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Mobility Plus: Voice-Controlled Wheelchair with Health Monitoring System and Oxygen Cylinder Integration

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Abstract:
A significant number of people who have impairments are dependent on other people for help with day-to-day activities, particularly with regard to mobility. Users in wheelchairs, in particular, often need assistance in order to operate their chairs. Their freedom may be increased via the use of a wheelchair control system that gives them the ability to control their mobility through the use of speech recognition technology. Microcontroller, motor control interface board, and Google Assistant are all components that are included into this system to provide voice command capabilities. Users are able to manoeuvre the wheelchair by just speaking orders to Google Assistant. These commands include turning left or right, going forward or backward, and turning left or right. Through the usage of this system, users are able to become more self-sufficient, the stress placed on carers is lessened, and they are given the ability to engage more actively in day-to-day life.
Key Words: *ROS, Encoded motors, Health monitoring system, Sensors, Raspberry pi pico w, Buzzer*

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I. Introduction

After being involved in an automobile accident that resulted in her suffering injuries, Sarah, a young lady, was able to endure a spinal cord damage as a consequence of her participation in the accident. As a result of the injuries she incurred, she is confined to a wheelchair and requires assistance in order to move about. It is difficult for her to move around without assistance. In order to carry out even the most rudimentary of tasks, Sarah is compelled to rely extensively on the aid of members of her family or carers. This is because her movement is severely restricted. Because of this, her freedom is somewhat limited, and she is unable to take part in things that she would normally enjoy doing. This is something that she would normally find pleasure in doing. In spite of the fact that Sarah has a strong will and a tremendous desire to participate in activities that are ordinary, she is unable to do so. The introduction of the Mobility Plus, a cutting-edge wheelchair technology that is intended to make her life easier, has had a profound impact on her life. As a result, her life has been substantially transformed. Her whole life has been completely transformed. The high-tech wheelchair that you are looking at has a number of different cutting-edge technology.

The user's general well-being as well as their level of freedom are both intended to be improved by the use of these technologies. It is the oxygen cylinder that serves as an essential element of the device that is considered to be one of the most important components of the device. As a result of this, Sarah is able to get oxygen treatment while she is on the go, which removes the need for additional medical equipment or constant monitoring. The voice-controlled navigation system, which allows her to exercise control over the wheelchair by means of easy spoken instructions, is another feature that contributes to the enhancement of her mobility. As a result, she is able to walk about with more ease. The fact that Sarah has this gift is directly responsible for her having the capacity to freely walk about and re-engage with the environment that surrounds her. Additionally, the Mobility Plus package includes a health monitoring system that is built using Arduino. This system is included in the bundle. Indicators such as the recipient's heart rate, blood pressure, and oxygen saturation levels are among the most important ones that are monitored by this system. In the event that any abnormalities are discovered, the system will immediately contact Sarah as well as the individuals who are responsible for managing her care. In the end, this ensures that the appropriate activities are carried out, which eventually leads to an increase in Sarah's degree of safety. Sarah not only has the opportunity to live a life that is more full and active as a consequence of this all-encompassing health care, but it also gives her the peace of mind that she need. Sarah's life has the potential to be more full and active overall.

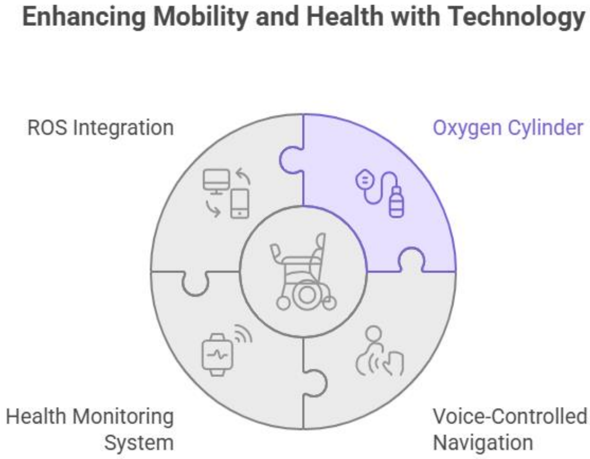

Figure: 1 Mobility and health with technology

Sarah and other people who find themselves in circumstances that are similar to hers are able to take use of the Mobility Plus system, which reimagines the alternatives that are open to them. This is accomplished via the use of a unified solution that incorporates both mobility and health management. The use of the Robot Operating System (ROS), which makes it possible for all of these cutting-edge technologies to collaborate with one another in a seamless manner, has led to a significant enhancement in Sarah's level of autonomy as well as her general quality of life.

