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International Journal of Electrical, Electronics and Computer Systems

ISSN: 2347-2820
Volume 14 Issue 01, 2025

Pose Estimation and Correcting Exercise Posture

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Peer Review Information

Submission: 07 Feb 2025
Revision: 16 Mar 2025
Acceptance: 18 April 2025

Keywords

AI-based Posture Detection
Motion Tracking
MediaPipe, BlazePose

Abstract

Posture plays a crucial role in maintaining both physical and mental well-being. Incorrect posture during exercises can lead to injuries and reduce workout efficiency. Traditional posture detection methods rely on **sensor-based and image-processing approaches**, but they often require **wearable devices or manual supervision**. This study proposes an **AI-powered exercise posture correction system** using **pose estimation techniques**, specifically **OpenPose**, a **multi-stage CNN model**. The system detects **key body joints** from images or videos, analyzes posture alignment, and provides **real-time corrective feedback** to improve form. By leveraging **computer vision and deep learning**, the proposed solution offers an **automated, non-invasive, and efficient** method for monitoring and improving exercise posture, benefiting applications in **fitness training, rehabilitation, and injury prevention**.

INTRODUCTION

Maintaining proper posture during exercise is essential for preventing injuries and maximizing workout efficiency. However, many individuals unknowingly perform exercises such as deadlifts, squats, and shoulder presses with incorrect form, leading to muscle strain**,** ligament injuries, and long-term musculoskeletal issues. The absence of professional supervision further increases the risk, highlighting the need for an intelligent, automated posture correction system. This project introduces a computer vision-based exercise posture detection system that utilizes human pose estimation to analyze body movements and provide real-time feedback**.**

The system leverages OpenPose, a deep learning framework, to extract skeletal key points from RGB images or depth maps, enabling accurate tracking of body posture. By integrating heuristic-based methods and machine learning algorithms, the system evaluates the quality of exercise posture and generates corrective suggestions.

This ensures that users receive precise guidance, reducing the risk of improper execution and enhancing overall workout efficiency.Unlike traditional methods that rely on wearable sensors or manual observation, this system provides a non-invasive and fully automated approach to posture correction. Computer vision and deep learning enable real-time tracking of movements, eliminating the need for expensive motion-capture setups. The system can be utilized in various domains, including fitness training, rehabilitation, and sports coaching,

allowing users to improve their form without requiring constant supervision.

The primary goal of this project is to assist users in maintaining optimal workout form**,** preventing potential injuries, and enhancing performance and efficiency. The final application consists of two main components: video-based exercise analysis and posture correction feedback, making it an effective solution for fitness enthusiasts, athletes, and rehabilitation program**s**. Additionally**,** real-time feedback and progress tracking enable users to monitor their posture improvements over time. With just a camera and a computer, individuals can access personalized posture assessments, ensuring safer and more effective workouts without the need for professional trainers.

LITERATURE SURVEY

S,Kale (2023) [1] introduces an AI-driven smart system that utilizes image and video processing to monitor and suggest corrections for exercise posture, aiming to enhance physical fitness and mental well-being. The system employs Python libraries such as MediaPipe, TensorFlow, and OpenCV for image and video acquisition, processing, and analysis. It detects key body parts and joints to assess exercise posture and identify deviations from correct form. Users receive visual feedback and corrective suggestions to improve their exercise technique.

A.Patil(2022) [2] presents an AI-powered exercise analysis system called BlazeFit, which utilizes MediaPipe to monitor body posture and deliver real-time feedback. Targeting medical exercises and remote rehabilitation, BlazeFit aims to bridge the gap between patients and healthcare providers by analyzing form, counting repetitions, recommending exercises, and potentially facilitating consultations based on exercise history.

R.R.Kanase (2021) [3] proposes a project designed to assist individuals in performing activities with proper posture. The project employs pose estimation to evaluate the user's workout posture, subsequently providing recommendations for improvement and feedback. The system comprises two main components: a pose estimator that employs a pre-trained OpenPose model to detect the user's posture, and a posture corrector that delivers feedback based on the analysis.

