

International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.206

Volume 9, Issue 2, February 2026



International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

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EMG Controlled Active Ankle Prosthetic Leg with Fall Detection

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ABSTRACT: This project presents the design and development of an EMG-controlled active ankle prosthetic leg integrated with a fall detection system to enhance mobility and safety for lower-limb amputees. Conventional passive prosthetic legs lack active ankle motion, resulting in unnatural gait patterns, increased fatigue, and higher risk of falls. The proposed system utilizes surface electromyography (EMG) sensors to capture muscle signals from the residual limb, which are processed by a microcontroller to control a high-torque servo motor responsible for ankle or inflexion and plantar flexion. Additionally, an inertial measurement unit (IMU) consisting of an accelerometer and gyroscope is used to detect sudden falls or abnormal body orientation. Up on detecting a fall, the system immediately disables ankle actuation to prevent injury. The prosthetic is designed using 3D printing technology to ensure lightweight, affordability, and customization. The developed prototype demonstrates real-time responsiveness, improved gait assistance, and enhanced user safety, making it a promising low-cost solution for assistive healthcare applications.

I. INTRODUCTION

Lower-limb amputees face significant challenges in mobility due to the absence of natural ankle movement. Traditional prosthetic legs are mostly passive and do not adapt to user intent, leading to inefficient walking patterns and increased energy consumption. Advanced powered prosthetics exist but are often expensive, heavy, and inaccessible to a majority of users.

Recent advancements in embedded systems, biomedical sensors, and additive manufacturing have enabled the development of intelligent prosthetic solutions. EMG-based control allows prosthetic devices to respond directly to the user's muscle activity, providing intuitive and natural movement. However, safety remains critical concern, as amputees are more vulnerable to falls.

This project aims to address both mobility and safety by developing an EMG-controlled active ankle prosthetic leg with an integrated fall detection system. By combining muscle signal interpretation with real-time motion monitoring, the system enhances walk in assistances while ensuring user protection

II. LITERATURE REVIEW

Several studies have explored EMG-based prosthetic control for upper-limb and lower-limb applications. Early research focused on EMG-controlled prosthetic hands, while later developments introduced powered ankle joints using DC motors or pneumatic actuators. However, these systems often require complex signal processing and expensive hardware

Research on fall detection systems primarily uses accelerometer and gyroscopes in wearable devices. Threshold-based and orientation-based algorithms have shown reliable fall detection accuracy. Some studies highlight the importance of combining fall detection with assistive devices to improve user safety.



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Recent literature suggests that integrating EMG control with IMU-based fall detection can significantly enhance prosthetic reliability. However, few low-cost implementations combine both features in a single ankle prosthetic system, indicating a clear research and implementation gap.

III. PROBLEM STATEMENT

Most commercially available prosthetic legs lack active ankle movement, resulting in unnatural gait and reduced mobility. Advanced powered prosthetics are expensive and inaccessible to many users. Additionally, existing system soft end on incorporate fall detection, increasing the risk of injury.

The problem is to design a low-cost, intelligent prosthetic ankle system that:

- Responds to user muscle intent using EMG signals
- Provides controlled ankle movement
- Detects falls in real time
- Enhances user safety and mobility

IV. SYSTEM ARCHITECTURE

The system consists of the following main components:

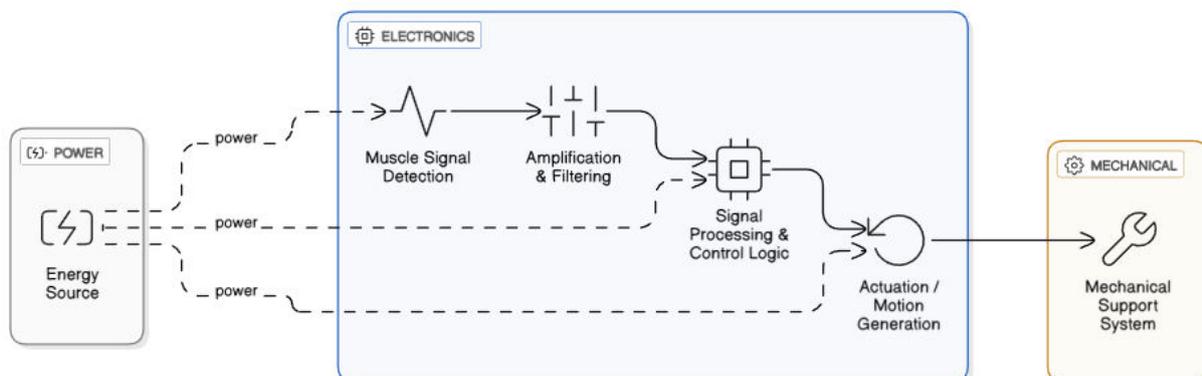
- EMG Sensor: Captures muscle activity signals from the residual limb
- Micro-controller: Processes EMG signals and controls the actuator
- Servo Motor: Provides active ankle movement
- IMU Sensor(Accelerometer +Gyroscope):Detects falls and abnormal orientation
- Power Supply :Battery-based regulated power system
- 3D Printed Prosthetic Structure :Light weight ankle and foot assembly

