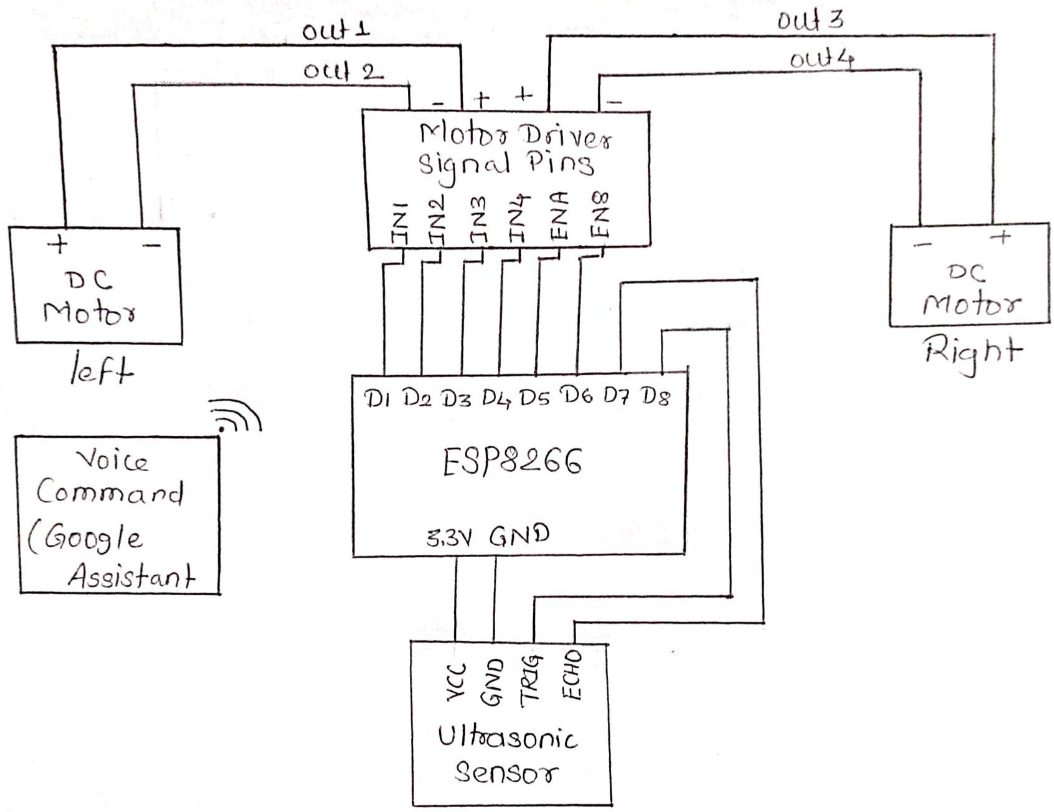

figure : Circuit Diagram

III. RESULT AND DISCUSSION

The performance of the voice-controlled wheelchair was evaluated by studying how the system operates in real time, how effectively it responds to user commands, and how safe it is during movement. During testing, the interaction between Goggle Assistant, Adafruit IO, MQTT, and the ESP8266 microcontroller worked smoothly, showing that the overall is suitable for indoor mobility support. The combined observations of system behavior, advantages, and practical limitations are described below.

The system operation starts when the ESP8266 connects to Wi-Fi network and establishes a link with the Adafruit IO server. This connection was achieved within a few seconds and remained stable during long testing sessions. Once connected, the microcontroller continuously listens for new commands that are uploaded to the cloud. When the user speaks to Google Assistant, the voice is converted into text and immediately sent to the Adafruit IO feed. The ESP8266 retrieves this text using MQTT and activates the required movement function. This process ensures a smooth flow from speech input to physical output. The average response time between giving a voice command and the wheelchair starting to move was around one to two seconds, depending, it is acceptable for indoor wheelchair applications.

During movement testing, the wheelchair responded correctly to almost all spoken commands, showing high recognition accuracy. Commands like “forward”, “left”, and “stop” were executed without any confusion because Google Assistant handled speech recognition reliably. The motor driver allowed the motors to run smoothly without jerks. The turning mechanism was tested several times, and the wheelchair successfully rotated in the expected direction each time. This confirms that the coordination between the motor driver and the microcontroller is stable and dependable. In addition, the ultrasonic sensor increased the safety of forward movement by measuring the distance to any object in front. When an obstacle came close to the

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sensor's preset range, the system responded quickly by stopping the motors. This feature prevented collisions and gave batter control in crowded or indoor environments.

One clear advantage observed during testing is that the system allows complete hand-free operation. This is especially helpful for individuals who cannot move their hands due to injury, disability, or age. The use of Google Assistant means the wheelchair can understand voice commands even from users with different accents. Another major benefit is the low cost of the components used. ESP8266, ultrasonic sensor, and motor driver modules are economical and easily available, making the design affordable for students and for people who need a budget-friendly mobility solution. The system is also energy-efficient and can be upgraded easily by adding more sensors or features.

However, testing also revealed some limitations. The biggest limitation is the dependency on Wi-Fi and internet access. If the network speed becomes slow or the connection drops, the wheelchair may take longer to respond or may not receive the command at all. This makes the system less suitable for areas with unstable internet. The ultrasonic sensor also has some limitations. It gives the best readings only in front of and may not detect obstacles on the sides or behind the wheelchair. In addition, very soft or shiny surfaces sometimes reflect ultrasonic waves differently, leading to small variations in distance readings. Another limitation observed is the presence of a short delay due to cloud-based processing, which may not ideal for fast or outdoor movements.

Putting all results together, the system performs well controlled indoor movement and offers significant advantages for users who need simple, hand-free mobility. The safety feature works reliably, the voice commands are processed accurately, and the motor movements are smooth. Even though internet dependency and limited sensing range exist, these limitations do not affect the basic purpose of the design. With some improvements- such as adding, multiple sensors or using offline voice processing- the system can become even more powerful and independent. Overall, the experiment results prove that the voice-controlled wheelchair is a practical, low-cost, and user-friendly solution for personal mobility assistance.

Fig. Working Model

IV. CONCLUSION

The project successfully demonstrates a simple, low-cost, and user-friendly voice-controlled wheelchair using ESP8266, Google Assistant and MQTT. The system allows hands-free movement through basic spoken commands, which is very helpful for elderly

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people or individual with physical disabilities. The automatic obstacle-detection feature increases safety by stopping the wheelchair whenever something is too close. All tests showed that the system performs well for indoor use, with smooth motor movement, accurate voice response and stable Wi-Fi communication. Although the system depends on internet connectivity and the ultrasonic sensor checks only the front area, these limitations do not affect basic operation. The design is flexible and cab be improved further by adding more sensors, offline voice control, or GPS tracking. Overall, this project proves that IoT-based voice-controlled mobility systems can improve comfort, independence and safety for people who require mobility support.

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