A.K.Patil(2021) [4] presents a real-time 3D human position monitoring and estimation system based on lidar and inertial sensors. Initially, the system identifies the human body and calculates its height and skeletal characteristics using lidar data. Subsequently, it utilizes data from both lidar and inertial sensors to track the body's position and orientation, ultimately reconstructing human movement on a three-dimensional avatar.

A.L.Liu(2020) [5] discusses a system designed to evaluate fitness posture from video footage using recurrent neural networks (RNNs). Users perform exercises such as dumbbell lateral raises and bicep curls while being recorded. The system first detects 25 body joints in each frame using OpenPose. The video is then segmented into individual exercises based on the motion of the wrist joint. Each exercise is represented by 17 keyframes, with each frame containing the coordinates of the 25 joints.

COMPARATIVE ANALYSIS

Feature	Existing Systems	Proposed Architecture
Functionality	AI-driven posture analysis with image/video processing for exercise monitoring.	Real-time CNN-based posture estimation with automated feedback and correction.
Technology Used	MediaPipe, OpenCV, OpenPose, Lidar, and RNN-based systems.	Convolutional Neural Networks (CNNs) and deep learning models for precise posture tracking.
Feedback Mechanism	Visual feedback and corrective suggestions.	AI-driven real-time feedback with detailed posture improvement recommendations.
Application Scope	Limited to exercise tracking, rehabilitation, and medical use.	Expanded applications in fitness training, physiotherapy, ergonomic assessments, and workplace safety.
Data Processing	Uses pose estimation techniques for detecting key joints.	Advanced CNN-based models with adaptive learning for personalized posture correction.
User Interaction	Users receive basic posture evaluations and recommendations.	Interactive system with real-time alerts, progress tracking, and AI-driven coaching.

Accuracy & Adaptability	Pose estimation accuracy varies based on dataset and approach (e.g., OpenPose, BlazeFit, Lidar-based models).	Enhanced accuracy using CNNs, with continuous learning from user posture data.

OBJECTIVE

The primary objective of this project is to develop exercise posture detection system that leverages computer vision and deep learning to provide real-time feedback and posture correction. The following objectives outline the key goals of this project:

- **Accurate Posture Detection** – Develop a deep learning-based system utilizing OpenPose to extract skeletal key points from RGB images or depth maps for precise posture tracking.
- **Real-Time Feedback and Correction** – Implement an automated posture correction system that provides instant feedback and customized recommendations to help users improve their exercise form.
- **Injury Prevention and Performance Enhancement** – Reduce the risk of muscle strain, ligament injuries, and poor posture habits by ensuring users maintain proper exercise alignment.
- **Non-Invasive and Cost-Effective Approach** – Eliminate the need for wearable sensors or expensive motion-capture setups, making posture correction accessible using just a camera and a computer.
- **Integration of Computer Vision and Machine Learning** – Utilize heuristic-based methods and deep learning algorithms to evaluate the quality of exercise posture and detect movement inefficiencies.
- **Wide-Scale Application** – Design the system for multiple domains, including fitness training, rehabilitation therapy, and sports coaching, ensuring adaptability for different user needs.
- **Progress Tracking and Personalization** – Enable users to monitor their posture improvements over time and implement adaptive learning techniques for personalized exercise recommendations.
- **User-Friendly Interface and Accessibility** – Develop a simple and interactive interface that allows users to analyze their workout posture without requiring technical expertise.

PROPOSED WORK

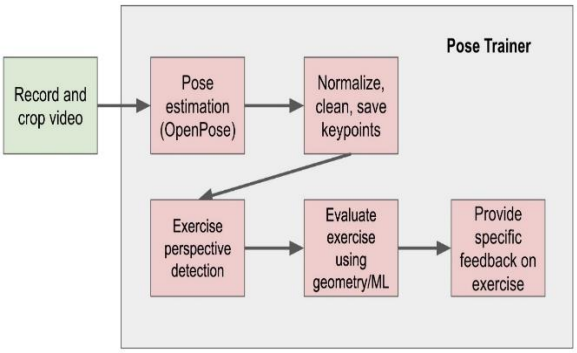

Figure1. Diagram showing the proposed methodology for exercise classification

The system integrates OpenPose, a multi-stage CNN model, to detect key body joints from video frames, analyze posture alignment, and provide real-time feedback for correction. Below is the workflow of the proposed system:

1. **Record and Crop Video:** The user records their exercise session, and the video is pre-processed to remove unnecessary background elements.
2. **Pose Estimation Using OpenPose:** The system extracts key body joints and skeletal points, detecting body posture, limb alignment, and movement dynamics.
3. **Normalize, Clean, and Save Keypoints:** The extracted skeletal points are cleaned, normalized, and stored while reducing noise for accurate posture assessment.
4. **Exercise Perspective Detection:** The system classifies the exercise (e.g., squat, push-up, deadlift) and adjusts the perspective for multi-angle posture analysis.
5. **Evaluate Exercise Using Geometry & ML:** The system compares the user's posture with an ideal exercise form using geometric rules and deep learning, detecting deviations in joint angles, body alignment, and symmetry.
6. **Provide Real-Time Feedback & Corrections:** Users receive instant feedback and corrective actions to improve posture and prevent injuries.
7. **Track Progress & Personalization:** Users can monitor posture improvements over time, and the system adapts to their body type and fitness level for personalized exercise recommendations.

METHODOLOGY

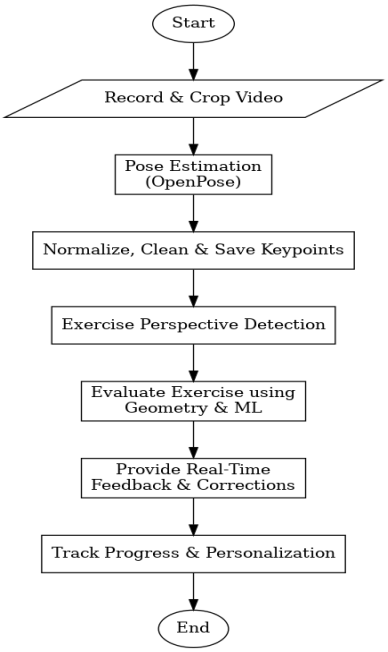

Figure2.Flowchart

This flowchart represents the Exercise Posture Detection System workflow. It outlines the steps involved in recording, analyzing, and correcting exercise posture using AI and computer vision. Here's a step-by-step explanation:

1. **Start** – The system initiates the exercise posture detection process.
2. **Record & Crop Video** – The user records their exercise session using a camera, and the video is preprocessed (cropped and resized) to focus on the relevant areas.
3. **Pose Estimation (OpenPose)** – The system extracts key skeletal joints and body posture using OpenPose, a deep learning-based pose estimation model.
4. **Normalize, Clean & Save Keypoints** – The extracted skeletal keypoints are refined, noise is removed, and the cleaned data is stored for further analysis.
5. **Exercise Perspective Detection** – The system identifies the type of exercise being performed (e.g., squat, push-up, deadlift) and adjusts the analysis accordingly.
6. **Evaluate Exercise using Geometry & ML** – The system compares the user's posture against an ideal reference model using geometric rules and machine learning techniques to detect any misalignment.
7. **Provide Real-Time Feedback & Corrections** – The system offers immediate feedback on the user's posture and suggests corrective actions to improve form and prevent injuries.
8. **Track Progress & Personalization** – Users can monitor their posture improvement over time, and the system adapts recommendations based on their fitness level and body type.
9. **End** – The process completes, providing users with detailed insights into their workout form and improvement areas.

CONCLUSION

This project presents an AI-powered exercise posture detection and correction system using computer vision and deep learning. By leveraging OpenPose for pose estimation and integrating machine learning algorithms, the system accurately detects body posture, evaluates exercise form, and provides real-time corrective feedback. Unlike traditional methods that rely on wearable sensors or manual supervision, this approach offers a non-invasive, automated, and cost-effective solution for improving workout efficiency and preventing injuries.The proposed system enhances fitness training, rehabilitation, and sports coaching by ensuring proper posture alignment and tracking user progress over time. With its adaptability to various exercises and personalized recommendations, it empowers individuals to achieve better form and safer workouts. Future enhancements may include expanding the model's accuracy, integrating voice-guided feedback, and developing a mobile-friendly interface for broader accessibility.

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