II. Literature Survey

Recent advancements in smart wheelchair technology have led to a variety of innovative designs aimed at improving mobility and autonomy for individuals with physical disabilities. One approach involves integrating a manual joystick-controlled wheelchair with an Android app via Bluetooth or Wi-Fi, enabling users to move independently while allowing caregivers to monitor them. However, joystick control can be tiring, and the system may be expensive to maintain [1]. Another design features multidirectional movement through DPDT switches and includes health monitoring tools like continuous pulse tracking and emergency alerts via GSM, powered by 12V rechargeable batteries [2]. Some systems incorporate infrared and ultrasonic sensors for obstacle detection and offer multiple control modes—autonomous, voice, and joystick. Yet, the sensors can misread gridlines as obstacles, raising costs [3]. One notable design, as described in the paper "A Novel Design of Gesture and Voice Controlled Solar-Powered Smart Wheelchair with Obstacle Detection," combines gesture and voice controls, making it adaptable even for users with limited physical capabilities. It uses solar power for motors and drivers and includes battery storage for efficient energy use [4]. Another study, "Design of Voice Controlled Smart Wheelchair," explores speaker-dependent voice navigation using Arduino boards, achieving high accuracy in various noise conditions. Voice training is emphasized as essential for reliable performance [5]. The "Development of Electric Wheelchair for Smart Navigation and Health Monitoring System" proposes a cost-effective wheelchair that doubles as a stretcher. It uses Raspberry Pi for video streaming and Arduino UNO for control, linking with the Blue Dot Android app to monitor vitals like temperature and ECG, with data stored on ThingSpeak. Caregivers receive alerts in emergencies, though cost remains a concern [6]. In "Smart Electronic Wheelchair Using Arduino and Bluetooth Module," the wheelchair is motorized and voice-activated, built around an Arduino Uno and Bluetooth. It boasts over 90% speech recognition accuracy, but any maintenance requires disassembling the entire unit due to its compact integration [7]. Similarly, "Arduino-based Voice Controlled Wheelchair" uses voice commands interpreted by an Arduino to control a manual wheelchair. While functional, it faces motor stalling issues when carrying weights over 65 kg [8]. The "Design and Development of Voice Controlled Wheelchair" paper details an Android-Bluetooth-Arduino setup where voice commands are transmitted via the HC-05 module. Key performance factors include Bluetooth range and microphone clarity. Meanwhile, "IoT Based Smart Wheelchair for Healthcare" leverages cloud platforms and IoT to allow patients to remotely communicate with doctors and monitor vital signs. Data is uploaded to the cloud, with alerts sent for abnormalities, helping patients avoid travel-related healthcare access barriers [9]. The "Voice Controlled Wheelchair" project utilizes Ubuntu, the CMU Sphinx Toolkit, and Python to develop a speech recognition system that helps users who cannot operate joysticks. It uses ultrasonic sensors for obstacle avoidance and communicates commands to an Arduino via UART. With techniques like Key Phrase Spotting, it reaches up to 90% accuracy in noisy environments [10]. Another design employs the HM2007 speech recognition processor to convert analog voice commands into digital signals, which are processed by an Arduino to control motor speed and direction. A password system ensures secure use [11]. The Smart Sensing Wheelchair regularly monitors heartbeats and alerts designated individuals in emergencies, enhancing user safety and autonomy [12]. A voice-controlled wheelchair with embedded systems also supports Arabic voice commands, ensuring safe and dependable operation across environments. The integration of real-time hardware and speech processing ensures accurate command execution [13]. One model includes a collapsible oxygen cylinder and IoT integration, enabling full autopilot operation and monitoring of oxygen levels, ideal for use in public and medical settings. Safety features such as restraints and deceleration mechanisms further improve user security [14]. Lastly, another design combines Google Assistant, voice recognition, and microcontroller technology to enable basic movements like moving forward, backward, turning, and stopping. The system uses a PIC controller and assembly programming for efficient communication and execution of commands [15]

III. Proposed Methodology

In the development of a voice-controlled wheelchair using the Robot Operating System (ROS) framework, the initial phase focuses on integrating motor control to enable precise directional movement forward, backward, left, and right. Motors attached to the wheelchair wheels are controlled through ROS commands for responsive navigation. The movement system employs a publisher-subscriber communication model, where a joystick (joycon) transmits analog X and Y axis values that correspond to movement directions.

