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SMART WHEELCHAIR WITH SAFETY, SPEECH AND IOT MONITORING

Muttholla Pravalika, Karre Bhargavi, Mojerla Priyanka, Pasupula Tejashwini

B. Tech Final Year Students, Department of ECE, JBIET, Hyderabad, Technology Dr.S. K. CHAYA DEVI ,

Professor -ECE Department, JB Institute of Engineering and Technology, Hyderabad, TG

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Abstract – This paper presents a smart wheelchair system with safety, speech communication, and IoT- based control designed to assist elderly and physically challenged people in daily mobility and communication. The system is built around an Arduino Nano microcontroller which acts as the central control unit for all modules. The wheelchair can be controlled manually using four control buttons for movement directions such as forward, backward, left, and right. In addition to manual operation, the wheelchair can also be controlled wirelessly through a mobile application using the Blynk IoT platform with an ESP8266 Wi-Fi module. This provides remote monitoring and control capability. For safety purposes, a limit switch is used to detect any collision or damage to the wheelchair. When such an event occurs, the system automatically sends an alert message to the caretaker's mobile phone using a GSM module via SMS, ensuring immediate notification in emergency situations. The system also includes a speech assistance feature for communication. Four command buttons are provided for the user to request help or basic needs such as food, water, medicine, or assistance. When a button is pressed, a pre-recorded voice message stored in the DF Mini Player module is played through a speaker, allowing the user to communicate easily. At the same time, the correspo- nding SMS notification is sent to the caregiver's mobile phone through the GSM module.

1.INTRODUCTION

Mobility and communication are major challenges faced by elderly and physically disabled people. Traditional wheelchairs often require assistance from another person, which reduces the independence of the user. With the development of embedded systems, Internet of Things (IoT), and smart communication technologies, it is possible to design intelligent assistive devices that improve the quality of life for such individuals. The Smart Wheelchair with Safety, Speech and IoT-Based Control is developed to provide an advanced mobility solution with additional safety and communication features. The system uses an Arduino Nano as the main controller to manage various modules such as motor driver, GSM module, Wi-Fi module, DF Mini Player, LCD display, and safety sensors. The wheelchair can be controlled manually using directional buttons or wirelessly using a mobile application through Wi-Fi.

To enhance safety, a limit switch is used to detect collision or damage to the wheelchair. When such a situation occurs, an alert message is sent to the caregiver through the GSM module. The system also includes speech assistance, where the user can press predefined command buttons to request help such as food, water, or medicine. These commands are announced through a speaker using the DF Mini Player and sent as SMS messages to the caregiver.

This system integrates mobility control, safety monitoring, speech assistance, and IoT communication, making the wheelchair more intelligent and useful for disabled individuals. The proposed design aims to improve user independence, safety, and communication.

2. LITERATURE SURVEY

Many researchers have worked on developing smart wheelchairs using different technologies to assist disabled people. Several studies proposed IoT-based smart wheelchair systems that allow remote monitor- ing and control through mobile applications. These systems improve user convenience by enabling wireless control and real-time status monitoring. Some research focused on voice-controlled wheelchairs, where users can control wheelchair movement through voice commands using speech recognition modules. These systems help users who cannot operate manual controls.

2.1. IoT-Based Smart Wheelchair with Multi- Model Interaction :

This paper studies the wheelchair's multi-mode perception and control technology based on rocker, gesture recognition and mobile app, and the system is divided into five layers: remote end, main control layer, communication layer, perception layer and drive layer. The system is divided into a five-layer structure of remote terminal, master control layer, communication layer, perception layer and driver layer.

2.2. Autonomous Wheelchair with IoT Health Monitoring:

In this paper we propose an intelligent autonomous wheelchair integrated with telemedicine sensors based on IoT, and the architecture of the wheelchair

system . Various sensors including wireless location, position accelerometer, seat cushion sensors, and biophysical sensors are embedded in the wheelchair to collect users' physiological and behavioral data in real time.

2.3. Smart Wheelchair Based on IoT for Disabled and Elderly:

This paper proposes a cost-effective IoT-based wheelchair focusing on mobility assistance. It highlights the importance of affordable assistive devices but lacks advanced safety alert systems.

