

AI-Driven Biomechanical Gait Analysis for Early Detection and Rehabilitation of Movement Disorders

Gait analysis, a fundamental branch of biomechanics, plays a crucial role in understanding human locomotion and detecting abnormalities associated with musculoskeletal and neurological disorders. It involves the systematic measurement and interpretation of walking patterns, providing valuable information about body mechanics, joint motion, and muscle coordination. Conventional gait analysis techniques, which depend on laboratory-based motion capture systems, force plates, and optical sensors, offer high precision but suffer from limitations such as high cost, complex setup, and restricted accessibility. These constraints hinder their routine use in clinical and rehabilitation settings.

Recent advances in artificial intelligence (AI), wearable sensor technology, and computer vision have created new opportunities for portable, real-time, and data-driven gait analysis systems. Integrating biomechanics with AI can enhance the interpretation of gait parameters and enable automated recognition of abnormal walking patterns. The proposed research focuses on developing an intelligent gait analysis framework that combines wearable inertial measurement units (IMUs), pressure sensors, and video-based tracking with machine learning models for comprehensive gait evaluation.

The study will extract key spatiotemporal and kinematic parameters—such as stride length, cadence, step time, ground reaction forces, and joint angles—from sensor data. Advanced algorithms, including convolutional neural networks (CNNs) and recurrent neural networks (RNNs), will be employed to classify normal and pathological gait patterns and to detect early indicators of disorders such as Parkinson’s disease, stroke-induced impairments, or cerebral palsy. Data preprocessing, noise reduction, and feature extraction techniques will be applied to ensure model robustness and clinical relevance.

Validation of the developed system will be performed through comparison with standard gait laboratory measurements to ensure accuracy and reliability. The proposed framework will also include a real-time feedback mechanism to assist in rehabilitation, allowing patients and clinicians to monitor progress remotely. This approach will significantly reduce the dependency on expensive laboratory equipment and provide an affordable, accessible, and efficient solution for both clinical and home-based rehabilitation applications.

The expected outcomes of this research include the creation of a reliable AI-driven biomechanical system for gait analysis, early detection of gait abnormalities, and enhanced rehabilitation monitoring. The system’s ability to provide continuous, real-time feedback will contribute to improved patient recovery and better clinical decision-making. Furthermore, this research will advance the integration of biomechanics, sensor technology, and artificial intelligence, paving the way for innovative healthcare solutions in preventive medicine, sports performance optimization, and assistive device development.