Chapter 1

INTRODUCTION

Voice-Controlled Smart Wheelchair with GPS, Joystick, and Fall Detection Alarm System
Mobility plays an essential role in human independence, yet millions of individuals worldwide face challenges due to physical disabilities, neurological disorders, and aging-related limitations. For people who rely on wheelchairs, movement can often be physically demanding, requiring manual force or joystick control. However, traditional wheelchairs present obstacles, as they may not be suitable for individuals with limited upper body strength, muscular disorders, or reduced dexterity.

With continuous advancements in artificial intelligence (AI), robotics, and IoT-enabled assistive technology, this project aims to transform mobility solutions by developing a fully motorized, voice-controlled smart wheelchair. This innovative system integrates GPS tracking, joystick control, and an intelligent fall detection alarm, ensuring greater independence, security, and adaptability for users.

Unlike conventional wheelchairs, which depend solely on manual maneuvering or joystick navigation, this prototype utilizes speech recognition technology, enabling users to move effortlessly using verbal commands. The design follows Mechatronic Systems Engineering, ensuring precision, efficiency, and real-time responsiveness.

The voice-controlled functionality operates through an Android smartphone connected via Bluetooth module HC-05, with speech commands processed by the ATMEGA 328 microcontroller to direct the wheelchair's movement. This hands-free approach allows individuals with limited motor control to navigate their surroundings with ease. Additionally, joystick control serves as an alternative method, giving users the flexibility to switch between manual and voice-assisted mobility based on preference or physical ability.

A breakthrough feature in this project is the Fall Detection & Alarm System, developed to enhance user safety in case of unexpected wheelchair tipping or falls. Falls can pose severe risks, leading to injuries, fractures, or prolonged recovery periods, especially for individuals with mobility impairments. To mitigate these risks, the wheelchair is integrated with tilt and motion sensors, capable of detecting sudden shifts in balance. If a fall occurs, the system automatically:

- Triggers an instant alarm to alert nearby individuals.
- Sends GPS-based emergency notifications to caregivers, family members, or medical personnel.
- Allows voice-activated emergency calls, enabling users to request help with a simple command (*"Help!"*).
- Provides mobile app integration, allowing caregivers to monitor alerts remotely and respond effectively.
- Furthermore, the wheelchair incorporates IoT-based smart connectivity, enabling remote monitoring, data logging, and predictive safety alerts, ensuring a comprehensive mobility solution.
- This project represents a revolutionary step in assistive mobility, combining AI-driven automation, obstacle detection, and IoT connectivity. The voice-controlled smart wheelchair has the potential for real-world applications in:
- Healthcare and rehabilitation centers, improving accessibility for patients with spinal cord injuries, muscular dystrophy, ALS, or post-surgical mobility restrictions.
- Elderly care facilities, allowing seniors to move independently while ensuring safety through fall detection alerts.
- Public accessibility enhancements, making it possible for individuals to navigate urban environments effortlessly.

Chapter 2

LITERATURE SURVEY

To understand the effectiveness of our project we had to first understand the types of the existing wheelchair, their advantages, and their shortcomings. Some of the types of wheelchairs are:

- Manual wheel Chair: Had to be manually operated.
- Electric Wheel Chair: Controlled by a lever but not automatic.
- Beach Wheel Chair: Good grip on sand but manual.
- Airplane Wheel Chair: Additional strapping but manual.
- Ergonomic Wheel Chair: Extremely comfortable but manual.
- Pediatric Wheel Chair: Kid-size Wheelchair Semi-Automatic.
- Reclining Wheel Chair: Can be tilted to a limited angle,
- Wheel Chair Stretches: Can be opened to a stretcher.

We even did our research by reading a few of the papers and here are what we understood and used through those.

We went through a paper that specified about the development of wheelchair that can be controlled by voice, eye or using joystick according to the severity of disability of handicap person. It also features a warning system that analyses the patient real situation such as heart rate, temperature, etc. and notifies the doctor regarding the same. It even has integrated robotic hand which helps the patient for taking medicines and food. This study paper concentrates on the queries of the handicapped individual and tries to resolve them in the best feasible way. The condition is that it ought to be formed independently for each single specified to its austerity which raises its price and time.

