International Journal of Creative and Open Research in Engineering and Management
ISSN: **3108-1754 (Online)**
Volume 02 Issue 03 March-2026 | Impact Factor: 3.5

Robotic Suit for Paralyzed Person

1 Dr Anto Francis Cherussery,2 Basil M Prasad,3 Gowrisankardas,4 Muhammed Muhsin C K

1 Professor,2 Student,3 Student,4 Student
1 Department of Mechatronics Engineering
1 Nehru College of Engineering and Research Centre, Thrissur, India

How to Cite this Article:

Prasad, B. M., Gowrisankardas, & Muhsin, M. (2026). Robotic Suit for Paralyzed Person. International Journal of Creative and Open Research in Engineering and Management, <i>02</i>(03). https://doi.org/10.55041/ijcope.v2i3.205

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Abstract: Paralysis caused by spinal cord injuries, neurological disorders, or muscle degeneration significantly affects the mobility and independence of individuals. Assistive robotic technologies such as wearable exoskeletons provide a promising solution to restore movement and improve quality of life. This project presents the design and development of a robotic suit intended to assist paralyzed individuals in performing lower limb movements and basic walking activities. The system integrates sensors, actuators, and an embedded control system to replicate natural human leg motion. Components such as an ESP32 controller, MPU6050 IMU sensor, flex sensors, motor drivers, and DC motors work together to detect user intention and generate assisted movement. The suit is designed using lightweight structural materials such as aluminium or steel to ensure durability and comfort. The robotic suit aims to enhance mobility, support rehabilitation processes, and increase independence for individuals with lower limb paralysis. This work demonstrates the potential of wearable robotics in improving human mobility and supporting modern rehabilitation technologies.

Index Terms **- Robotic Suit, Exoskeleton, Paralysis Rehabilitation, Assistive Robotics, Mechatronics, Wearable Robotics**

I. INTRODUCTION

Paralysis affects millions of people worldwide and often results in the loss of voluntary movement in certain parts of the body. Individuals with lower limb paralysis face severe challenges in performing daily activities such as walking, standing, or maintaining balance. These limitations significantly reduce independence and overall quality of life.

Recent developments in robotics and mechatronics have introduced wearable robotic systems known as exoskeletons, which can assist individuals with impaired mobility. These robotic suits are designed to support and augment human movement by providing mechanical assistance to joints.

The main goal of this project is to develop a robotic suit for paralyzed individuals that can assist leg movement and support mobility. The system integrates sensors, motors, and intelligent control algorithms to detect user motion and provide appropriate mechanical assistance.

THE ROBOTIC SUIT IS INTENDED TO:

- Assist lower limb movement
- Improve rehabilitation outcomes
- Enhance independence and mobility
- Reduce physical strain during assisted walking

II. LITERATURE REVIEW

Several studies have explored robotic exoskeleton systems designed for rehabilitation and mobility assistance.

Research on the ReWalk powered exoskeleton demonstrated that individuals with spinal cord injuries could achieve assisted walking with improved mobility and minimal safety risks. Clinical trials indicated that approximately 76% of participants were able to walk with assistance using the system.

Another study investigated soft robotic exosuits for stroke patients, where wearable assistive systems improved walking speed and reduced the metabolic cost of movement. These suits used lightweight materials and flexible structures to support natural human motion.

Hybrid systems integrating Functional Electrical Stimulation (FES) with robotic exoskeletons have also been explored to improve rehabilitation outcomes. These systems combine muscle stimulation with robotic assistance to enhance walking performance.

A systematic review of wearable lower limb exoskeletons identified several benefits, including improved gait stability, enhanced rehabilitation outcomes, and increased walking endurance. However, many systems face challenges such as high cost, limited portability, and battery limitations.

These studies highlight the potential of wearable robotic suits in assisting individuals with mobility impairments while also emphasizing the need for more accessible and adaptable solutions.

III. METHODOLOGY

The proposed leg exoskeleton system consists of three main modules:

1. Mechanical structure
2. Sensor system
3. Control and actuation system

The system is designed to support the lower limbs and assist the user during walking.

Mechanical Structure

The exoskeleton frame is constructed using lightweight aluminum or carbon fiber to ensure strength and reduce weight. The structure supports the hip and knee joints.

Processing Unit

A microcontroller (Arduino / Raspberry Pi) is used to process sensor data and control the motor system.

Actuation System

Motors such as servo motors or brushless DC motors are attached to the joints to assist movement.

Sensor System

The system integrates sensors such as:

- IMU sensor for orientation detection
- Force sensors for weight distribution
- Pressure sensors for foot contact detection

IV. System Architecture

The system architecture consists of interconnected hardware modules.