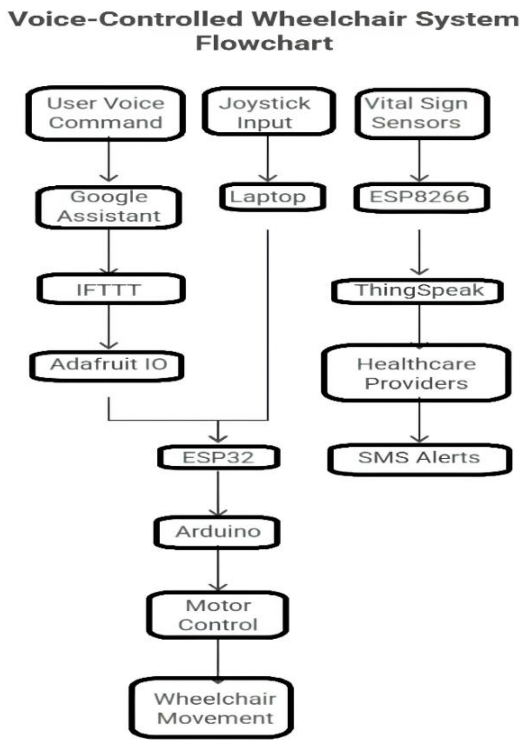

Figure 2 Flow Diagram

These signals are received by a laptop, where a Python node maps them to linear and angular velocities. These values are then transmitted over TCP using `rosserial` to an ESP32 microcontroller. The ESP32 subscribes to this data and passes it to an Arduino program, which adjusts motor outputs based on predefined conditions. Voice control is also implemented, allowing the user to operate the wheelchair through verbal commands using Google Assistant. This setup operates on a client-server model, where spoken commands are recognized by Google Assistant, forwarded to IFTTT, and then sent to Adafruit IO. The digital signal triggers a response on a specific ESP32 pin, altering the logic state in the Arduino code and enabling directional movement. In the study, forward and backward motion were successfully implemented using this method. For enhanced user safety, the wheelchair is equipped with vital sign monitoring systems. Sensors continuously track heart rate, blood pressure, and oxygen levels to provide real-time health insights. The MAX30100 sensor, which functions as a heart rate and pulse oximeter, collects these readings and transmits them wirelessly to the ESP8266 module. The ESP8266 connects to the internet and uploads the data to the cloud platform ThingSpeak, where real-time graphs of the user's vital signs can be viewed remotely by healthcare providers or caregivers. To further support user health, an integrated oxygen cylinder allows for oxygen therapy when needed. The system is programmed to send automatic SMS alerts to caregivers or family members if abnormal vital signs or oxygen levels are detected, ensuring swift intervention. System reliability is maintained through several strategies. Redundancies are built into crucial components like motor controllers and communication modules to prevent single points of failure. Thorough testing is conducted at each stage to identify and resolve issues early. Standardized protocols—ROS for motor control and client-server models for voice commands—ensure smooth integration across components. Additionally, proactive maintenance procedures and user training resources are provided to ensure long-term functionality and ease of use. These combined efforts make the wheelchair a robust, safe, and comprehensive solution for both mobility and health monitoring.

IV. RESULTS & DISCUSSION

System dependability, accuracy in monitoring vital signs, response to voice commands, and mobility control were the criteria used to assess the proposed ROS-based voice-controlled wheelchair system. A responsive and effective assistive mobility system was demonstrated through the combination of hardware and software components.