2.4. IoT-Based Smart Wheelchair for Healthcare Monitoring:

This paper presents the development and implementation of an Internet of Things (IoT) -enabled smart wheelchair designed to enhance mobility and independence for individuals with disabilities. By integrating advanced assistive technologies and internet connectivity, the system offers a comprehensive solution that addresses key challenges in wheelchair navigation and user autonomy. The smart wheelchair is equipped with a suite of sensors, including ultrasonic and infrared, to perceive its environment, detect obstacles, and provide real-time feedback to the user.

2.5.IoT-Based Mobility Wheelchair :

The paper presents current mobility chair systems primarily offer manual controls like handles or buttons, which can be difficult for users with restricted movement the manual control provided by many mobility chair systems on the market today handles or buttons can be challenging. Although they exist, basic obstacle detection systems are frequently insufficient. Therefore, the requirement for an enhanced solution is evident. By combining sophisticated obstacle detection with joystick control, the suggested smart mobility chair increases user autonomy and safety.

2.6. IoT-Based Smart Healthcare Wheelchair :

The paper presents is to fabricate a shrewd detecting wheelchair through the establishment of sensors inside its structures. The innovation grasped is the Internet of Things, where sensors screen the heartbeat and blood oxygen levels, measure them through implanted frameworks, and move them to the cloud to initiate a trigger in case of any anomaly. The trigger made can be as an SMS and email.

2.7. Voice-Controlled Smart Wheelchair :

Main goal of the SMART WHEELCHAIR project is to control a wheelchair using a voice recognition module (HC-05). This system is designed. ed to control the wheelchair with a human voice. The aim of this project is to facilitate the mobility of people with disabilities and disabilities, as well as elderly people with mobility difficulties. The goal of this system is to allow certain people to live their lives less dependent on others for their daily movements. Speech recognition technology is a key technology that gives new ways of human Interaction with machines and tools. So, using voice recognition technology in the movement of the wheelchair can solve the problem they are facing. This can be achieved and optimized by using a smartphone device as an intermediary or interface. This project uses an Arduino UNO microcontroller circuit and four of his DC motors to generate movement of the wheelchair and an ultrasonic sensor to control the movement of his hurdles between the wheelchair and the direction detect. The results and analysis of these innovations are explained in this paper. This result indicates that the module can be used in future research work and develop excellent innovations to meet market demands and public interest.

3. PROBLEM INDENTIFICATION

1. People with physical disabilities and elderly individuals often face serious challenges in mobility due to the limitations of conventional wheelchairs. Most traditional wheelchairs are either manually operated or controlled using joysticks, which require physical strength and hand coordination. This makes them unsuitable for users with severe disabilities, paralysis, or limited motor control, forcing them to depend heavily on caregivers for movement and daily activities. Such dependence reduces their independence and confidence in performing routine tasks.

2. Another major issue is the lack of built-in safety features. Conventional wheelchairs do not have obstacle detection systems, which increases the risk of collisions, especially in crowded or unfamiliar environments. Users may accidentally hit objects, walls, or people, leading to injuries. Additionally, there is no automatic braking or alert mechanism to prevent accidents, making it unsafe for independent use.

3. Furthermore, traditional wheelchairs do not support real-time monitoring or communication. Caregivers and family members have no way to track the user's location or monitor their movement remotely. In emergency situations such as falls, health issues, or accidents, there is no alert system to inform others, which can delay immediate assistance and increase risk.

4. With the advancement of technology, there is a growing need for smarter solutions that improve the quality of life for disabled individuals. A smart wheelchair with speech control can allow users to operate it using simple voice commands, eliminating the need for physical effort. Integrating safety features like obstacle detection ensures secure navigation, while IoT-based monitoring enables real-time tracking, data sharing, and emergency alerts. Therefore, developing a smart wheelchair system that combines safety, speech recognition, and IoT technology is essential to provide safe, independent, and efficient mobility for users

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4. EXISTING SYSTEM

4.1. Manual Wheelchairs:

A manual wheelchair typically consists of a lightweight frame, two large rear wheels, two smaller front caster wheels, a seat, backrest, footrests, and hand rims attached to the rear wheels. The user propels the wheelchair by gripping and pushing the hand rims, or it can be moved with the assistance of a caregiver. Steering is achieved by applying different levels of force to each wheel, allowing directional control.

4.2. Electric Wheelchairs:

An electric wheelchair typically consists of a motorized base, rechargeable batteries, control system, and user interface. The main components include DC motors attached to the wheels, a battery pack , a joystick or control panel, a motor driver, and a sturdy frame with seating support. The user operates the wheelchair using a joystick, which sends signals to the controller. The controller then regulates the speed and direction of the motors, allowing forward, backward, and turning movements.