The microcontroller acts as the central unit, processing EMG and IMU data and ensuring safe operation.

V. SYSTEM OVERVIEW

The EMG sensor continuously monitors muscle contractions and sends analog signals to the microcontroller. These signals are filtered and mapped to ankle joint movement. The servo motor rotates accordingly, enabling dorsiflexion and plantar flexion.

Simultaneously, the IMU monitors motion patterns and orientation. If a sudden fall or abnormal posture is detected, the system immediately disables ankle movement to prevent further injury. The modular architecture allows easy customization and future enhancements.





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VI. IMPLEMENTATION

❖ Hardware Implementation

- EMG sensor placed on residual limb muscles
- Servo motor mounted at ankle joint
- IMU sensor fixed on prosthetic structure
- Micro controller interfaced with all sensors and actuators
- Battery-powered operation

❖ Software Implementation

- EMG signal acquisition and threshold processing
- Servo control logic using PWM
- Fall detection algorithm using acceleration and tilt angle
- Safety override logic during fall detection

VII. TESTING AND RESULTS

The system was tested under simulated walking and fall conditions. EMG-based ankle movement responded accurately to muscle contractions. The fall detection algorithm successfully identified sudden falls and disabled motor movement instantly. Repeated testing showed stable and reliable operation, demonstrating the feasibility of the proposed system.

VIII. WORKING PRINCIPLE

The working principle is based on sensor fusion and real-time control. EMG sensors detect muscle activity, which is translated into ankle motion via servo motor. The IMU continuously monitors acceleration and orientation. When thresholds indicating a fall are exceeded, the system activates safety protocols and halts ankle movement. This dual-layer control ensures both functionality and safety.

IX. THE CRITICAL PROBLEM

- Lack of natural ankle motion in passive prosthetics
- High cost of advanced powered prosthetics
- Increased fall risk for amputees
- Absence of integrated safety mechanisms

X. PROPOSED SYSTEM ARCHITECTURE

Detection Phase:

EMG sensors detect muscle intent, IMU monitors body motion

Processing Phase:

Microcontroller analyzes sensor data and applies control logic

Actuation & Safety Phase:

Servo motor drives ankle movement; fall detection disables motion when required.

XI. ADVANTAGES & DISADVANTAGES

Advantages

- Natural and intuitive ankle movement
- Improved gait stability
- Integrated fall detection for safety
- Low-cost and customizable design
- Light weight 3D printed structure



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Disadvantages

- EMG signals vary between users
- Requires calibration for each user
- Limited to require compared to high-end prosthetics

XII. CONCLUSION AND FUTURE SCOPE

The EMG-controlled active ankle prosthetic leg with fall detection successfully demonstrate functional, low-cost solution for improving mobility and safety of amputees. The integration of EMG-based control and IMU-based fall detection enhances both usability and reliability.

Future enhancements include:

- Adaptive learning for EMG signal interpretation
- Wireless health and fall alerts
- Improved actuation mechanisms
- Clinical trials an ergonomic optimization

REFERENCES

1. EMG-Based Prosthetic Control
<https://ieeexplore.ieee.org/document/8466767>
<https://www.sciencedirect.com/science/article/pii/S1746809418300216>
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6767135/>
2. Active Ankle & Lower Limb Prosthetics
<https://ieeexplore.ieee.org/document/7356686>
<https://www.sciencedirect.com/science/article/pii/S0966636218304235>
<https://www.researchgate.net/publication/322707798>
3. EMG Signal Processing
<https://www.mathworks.com/help/signal/ug/emg-signal-processing.html>
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6164712/>
4. Fall / Accident Detection Using IMU
<https://ieeexplore.ieee.org/document/7808684>
<https://www.sciencedirect.com/science/article/pii/S0169260718301736>
<https://www.mdpi.com/1424-8220/20/5/1376>



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