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INNOARM: Pose Right – AR/VR-Based Exercise Pose Correction System

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ABSTRACT

With the increasing adoption of home workouts and virtual fitness programs, the absence of real-time supervision often leads to incorrect exercise posture, reduced effectiveness, and a high risk of injuries. To address this challenge, Pose Right is proposed as an Augmented Reality (AR) and Virtual Reality (VR)-based exercise pose correction system that acts as an intelligent virtual fitness trainer. Unlike traditional prosthetics that rely on mechanical switches or complex interfaces, INNOARM offers direct bio-signal control, enhancing usability and responsiveness. The system is built using low-cost, open-source components, making it accessible for wider adoption. Experimental evaluation demonstrates high signal detection accuracy, low response time (less than 200 ms), and reliable performance under different conditions. The results highlight the effectiveness of integrating bio-signal processing, embedded systems, and robotics.This project demonstrates how AR/VR and artificial intelligence can be combined to enhance digital fitness, prevent injuries, and improve exercise accuracy, making it a promising solution for the future of smart health and virtual training.

1. Introduction

The rapid advancement of computer vision, artificial intelligence, and immersive technologies such as Augmented Reality (AR) and Virtual Reality (VR) has transformed the fitness and healthcare industries. With the growing popularity of home workouts and virtual fitness training, there is an increasing need for intelligent systems that can guide users and ensure exercises are performed safely and correctly. Traditional fitness applications mainly provide prerecorded videos or basic instructions, which lack real-time monitoring and personalized feedback. Incorrect exercise posture is a major cause of muscle strain, joint injuries, and reduced workout effectiveness. Without the supervision of professional trainers, users often perform exercises incorrectly without realizing their mistakes. To address this challenge, modern fitness technologies are moving toward smart systems capable of analysing human movement and providing real-time correction.

However, existing smart fitness and rehabilitation systems face challenges such as high cost, limited accessibility, complex setup, and lack of real-time personalized guidance. Many advanced training systems require expensive equipment or professional supervision, making them unsuitable for everyday users.

Research Gap:

Although many fitness and rehabilitation technologies exist, several limitations remain in current systems:

- No real-time correction in most fitness apps.
- Vision-only systems cannot detect muscle activity.
- Very limited use of EMG in workout training.
- AR/VR is rarely used for exercise guidance.
- Lack of personalized feedback and progress tracking.

Objective:

The objectives of this work are:

- To develop a system that detects human body posture during exercises in real time.
- To integrate EMG sensors for monitoring muscle activity during workouts.
- To compare user posture with ideal exercise models using AI algorithms.
- To reduce workout injuries and improve exercise accuracy.
- To create a low-cost and user-friendly virtual fitness trainer for home use.
- To provide instant corrective feedback using AR/VR visualization and voice guidance.

2. Literature Review

2.1 Evolution of Exercise Monitoring Systems

The development of exercise monitoring systems has progressed significantly with advancements in sensing technologies, artificial intelligence, and immersive computing. Early fitness monitoring relied entirely on manual supervision by trainers and physiotherapists. Although effective, this approach was expensive, time-consuming, and limited to physical locations such as gyms and rehabilitation centers. The lack of continuous monitoring created a demand for technology-based solutions that could support users at home.With the rise of wearable technology, sensor-based systems using accelerometers and gyroscopes were developed to track physical activity, repetitions, and movement intensity. While these devices improved activity tracking, they were unable to accurately capture full-body posture or provide visual correction. This led to the adoption of computer vision and deep learning for human pose estimation.

2.2 Review of Existing Systems

Several exercise monitoring and virtual fitness systems have been developed in recent years to improve workout accuracy and remote training. These systems mainly focus on posture detection, wearable sensing, or virtual training environments. However, most existing solutions address only part of the problem and lack a fully integrated approach.

In the rehabilitation field, EMG-based systems are used to monitor muscle activity and assist physiotherapy training. These systems provide valuable insights into muscle engagement and recovery. However, they are usually expensive, require professional setup, and are rarely combined with AR/VR or computer vision for general fitness applications. Recent AR/VR fitness platforms provide immersive workout experiences and improve user motivation through gamification. Despite their advantages, most of these systems do not include accurate posture analysis or muscle monitoring, limiting their effectiveness as intelligent trainers.

