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Design and Implementation of a Wearable System for Real-Time Shoulder Rehabilitation Monitoring

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Home-based shoulder rehabilitation is an essential part of recovery following injury or surgery, yet patients often perform exercises without continuous clinical supervision. This can lead to incorrect movements, unsafe loading, and delayed recovery. Wearable sensing technologies combined with the Internet of Things (IoT) and artificial intelligence (AI) offer an opportunity to provide real-time monitoring and feedback outside clinical settings (Patel et al., 2012; Papi et al., 2017).

This research presents the design and implementation of a low-cost wearable rehabilitation system that integrates an MPU9250 inertial measurement unit (IMU), an ESP32 microcontroller, and Arduino IoT Cloud for real-time shoulder movement monitoring. The system estimates shoulder joint angles using complementary sensor fusion, a method supported by systematic evidence on wearable sensor validity for joint angle estimation (Poitras et al., 2019), wirelessly transmits rehabilitation data to a cloud dashboard, and provides immediate audible alerts when unsafe movement or excessive loading is detected. A Random Forest machine-learning model developed in Google Colab performs live exercise recognition and evaluates rehabilitation performance, enabling intelligent remote monitoring.

In this presentation, I will demonstrate the complete wearable rehabilitation platform, including the hardware design, embedded software implementation, cloud-based monitoring dashboard, and AI-assisted exercise recognition framework. The presentation will also discuss the experimental evaluation of the system and illustrate how integrating wearable sensing, IoT connectivity, and AI can improve patient safety, support home-based rehabilitation, and reduce reliance on continuous clinical supervision.

The proposed platform demonstrates the potential of intelligent wearable technologies to deliver accessible, scalable, and real-time rehabilitation monitoring for future healthcare applications.

Keywords
Wearable Rehabilitation, Internet of Things (IoT), Artificial Intelligence, ESP32, MPU9250, Shoulder Rehabilitation, Machine Learning, Real-Time Monitoring

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