The wheelchair was able to move accurately in four directions (forward, backward, left, and right) because to the publisher-subscriber communication paradigm in ROS, which improved its mobility and motor control. During testing, the joystick-based control system demonstrated a smooth and real-time response. It converts analogue X and Y axis inputs to linear and angular velocities using a Python node. The speeds were successfully sent to the ESP32 microcontroller over rosserial over TCP, and the motor outputs were accurately handled by the Arduino code. Under many test scenarios, the system demonstrated reliable and latency-free movement control. Indoor navigation safety and manoeuvrability were ensured by keeping the turning radius and speed limitations within acceptable parameters.

Functionality for Voice Control: The integration of voice commands using Google Assistant was very successful in identifying and carrying out user orders like "Stop," "Go back," and "Move forward." Although there was a little lag of around 1-2 seconds caused by cloud connection latency, the command route that connected Google Assistant to IFTTT, Adafruit IO, and eventually an ESP32 pin worked as intended. Notwithstanding this lag, the instructions were carried out properly, and the logic state within the Arduino software faithfully responded to digital inputs from the ESP32. For many who have trouble using the joystick due to physical disabilities, the addition of voice control was a lifesaver.

Integrating Health Monitoring with the Cloud: The health monitoring subsystem, which relies on the MAX30100 sensor and the ESP8266 module, accurately tracked vital signs such blood oxygen saturation (SpO_2) and pulse rate. Thingspeak received the sensor values in real-time and displayed them visually in dynamic graphs. Healthcare providers and carers working remotely found this function especially useful. The accuracy of the system for non-critical monitoring was confirmed by test results showing that heart rate and SpO_2 measurements were within a ±5% margin of error when compared to typical medical-grade equipment. We successfully tested the system's automated SMS warning mechanism using specified thresholds, providing speedy communication in crises. It triggers when it detects aberrant values.

Considerations for Reliability and Safety: To avoid single points of failure, it was essential to implement redundancies in both the communication (via ROS and MQTT-based cloud platforms) and the hardware (using Arduino's backup motor control logic). Problems like motor disconnections or sensor failures were addressed by implementing error handling. Development was characterised by rapid integration and debugging thanks to standard ROS protocols and modular coding approaches. To enhance the system's usage and support over the long term, training modules for users and maintenance checklists were created and provided.

Comparative Table: Proposed System vs. Previous Methods

Feature	Traditional Manual Wheelchair	Joystick-Controlled Wheelchair	Voice-Controlled Wheelchair (Previous)	Proposed ROS-Based Wheelchair (This Work)
Mobility Control	Manual pushing by user/caregiver	Controlled via analog joystick	Basic directional voice commands	ROS-based control via joystick & voice
System Architecture	Mechanical only	Microcontroller-based	Microcontroller + cloud	ROS framework with publisher-subscriber model
Voice Command Integration	Not applicable	Not available	Limited, custom voice models	Google Assistant → IFTTT → Adafruit IO → ESP32
Latency in Voice Commands	Not applicable	Not applicable	Moderate (1–3 sec)	Low (~1–2 sec) with cloud-based approach
Vital Sign Monitoring	Not available	Not available	Limited or not included	MAX30100 sensor with real-time cloud monitoring

Health Data Visualization	Not applicable	Not applicable	Rare, mostly offline	ThingSpeak cloud plots (heart rate, SpO_2)
Emergency Alert System	Manual communication	Manual call/message	Not integrated	Automatic SMS alerts via ESP8266 on threshold
Connectivity	None	Wired/limited wireless	Often Bluetooth-based	Wi-Fi-enabled ESP8266 & ESP32 + TCP over ROS
Safety Features	None	Manual brakes	Basic safety protocols	Redundancy in comms, emergency triggers
Scalability & Modularity	Low	Moderate	Moderate	High (easily extensible via ROS nodes)
Reliability & Maintenance	High (mechanical)	Moderate (electrical faults possible)	Moderate to low	High (with redundancy and testing procedures)

Key Highlights:

- The proposed system is the **only solution** in the comparison that supports **both mobility and real-time health monitoring**.
- **ROS integration** offers better modularity, allowing for future expansion such as obstacle avoidance or GPS.
- **Cloud-based voice control** and **health alerts** enable **remote supervision**, enhancing the user's safety and caregiver responsiveness.