2.3 Identified Research Gaps

Existing studies on fitness monitoring, pose estimation, and rehabilitation reveal several limitations that motivate the development of the Pose Right system. Current fitness applications mainly provide prerecorded videos and basic instructions without monitoring the user's posture in real time. As a result, users often perform exercises incorrectly, which increases the risk of injury and reduces workout effectiveness. This shows a clear need for systems that can provide instant posture correction. Advanced motion-tracking and rehabilitation systems are often expensive and require professional setup, making them inaccessible for everyday users. There is a need for a low-cost and user-friendly solution suitable for home workouts.

3. Proposed System

The system architecture of Pose Right is designed to integrate computer vision, electromyography (EMG) sensing, artificial intelligence, and AR/VR visualization into a unified framework for real-time exercise monitoring and feedback. The architecture begins with the data acquisition stage, where user movement and muscle activity are captured simultaneously. A camera or VR headset records the user's body movements during exercise, while wearable EMG sensors placed on key muscle groups capture electrical signals generated during muscle contraction. These inputs provide both external posture data and internal muscle activation information, ensuring a comprehensive understanding of the user's workout performance.

The captured data is then transferred to the processing layer, which serves as the core of the system. In this stage, computer vision algorithms perform pose estimation by identifying body key points and calculating joint angles. At the same time, the EMG signals are amplified, filtered to remove noise, and converted into digital form for analysis. Artificial intelligence models combine the pose data and muscle activation data to compare the user's posture with predefined ideal exercise models. Any deviations, incorrect angles, or improper muscle engagement are detected in real time, and the system generates appropriate corrective instructions.

3.1 User Interface Module

The User Interface (UI) module serves as the main interaction layer between the user and the Pose Right system, providing a simple and user-friendly environment to operate the application. It allows users to create profiles, choose exercises, and start or stop workout sessions while displaying real-time AR/VR posture guidance, visual alerts, and voice instructions during workouts. The interface also presents performance details such as repetition count, accuracy score, and progress reports after each session, ensuring an engaging and easy-to-understand experience that helps the system function like a virtual fitness trainer.

3.2 Video Capture Module

The Video Capture Module in the Pose Right system is responsible for capturing real-time visual data of the user during exercise using a webcam, smartphone camera, or VR headset camera. It continuously records video frames and converts them into image sequences that are sent to the pose detection module for further analysis. Basic pre-processing such as frame resizing, lighting adjustment, and noise reduction is applied to improve accuracy and ensure smooth tracking. The module also guides the user to stay within the camera's field of view for consistent monitoring, making it an essential component for real-time posture detection and feedback generation.

3.3 Pose Detection Module

The Pose Detection Module is the core part of the Pose Right system that tracks and analyzes the user's body posture during exercise using computer vision and machine learning. It captures live video from a camera or VR device and identifies key body points such as the head, shoulders, elbows, hips, knees, and ankles to create a real-time digital skeleton model. The system then calculates joint angles and body alignment to determine whether the exercise is performed correctly. The detected posture is continuously compared with ideal exercise models, and the results are sent to the feedback module to provide instant corrections. This module enables real-time posture monitoring, improves exercise accuracy, and helps prevent injuries during workouts.

3.4 EMG Signal Processing Module

The EMG Signal Processing Module captures and analyzes muscle activity during exercise to improve the accuracy of the Pose Right system. EMG sensors placed on key muscle groups detect small electrical signals generated during muscle contraction. These raw signals are first amplified and then filtered to remove noise and interference before being converted into digital data. The processed signals are analyzed to determine muscle activation levels, detect fatigue, and identify whether the correct muscles are being engaged. This information is combined with pose detection results to provide real-time feedback, helping users perform exercises safely and effectively.

3.5 Performance Tracking Module

The Performance Tracking Module monitors and records the user's workout performance during each session. It collects data such as posture accuracy, repetition count, exercise duration, and muscle activation from the pose detection and EMG modules. This information is analyzed to generate a performance score and maintain a history of previous workouts. By comparing past and current results, the system shows progress, highlights common mistakes, and provides simple recommendations for improvement, helping users stay motivated and achieve better fitness results over time.

4. Experimental Results and Discussion

The experimental setup of the Pose Right system is designed to test real-time exercise monitoring and feedback. A standard webcam or smartphone camera is placed in front of the user to capture body movements during exercise. Wearable EMG sensors are attached to major muscle groups such as the arms, legs, and lower back to measure muscle activity. during testing, the system provides real-time feedback through visual AR overlays and voice guidance. Performance data such as posture accuracy, repetition count, and muscle activation are recorded for evaluation. This setup helps validate the accuracy, responsiveness, and usability of the Pose Right system.