The other paper which we through focuses on the development of solar based wheelchair which helps in reducing the running cost of the wheelchair. It is specifically created for hemipelagic users to control the wheelchair efficiently. The control of the wheelchair can be assigned to either side to help the user. The wheelchair has significant benefits but still restricts from the circumstance that it has larger battery charging time and less capacity to climb up the slope

The other paper specified about the high costing of the electric wheelchair and modifying the present electric wheelchairs to make it affordable to the common people. It put importance on the utilization of sources open locally to cut the price of wheelchair. It utilizes pair of dc gear motor, PIC microcontroller and h bridge module for commanding the movement of wheelchair. The shortcoming of this research is that expense of the wheelchair is still huge for the ordinary people to afford it.

After looking at all the work we came to the decision that there was no voice-controlled wheel chair which would use an android phone for controlling it through the App where it would send signal through Bluetooth to the HC05 and the rest of the function would take place. Hence our idea would be the first of its kind. But it came with the added disadvantage of 3rd party intervention and failure of the voice control leads to failure of the entire system.

Chapter 3

Aim

The primary aim of this project is to develop an intelligent, motorized wheelchair that integrates voice control, GPS tracking, joystick navigation, and an advanced fall detection alarm system. The goal is to provide a highly efficient and accessible mobility solution for individuals with physical disabilities, ensuring greater independence, security, and adaptability in everyday movement.

This wheelchair is designed to:

- Enhance accessibility by allowing users to control movement hands-free using voice recognition.
- Integrate multiple control options, including joystick functionality, for flexibility in navigation.
- Improve user safety by incorporating real-time fall detection alerts using motion sensors.
- Enable seamless communication between the wheelchair and caregivers via Bluetooth and IoT-based smart monitoring.
- Support long-distance travel with an optimized power system and battery efficiency.
- Ensure lightweight, cost-effective design, making the prototype practical for users.
- Facilitate remote control and emergency notifications, enhancing response in critical situations.

Scope of the Present Investigation

Disability affects millions worldwide, and the need for advanced assistive mobility technology continues to grow. It is estimated that 100-130 million individuals rely on wheelchairs due to:

- Inherited genetic disorders such as muscular dystrophy.
- Congenital conditions affecting spinal structure, such as spina bifida.
- Traumatic injuries, including spinal cord damage or brain trauma from accidents.

Experts predict that wheelchair users will increase by 22% in the next decade, driving the demand for smart, automated mobility solutions. Conventional manual wheelchairs require physical effort, which may be challenging for individuals with severe muscular or neurological limitations. Additionally, standard wheelchairs are difficult to maneuver on rough terrain or inclined surfaces and often rely on caregiver assistance.

The introduction of voice-controlled, sensor-equipped, smart wheelchairs offers enhanced mobility, safety, and autonomous navigation. By integrating speech recognition, joystick control, real-time GPS tracking, and Bluetooth communication, this system significantly improves independence and accessibility for users.

Features and Functionalities

- AI-Based Speech Recognition System
- Machine learning algorithms ensure personalized adaptation to user voice patterns.
- Multi-command processing allows users to navigate efficiently with complex commands such as "Move forward 3 meters, turn left, and stop."
- Emergency voice activation, enabling users to say *"Help!"* to trigger alerts.
- 2. GPS-Based Route Planning & Safety Alerts
- Real-time GPS tracking, enabling users and caregivers to monitor location.
- Geo-fencing alerts, notifying caregivers when a user moves beyond predefined safe zones.

Fall Detection & Automatic Emergency Response

- Tilt and motion sensors continuously monitor stability to prevent falls.
- If a fall or tipping risk is detected, the alarm system activates and:
- Sends alerts to caregivers via Bluetooth or IoT communication.
- Shares the user's GPS coordinates for emergency response.
- Allows voice-triggered emergency calls if movement ceases post-fall.
- 4. Hybrid Joystick & Voice Navigation
- Seamless switching between joystick-controlled movement and voice navigation.