4.3. Joystick-Based Control Systems:

The existing system for a joystick-based wheelchair is a common control method used in most electric (powered) wheelchairs, where the user operates the chair through a joystick interface for smooth and intuitive movement.

4.4. Basic Safety Features:

The existing systems for safety features in wheel- chairs especially electric and smart wheelchairs are designed to protect users, enhance stability, and pre- vent accidents during operation. These systems combine mechanical ,electrical, and sometimes electronic safety mechanisms.

4.5. Lack of IoT Integration:

The lack of IoT (Internet of Things) integration in existing wheelchair systems is a major limitation, especially in traditional electric and joystick-based models. While these systems provide basic mobility and safety features, they generally operate as standalone devices without connectivity or real-time data capabilities.

4.6. Limitations of existing system:

Existing wheelchair systems, including manual and basic electric models, have several limitations that reduce their effectiveness for physically challenged and elderly users. Manual wheelchairs require continuous physical effort, making them unsuitable for individuals with severe disabilities or low strength, while electric wheelchairs mainly rely on joystick control, which is difficult for users with limited hand movement or paralysis. These systems also lack advanced safety features such as obstacle detection and automatic braking, increasing the risk of accidents. Moreover, there is no provision for real-time monitoring or IoT integration, so caregivers cannot track the user's location or status remotely. In emergency situations, the absence of an alert system can delay immediate assistance and pose serious risks to the user. Therefore, these limitations highlight the need for a more advanced and efficient smart wheelchair system.

5. METHODOLOGY

The proposed system is a smart wheelchair designed to provide safe, independent, and intelligent mobility for physically challenged and elderly individuals. It overcomes the limitations of traditional wheelchairs by integrating advanced technologies such as speech control, safety sensors, and IoT monitoring. The system reduces dependency on caregivers. Smart

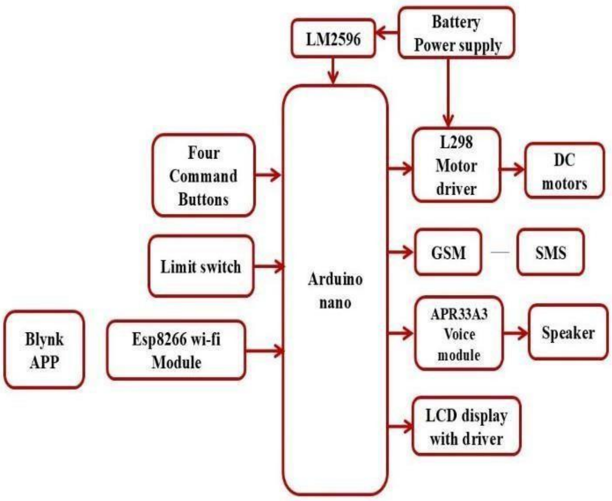

FIG:5.1 Block Diagram

Wheelchair with Safety, Speech Control and IoT Monitoring project focuses on designing an intelligent and user-friendly mobility system for physically challenged individuals. The system integrates advanced technologies such as speech recognition, obstacle detection, and IoT-based remote monitoring to ensure safe and efficient operation. The overall design aims to provide independence to users while allowing caregivers to track and assist them when needed.

In the initial stage, the system architecture is developed by combining both hardware and software components. A microcontroller acts as the central unit, connecting all modules such as sensors, motor drivers, and communication devices.

Proper interfacing of these components is carried out to ensure smooth communication and reliable performance of the wheelchair system.

The hardware implementation involves assembling components like DC motors for movement, a motor driver for controlling speed and direction, ultrasonic sensors for obstacle detection, and a speech recognition module for voice commands. Additionally, a Wi-Fi or GSM module is included to enable IoT connectivity. These components are mounted onto the wheelchair and connected systematically.

5.1.Arduino Nano: This is a 3.3V Arduino running the 8MHz bootloader. Arduino Pro Mini does not come with connectors populated so that you can solder in any connector or wire with any orientation

you need. We recommend first time Arduino users start with the Uno R3. It's a great board that will get you up and run quickly. The Arduino Pro series is meant for users that understand the limitations of system voltage (3.3V), lack of connectors, and USB off board.