1. Processing Unit

The microcontroller acts as the central controller that processes sensor data and generates motor control signals.

2. Sensor Module

Sensors continuously monitor body posture, joint movement, and walking patterns.

3. Actuation Module

Motors generate mechanical torque to assist hip and knee movement.

4. Power Supply

A rechargeable Li-ion battery pack powers the entire system.

5. Human Interface

The user wears the exoskeleton frame which synchronizes with their walking motion.

V. Procedure

The operation of the leg exoskeleton system follows several stages.

1. System Initialization

All sensors, motors, and controllers are initialized. Communication between modules is established.

2. Sensor Data Acquisition

IMU sensors detect body orientation while force sensors measure weight distribution on the legs.

3. Movement Detection

The controller analyzes sensor data to determine the user's walking intention.

4. Motor Activation

Based on the detected movement, motors assist the hip and knee joints to perform stepping motion.

5. Gait Assistance

The motors follow predefined gait patterns to provide smooth walking support.

6. Balance Monitoring

Sensor feedback continuously monitors body posture and adjusts motor assistance if instability is detected.

7. Continuous Feedback Loop

The system constantly updates motor commands based on sensor readings to maintain stable locomotion.

VI. Data Analysis

Data analysis focuses on evaluating the performance of the exoskeleton during assisted walking.

Gait Analysis

Parameters measured include:

- Step length
- Step timing
- Walking speed

Balance Analysis

IMU sensors measure:

- Pitch angle
- Roll angle
- Acceleration

These values help determine the stability of the user during walking.

Motor Performance Analysis

Motor torque and energy consumption are analyzed to evaluate efficiency.

VII. Results

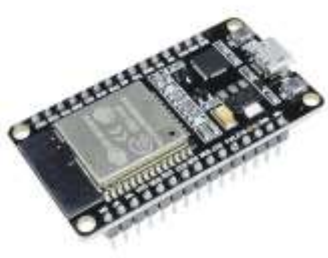
The developed exoskeleton prototype successfully demonstrates assisted walking capability.

- The system supports hip and knee joint movement.
- Sensors successfully detect body posture and walking motion.
- Motor assistance reduces physical effort during walking.
- The system maintains stability through continuous sensor feedback.

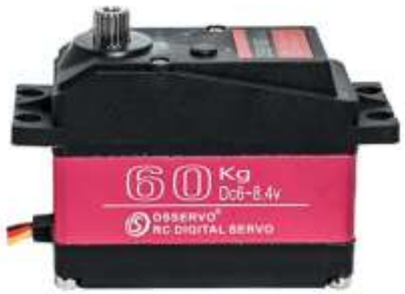
VIII. System and Components

The robotic exoskeleton system consists of multiple components.

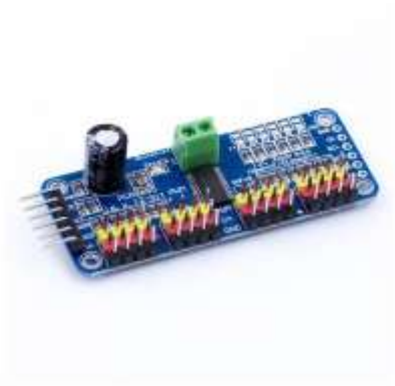
- **Microcontroller**– Esp32– Controls the entire system by processing sensor data and sending commands to the motors.



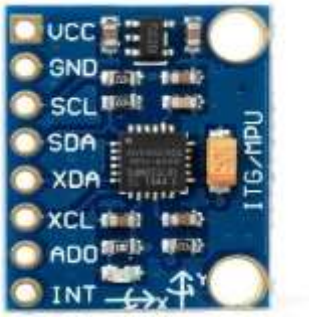
- **Servo Motors**– Drive the robot's leg joints.



- **PCA9685 Servo Driver** – Controls multiple servo motors.



- **MPU-6050** – Provides orientation and balance data



- **Lithium-ion Battery** – Supplies portable electrical power to the exoskeleton system.
- **Lightweight Mechanical Frame** – Provides structural support and connects the exoskeleton to the user's legs.

IX. Conclusion

This project presents the design and implementation of a leg exoskeleton system for assisted locomotion. The system integrates sensors, actuators, and embedded controllers to support walking movements.

The results demonstrate that the exoskeleton can effectively assist lower limb movement while maintaining stability and user safety. The system has potential applications in rehabilitation therapy, mobility assistance for disabled individuals, and industrial worker support.

Future improvements may include:

- AI-based gait prediction
- EMG-based muscle control
- Lightweight materials for better comfort
- Advanced balance control algorithms

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