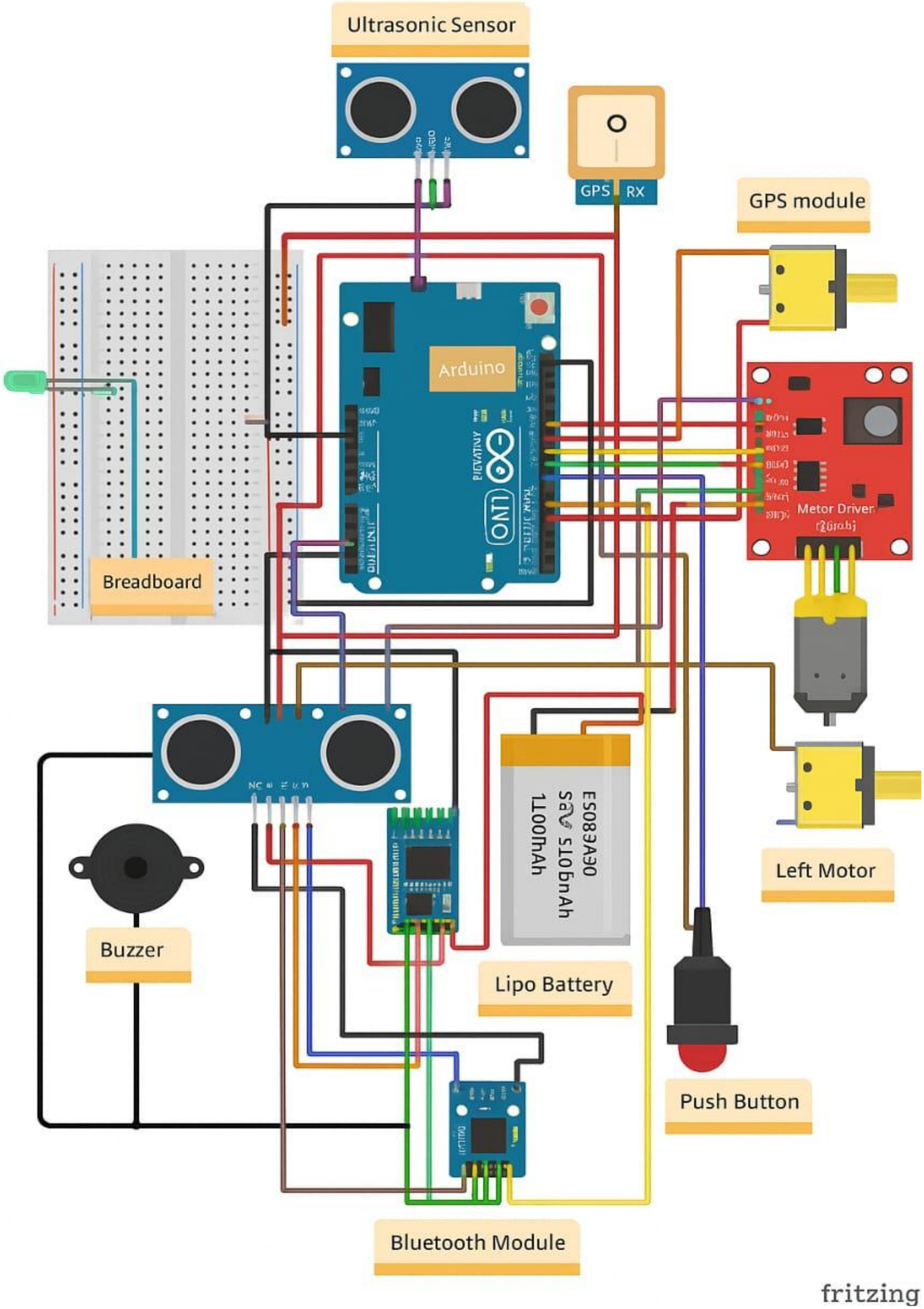
- Ergonomic joystick placement, ensuring comfortable accessibility for manual use.
- 5. Wireless Connectivity & IoT Functionality
- Android-based remote-control app ensures wireless operation up to 100 meters.
- Bluetooth and Wi-Fi compatibility allow integration with smart home and medical monitoring systems.

Materials Required:

- Arduino Uno Board – The central processing unit for controlling the wheelchair's movements.
- Arduino Cable – Used for programming and data transfer.
- Motor Driver Module (L293D) – Controls the direction and speed of the DC motors.
- Motors (2) – Provide movement control for the wheelchair.
- Caster Wheel – Enhances stability and maneuverability.
- Wheels (2) – Main driving mechanism for navigation.
- Bluetooth Module (HC-05) – Enables wireless communication between the wheelchair and the Android smartphone.
- Power adapters or battery – Provides energy for prolonged mobility.

New Features Added:

- GPS Module – Enables real-time location tracking and navigation assistance.
- Ultrasonic Sensors – Detect obstacles and prevent collisions for safer movement.
- Joystick Control – Provides manual movement control as an alternative to voice commands.
- Intelligent Fall Detection Sensors (Gyroscope & Accelerometer) – Monitor wheelchair stability, detecting sudden falls or tipping events.
- Alarm System – Sounds an alert if the wheelchair falls or tips, notifying caregivers via mobile app integration and emergency alerts.
- Android App - BT Voice Control for Arduino (Google Play Store) – Allows users to issue voice commands, monitor movement, and control emergency functions remotely.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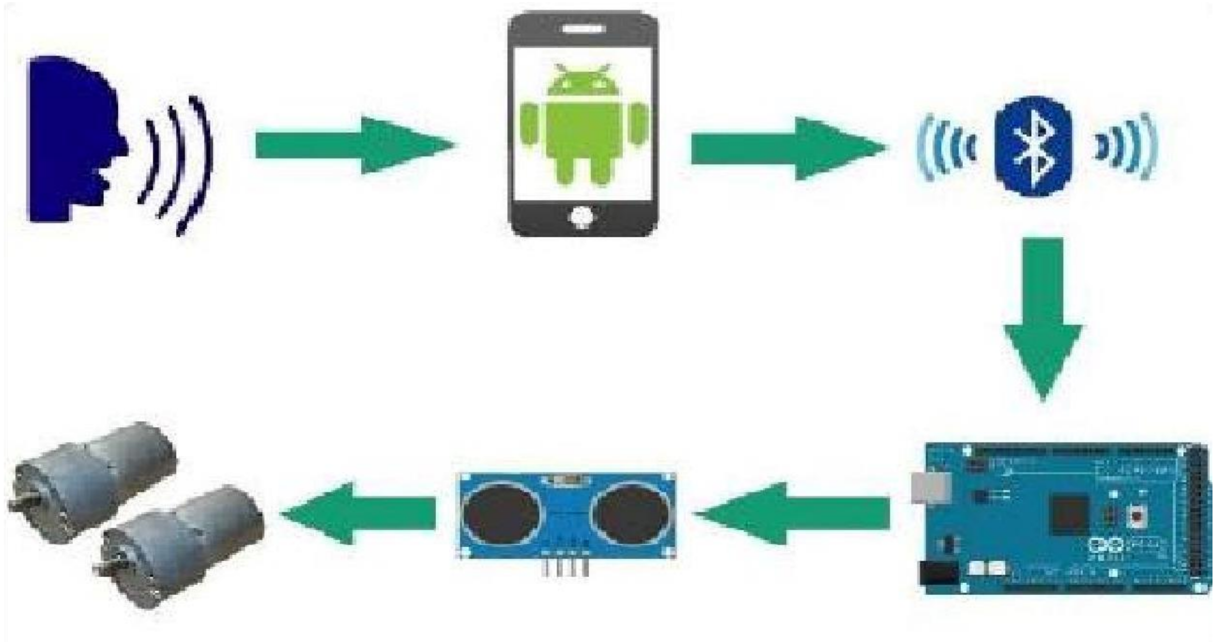

- When the app is started at that point a request is created if the Bluetooth is not switched on.
- A combined virtual switch is near which is utilized to combine the Android mobile phone with the device Bluetooth HC-05 for wireless transmission of data.
- When the Bluetooth has turned on the request considers the information when the user affects the virtual button.
- If the requirement is forward and only if the ultrasonic sensor does not sense any object within 30 cm in front of it then all the dc motors are provided with 5V and submitted in forwarding directions for linear progression.
- If the condition is opposite then all the dc motors are provided with 5V and moved in reversed tracks for linear movement.
- If the condition is to switch left then the left dc motors are suspended and the right dc motors are provided with 5V and the wheelchair progress in left direction.
- If the condition is to turn right then the right dc motors are suspended and the left dc motors are provided with 5V and the wheelchair progress in right direction.

- If STOP over the voice command is said then all the dc motors are stopped.

Chapter 4

Proposed Methodology

The proposed methodology for developing the Voice-Controlled Smart Wheelchair with GPS, Joystick, and Fall Detection Alarm System involves a systematic approach integrating hardware development, software programming, sensor calibration, and real-time testing. The following steps outline the key phases of the project:

1. System Design & Requirements Analysis

- Conduct an in-depth analysis of user needs, mobility challenges, and accessibility features.
- Define functional requirements, including voice recognition accuracy, joystick responsiveness, GPS tracking efficiency, and fall detection sensitivity.
- Determine hardware specifications, selecting optimal sensors, microcontrollers, and wireless communication modules.

2. Hardware Development & Integration

- Assemble the Arduino Uno microcontroller, motor driver module (L293D), and DC motors for precise wheelchair movement.
- Integrate Bluetooth module (HC-05) for wireless voice commands via an Android smartphone.
- Install ultrasonic sensors for obstacle detection and gyroscope & accelerometer sensors for fall detection.
- Mount a GPS module for real-time location tracking and emergency alerts.
- Configure battery and power systems for long-distance travel and extended use.