5.2.Li-ion Battery Power Supply:3.7v li-ion battery is used to give the power supply of the project.

5.3.LED:A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices and are increasingly used for lighting. Introduced as a practical electronic component in 1962, early LEDs emitted low-intensity red light, but modern versions are available across the visible, ultraviolet and infrared wavelengths, with very high brightness.

5.4.DC Motor: A dc motor uses electrical energy to produce mechanical energy, very typically through the interaction of magnetic field and current carrying conductor. The reverse process, producing electrical energy from mechanical energy, is accomplished by alternator, generator or dynamo. Many types of electric motors can be run as generators, and vice versa. The input of a DC motor is current/voltage and its output is torque.

5.5.DC Motor Driver: The L298N is an integrated monolithic circuit in a 15- lead Multiwatt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver de-signed to accept standard TTL logic level sand drive inductive loads such as relays, solenoids, DC and stepping motors. Two enable inputs are provided to enable or disable the device independently of the in-put signals. The emitters of the lower transistors of each bridge are connected rand the corresponding external terminal can be used for the connection of an external sensing resistor. An additional Supply input is provided so that the logic works at a lower voltage.

5.6. Limit switch: A limit switch is a mechanical switch used to detect the physical position, movement, or collision of an object. It operates when a moving object presses the switch lever, causing the electrical contacts inside the switch to open or close. In Smart Wheelchair In the smart wheelchair system, the limit switch is used for safety purposes. It helps to detect damage, collision, or abnormal movement of the wheelchair.

5.7. ESP8266 WI-FI: The ESP8266 Wi-Fi Module

is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much Wi-Fi-ability as a Wi-Fi Shield offers. The ESP8266 module is an extremely cost-effective board with a huge, and ever growing, community.

5.8. GSM: GSM, which stands for Global System for Mobile communications, reigns (important) as the world's most widely used cell phone technology. Cell phones use a cell phone service carrier's GSM network by searching for cell phone towers in the nearby area. Global system for mobile communication (GSM) is a globally accepted standard for digital cellular communication.

5.9. Push Buttons: Buttons are simple input devices used to send control signals to the microcontroller when pressed. In this project, push buttons are used to control the movement of the wheelchair and to send voice assistance commands.

These buttons are used to move the wheelchair manually.

- Forward button – Moves the wheelchair forward
- Backward button-- Moves the wheelchair back- ward
- Left button – Turns the wheelchair left
- Right button – Turns the wheelchair right.

5.10. Working Principle

The smart wheelchair system works by combining control, communication, safety, and mobility features using the Arduino Nano as the main controller. When the system is powered on, all components such as the Arduino Nano, ESP8266 Wi-Fi module, GSM module, LCD display, motor driver, and voice module are initialized, and the LCD shows that the system is ready. The wheelchair can be controlled remotely through the Blynk mobile app, where the user or caregiver sends movement commands like forward, backward, left, right, and stop via the internet using the ESP8266 module; these commands are received and processed by the Arduino, which then sends signals to the L298 motor driver to control the DC motors for smooth movement. For safety, a limit switch detects coll-isions, and when triggered, the Arduino immediately stops the motors and sends an alert message to the caregiver through the GSM module. The system also includes a speech assistance feature with four buttons for needs such as food, water, medicine, and help; when pressed, the Arduino activates the APR33A3 voice module to play a prerecorded message through a speaker and simultaneously sends an SMS alert. The GSM module is used to send notifications during emergencies or user requests using AT commands. Additionally, a 16×2 LCD display provides real-time updates such as movement status, user commands, and alerts. Overall, the system continuously monitors inputs from the app, buttons, and sensors, processes them through the Arduino Nano, and controls outputs like motors, voice messages, GSM alerts, and display, ensuring safe movement, effective communication, and easy remote monitoring.

FIG 5.2 Wheelchair operation

6. ADVANTAGES

6.1. Enhanced Independence:

Speech control allows users to operate the wheelchair using voice commands, reducing the need for physical effort or assistance. This is especially helpful for individuals with severe mobility impairments.

6.2. Improved Safety Features

Built-in safety mechanisms such as obstacle detection, limit switches, and automatic braking help prevent collisions and accidents. Some systems can also send alerts during emergencies.

6.3. Real-Time IoT Monitoring

With IoT integration, caregivers or family members can monitor the wheelchair remotely. Features like GPS tracking, health status updates, and system diagnostics ensure better supervision and quick response when needed.