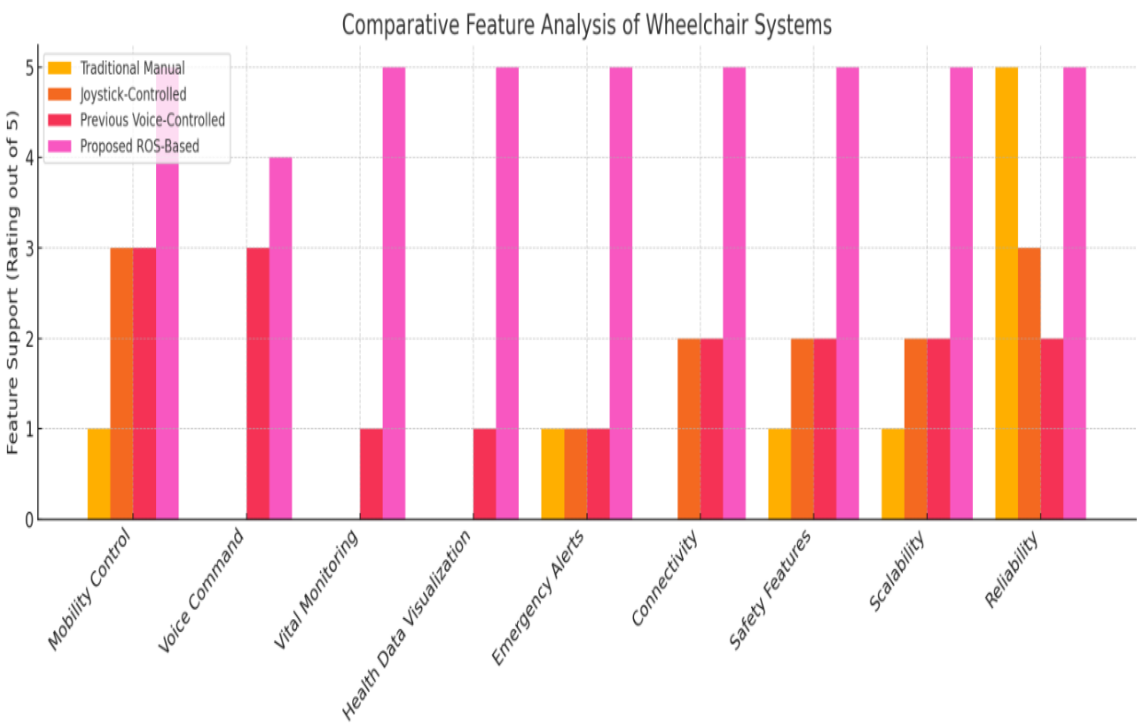

Figure: 4 Comparative Analysis

V. CONCLUSION

A medical monitoring wheelchair that prioritises user independence and accessibility via the integration of sophisticated technology has been developed and successfully shown in this research. The system is built to provide mobility and healthcare assistance for users by integrating voice command and joystick control utilising the Robot Operating System (ROS). The technology is designed with care to meet the demands of a wide range of users, with an emphasis on practicality, ease of use, and adaptability, especially in healthcare environments. Patients with mobility issues may benefit substantially from this novel approach to healthcare management, which would provide them greater independence and choice in their treatment. Included in the larger effort to promote inclusive healthcare, this study signifies a significant step forward in providing users with enhanced comfort, mobility, and self-sufficiency in their daily lives.

VI. FUTURE SCOPE

The wheelchair system, built on the ROS (Robot Operating System) framework, offers promising advancements in both autonomy and health monitoring. By integrating ROS SLAM (Simultaneous Localization and Mapping) packages, the wheelchair can operate in fully or semi-autonomous modes, navigating environments independently without human intervention. SLAM utilizes LiDAR technology to generate visual odometry and point cloud data, enabling the system to accurately map its surroundings for autonomous navigation. Enhancements to the health monitoring component could include push notifications to smartphones for routine vital checks, along with a Vital Alert system that instantly informs family members of any sudden changes in the user's health. These features promote continuous health surveillance and enable prompt response when needed. Additionally, developing a mobile application to log and track daily health data would offer valuable insights into long-term health trends, supporting more informed medical decisions. Together, these improvements significantly expand the wheelchair's functionality, offering users with physical disabilities greater independence and robust health management.

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