3. Software & Control System Implementation

- Develop Arduino-based programming to process voice commands and joystick inputs.
- Implement speech recognition algorithms to ensure accurate command execution via Android app integration.
- Program fall detection algorithms, triggering an alert upon detecting a sudden tilt or fall.
- Establish IoT connectivity for remote monitoring and caregiver assistance.

4. Testing & Calibration

- Conduct sensor calibration to optimize responsiveness and accuracy.
- Perform real-world testing to ensure voice commands, joystick control, GPS tracking, and fall detection alarm function seamlessly.
- Analyze wheelchair stability on various terrains, including ramps, uneven surfaces, and inclines.
- Fine-tune emergency alert activation thresholds for real-time responsiveness.

5. Deployment & User Feedback Collection

- Deploy the wheelchair prototype for usability testing.
- Gather feedback from individuals with mobility impairments, caregivers, and healthcare professionals.
- Improve functionality based on real-world observations to enhance accessibility, reliability, and efficiency.

Working Principle of the Voice-Controlled Smart Wheelchair

The Voice-Controlled Smart Wheelchair with GPS, Joystick, and Fall Detection Alarm System operates using a combination of sensors, microcontrollers, and wireless communication modules, ensuring automated mobility and real-time safety monitoring.

1. Voice Command Processing & Motion Control

- The Bluetooth module (HC-05) receives voice commands from the user's Android smartphone.
- The Arduino Uno microcontroller processes the command and converts it into movement instructions.
- The motor driver module (L293D) controls the wheelchair's motors, executing movement in the specified direction.
- The wheelchair moves forward, backward, left, or right based on voice inputs.

2. Hybrid Control Using Joystick & Voice

- Users can also operate the wheelchair manually via joystick navigation.
- The system allows seamless switching between voice commands and joystick control, ensuring flexibility.

- The Arduino board processes joystick inputs and directs the motor drivers accordingly.

3. GPS Tracking & Navigation

- The GPS module continuously tracks the user's location.
- In emergency situations, GPS data is transmitted to caregivers or emergency responders.
- The system supports predefined safe routes, ensuring efficient and secure mobility.

4. Obstacle Detection & Safety Mechanisms

- Ultrasonic sensors detect obstacles in the wheelchair’s path.
- If an obstacle is detected, the system stops movement, preventing collisions.
- Alerts can be issued via mobile notifications, warning the user about obstacles ahead.

5. Fall Detection & Alarm System

- Gyroscope and accelerometer sensors monitor the wheelchair’s balance and tilt angle.
- If a fall or tipping is detected:

- An alarm is triggered, notifying nearby individuals.
- A notification is sent to caregivers via Bluetooth or IoT-based mobile apps.
- GPS coordinates are shared with caregivers for quick assistance.
- The user can activate emergency calls using voice commands (*"Help!"*).

6. Wireless Communication & Remote Monitoring

- The wheelchair is connected to an Android-based mobile application for remote control and monitoring.
- Caregivers can:

- Track the wheelchair’s location using GPS.
- Receive fall detection alerts in real-time.
- Control the wheelchair wirelessly up to 100 meters.

Chapter 5

Project Outcomes

The Voice-Controlled Smart Wheelchair with GPS, Joystick, and Fall Detection Alarm System successfully addresses key challenges faced by individuals with mobility impairments, improving accessibility, independence, and safety. The expected outcomes of this project include:

1. Enhanced Mobility and Independence

- Users can move effortlessly through voice commands, reducing dependence on caregivers.
- Hybrid control system enables seamless switching between joystick and voice navigation.
- Long-distance travel capability ensures extended usability with optimized battery performance.

2. Real-Time Safety & Emergency Response

- Fall detection sensors provide instant alerts when the wheelchair tips or falls.
- Emergency alarm system activates voice-triggered emergency calls (*"Help!"*) in critical situations.
- GPS tracking allows caregivers to monitor user location remotely for safety assurance.

3. Intelligent Navigation & Obstacle Avoidance

- Ultrasonic sensors prevent collisions, ensuring safer movement in crowded spaces.
- IoT-based smart connectivity enables caregivers to control and monitor movement remotely.
- Geo-fencing alerts notify caregivers if users exit predefined safe zones.

4. Cost-Efficient, Lightweight & Scalable Design

- Simplified hardware integration makes the wheelchair affordable and easy to manufacture.
- The compact, lightweight structure improves maneuverability and portability.
- The system can be adapted for future improvements, including self-balancing and AI-driven automation.

5. Future Research & Development Scope

AI-powered mobility solutions. Healthcare and rehabilitation centers, enhancing accessibility for patients recovering from injuries or surgeries.

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