6.4. Ease of Communication

Speech modules enable smoother interaction between the user and the wheelchair system, making operation intuitive and user-friendly even for elderly people.

6.5. Remote Control & Automation

Using smartphone apps or web interfaces, the wheelchair can be controlled or monitored from anywhere, offering flexibility and convenience.

6.6. Increased Mobility Efficiency

Motorized control with intelligent navigation reduces manual effort and allows smoother, more precise movement in different environments.

6.7. Emergency Assistance

GSM or IoT modules can send alerts or messages to predefined contacts in case of danger, improving user safety.

6.8. Customization & Scalability

The system can be upgraded with additional features like health monitoring sensors, AI-based navigation, or voice assistants.

6.9. Better Quality of Life

Overall, combining safety, speech recognition, and IoT helps users live more independently, confidently, and comfortably in their daily lives.

7. FUTURE SCOPE :

The system can be further improved with advanced features in the future.

- Integration of voice recognition control for hands-free operation.
- Addition of obstacle detection sensors such as ultrasonic sensors for automatic obstacle avoidance.
- Implementation of GPS tracking to monitor the wheelchair location.
- Development of a mobile application with more advanced control features.
- Integration of health monitoring sensors such as heart rate and temperature sensors.
- Implementation of AI-based autonomous navigation for automatic wheelchair movement. These improvements can make the smart wheelchair more advanced, reliable, and helpful for disabled users.

8. CONCLUSION

The Smart Wheelchair with Safety, Speech Control and IoT Monitoring system provides an advanced and efficient solution for assisting physically challenged individuals in their daily mobility. By integrating modern technologies such as voice recognition, obstacle detection, and IoT connectivity, the system enhances user independence and reduces the need for constant manual assistance. The implementation of speech control allows users to operate the wheelchair easily without physical effort, making it highly beneficial for people with severe disabilities. The inclusion of ultrasonic sensors ensures safety by detecting obstacles and preventing collisions, thereby creating a secure environment for movement.

Furthermore, the IoT monitoring feature plays a significant role in improving caregiving. It enables real-time tracking and status monitoring of the wheelchair, allowing family members or caregivers to stay informed and respond quickly during emergencies. This adds an extra layer of security and reliability to the system. Overall, the proposed system successfully combines safety, convenience, and smart technology into a single platform. It is cost-effective, user-friendly, and highly adaptable for future enhancements such as GPS tracking, health monitoring, and mobile app integration. Thus, this smart wheelchair system contributes significantly to improving the quality of life and independence of differently abled individuals.

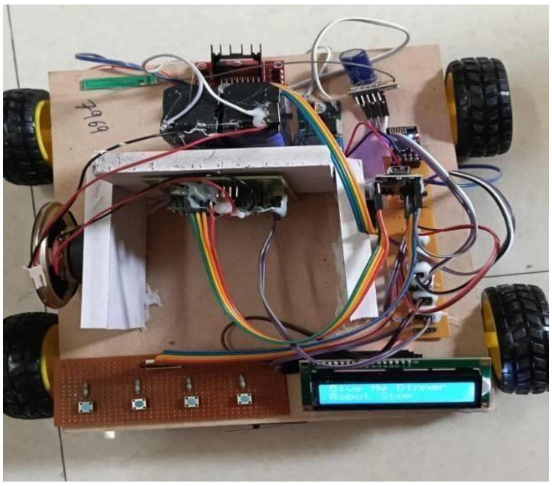

Fig 8.1: Output

Fig 8.2: Output shown in LCD display

The Smart Wheelchair with Safety, Speech, and IoT- Based Control system was successfully designed and implemented using an Arduino Nano and other supporting modules. The wheelchair was able to move in different directions such as forward, backward, left, and right using manual control buttons. The wireless control using the mobile application through the Wi-Fi module also worked successfully, allowing the user to control the wheelchair remotely. The motor driver controlled the DC motors effectively according to the commands received from the controller. The limit switch successfully detected collision or damage situations. When the switch was triggered, the GSM module sent an alert SMS to the caregiver's mobile phone. The speech assistance system using the DF Mini Player played predefined voice messages 65 through the speaker when command buttons were

pressed. At the same time, the corresponding request message was sent to the caregiver through SMS. The LCD display showed the system status clearly. Overall, the system worked properly and demonstrated improved mobility, safety, and communication for wheelchair users.

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