Table 1 Performance Evaluation Metrics

Metric	Value
Pose Detection Accuracy	≥ 90
System Response Time	≤ 1 sec
User Improvement Rate	≥ 20%
Stability	High

The Pose Right system was tested with users performing common exercises such as squats, push-ups, and lunges in a controlled indoor environment. The system successfully detected body posture and provided real-time correction through AR/VR feedback. The pose detection module achieved high accuracy in identifying joint positions and counting repetitions, while the EMG module effectively monitored muscle activation and detected improper muscle usage. The system response time was fast enough to provide instant feedback, allowing users to correct their posture during exercise.

The performance tracking results showed noticeable improvement in user posture accuracy and exercise consistency over multiple sessions. Users reported that the visual overlays and voice guidance helped them understand mistakes easily and stay motivated. Overall, the results demonstrate that the Pose Right system is reliable, user-friendly, and effective in improving exercise performance and reducing the risk of injury.

In the Pose Right system, signal analysis focuses on processing EMG signals collected from wearable sensors during exercise. When muscles contract, they generate small electrical signals that are captured by the sensors. These raw signals often contain noise caused by body movement and environmental interference, so they must be filtered and amplified before use. Basic signal processing techniques such as smoothing and normalization are applied to obtain clear and reliable muscle activity data. After cleaning the signals, the system analyzes the strength and pattern of muscle activation during each exercise. The processed EMG data is combined with camera-based pose detection to understand both posture and muscle engagement. This helps the system identify incorrect muscle usage, detect fatigue, and provide accurate feedback to improve exercise performance.

The performance of the Pose Right system was evaluated by testing users while performing exercises such as squats, push-ups, and lunges. The results showed that the pose detection module was able to accurately identify body joints and provide real-time feedback with minimal delay. The repetition counting and posture correction features worked reliably, helping users identify and correct common mistakes during workouts. The EMG module successfully detected muscle activation and provided additional insights about muscle usage and strain. Over multiple sessions, users showed noticeable improvement in posture accuracy and exercise consistency. The performance tracking module helped users monitor their progress and stay motivated through visual reports and feedback. Overall, the system demonstrated good accuracy, fast response time, and a user-friendly experience, proving its effectiveness as a virtual fitness trainer.

The Pose Right system demonstrates how AR/VR, computer vision, and EMG sensing can work together to create a smart and interactive fitness assistant. The experimental results show that the system is capable of detecting exercise posture in real time and providing instant corrective feedback. This helps users understand their mistakes immediately and improve their exercise performance. The integration of EMG sensors adds an important advantage by monitoring muscle activity during workouts. This allows the system to identify incorrect muscle usage and potential strain, which cannot be detected by camera-based pose estimation alone. As a result, the system provides more accurate and safer exercise guidance. The performance tracking module plays a key role in motivating users by showing progress and improvement over time. By analyzing workout history and generating performance scores, the system encourages consistency and helps users stay engaged in their fitness routines. Overall, the results indicate that the Pose Right system is a promising low-cost solution for home fitness and rehabilitation. Although further improvements can be made in accuracy and advanced personalization, the system successfully demonstrates the potential of intelligent AR/VR-based exercise monitoring.

6. Conclusions

The Pose Right system was developed to provide a smart and affordable solution for improving exercise posture and preventing workout-related injuries. By combining computer vision, AR/VR technology, and EMG sensing, the system acts as a virtual fitness trainer that can guide users during home workouts. This approach helps users perform exercises correctly without the need for constant supervision from professional trainers. The system successfully demonstrates real-time posture detection and instant corrective feedback using AR overlays and voice guidance. The integration of EMG sensors adds an additional layer of accuracy by monitoring muscle activity and ensuring proper muscle engagement during exercises. This makes the system more effective than traditional fitness applications that rely only on prerecorded videos. Through performance tracking and progress analysis, the system encourages users to stay motivated and improve over time. The experimental results show that the system can provide fast responses, accurate repetition counting, and useful feedback, making it suitable for everyday fitness and basic rehabilitation support. In conclusion, Pose Right shows strong potential as a low-cost and user-friendly smart fitness assistant. With future improvements such as personalized workout plans and cloud-based tracking, the system can become a powerful tool for safer, more effective, and accessible fitness training.

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