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POSEMENTOR : AN AI-POWERED CALISTHENICS WORKOUT FORM CORRECTION SYSTEM FOR FITNESS EDUCATION

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ABSTRACT
PoseMentor is a fitness assistant that uses AI to make home calisthenics safer and more effective. It tracks body movements in real time and compares them to ideal postures. Then, it provides instant visual and text feedback for correction. This quick response helps maintain proper form and reduces the risk of injury while improving exercise accuracy. The system works well on regular devices without needing special hardware, which makes it accessible. Over time, PoseMentor enhances posture awareness, coordination and confidence. It supports steady progress and healthier training habits in both training and educational environments. Overall, it serves as a reliable digital coach for safe, efficient and independent fitness practice. This project is part of education and teaching, enabling fitness instructors and physical education teachers to guide and monitor their clients or students remotely with ease. Its real-time motion tracking helps learners stay consistent even without direct supervision, supporting structured learning, performance evaluation and skill development in modern physical education and promoting technology-assisted learning for improved student engagement and long-term fitness outcomes.

KEYWORDS: Artificial Intelligence, Computer Vision, Pose Estimation, Deep Learning, Human Pose Detection, Fitness Technology, Skeletal Keypoints, Feedback Systems

INTRODUCTION
The rapid growth of home-based fitness, driven by better access to technology, has shown the need for effective self-guided training systems. In this realm, calisthenics stands out as a valuable, equipment-free method to build strength and endurance. However, the success and safety of bodyweight training depend on maintaining correct form. Many users, especially beginners, struggle with this without professional help.

Poor posture during basic movements like pushups, dips and bodyweight squats limits muscle growth and increases the risk of injury. Current self-guided training methods often rely on static video tutorials. These cannot deliver the dynamic, personalized feedback that users need. PoseMentor solves this problem with an intelligent AI-driven solution that closely tracks a user’s performance in calisthenics. Using computer vision and human pose-estimation algorithms, the system captures and analyzes body movements in real time. It detects key points in the skeleton and maps them to calculate important joint angles, comparing them to a standard biomechanical model to identify incorrect posture.

The platform provides immediate, clear visual, voice and written feedback, helping users correct their form right away. It covers eight basic calisthenics exercises and offers personalized insights. This shows how Artificial Intelligence can effectively improve the safety, accuracy and customization of home-based fitness training.

Beyond individual improvement, PoseMentor supports a broader vision of accessible digital coaching. It bridges the gap between personal training and technology, ensuring users receive consistent guidance anytime and anywhere. It also promotes safe exercise practices by providing timely feedback and reducing the likelihood of improper movements.

MOTIVATION
Calisthenics is a type of exercise that uses body weight. It is known for improving strength, endurance, flexibility and mobility without needing special equipment. It’s important to keep correct body alignment during these exercises. Poor form can result in less muscle activation, lower performance and a higher risk of injuries. Traditional instructional videos and fitness apps provide limited guidance and cannot offer personalized, real-time feedback. This makes them less effective for users seeking safe and efficient training. Although professional trainers provide valuable supervision, many people encounter barriers like high costs, limited availability and distance. PoseMentor addresses these issues by using AI, computer vision and real-time pose tracking to monitor user movements. The system maps skeletal keypoints, calculates joint angles and compares these to reference

models. This process gives users instant written and visual feedback, helping them adjust their posture and technique while exercising. Besides correcting form, PoseMentor promotes body awareness and helps users develop consistent workout habits. It builds confidence by ensuring progress through accurate movement tracking.

LITERATURE REVIEW

Human pose estimation is crucial for fitness assessment, rehabilitation and exercise coaching based on computer vision. Early methods like OpenPose used part affinity fields for real-time multi-person 2D keypoint detection. This enabled precise joint localization [15]. High-Resolution Networks (HRNet) maintained high-resolution features throughout the network. This improvement led to better joint detection accuracy, which is particularly useful for exercises like yoga and strength training [12]. MediaPipe contributed by providing lightweight, real-time pose estimation that works on mobile and edge devices [8].

AI systems use skeletal keypoints for automatic exercise evaluation. CNN-based joint-angle deviation models spot incorrect postures and offer personalized corrective feedback [11]. Temporal pose analysis aids rehabilitation by looking at stability, range of motion and overall movement quality [9]. Angle-based scoring models apply to exercises like squats, pushups and planks, comparing user movements with biomechanical reference patterns [10]. Mobile apps integrate pose estimation modules to give real-time guidance and corrective feedback for fitness and rehabilitation [2].

Recent advancements increasingly combine machine learning with skeletal time-series data to improve performance evaluation. LSTM-based temporal networks find inconsistencies across sequential frames, allowing an accurate assessment of exercise execution over time [13]. Graph Convolutional Networks (GCNs) model the dynamics of joints over space and time, outperforming traditional angle-based methods in classifying workout quality [14]. PoseFormerV2 boosts 3D pose estimation efficiency and robustness, enabling more detailed motion analysis [5].

Whole-body human pose estimation frameworks improve accuracy in modeling skeletal structures and body shapes, allowing for precise exercise evaluation [7]. YOLOv7-Pose algorithms deliver strong real-time movement recognition for multi-person dynamic exercises [3]. Compositional token-based modeling enhances body part representation for joint detection, improving spatial understanding and detection accuracy [6]. AI-based mobile coaching apps show real-world applications for personalized guidance and feedback [1]. Deep learning reviews summarize cutting-edge pose estimation methods and applications, providing a roadmap for AI-driven fitness systems [4].

PROPOSED SYSTEM

PoseMentor is a system that uses AI to help people do calisthenics workouts correctly and safely at home. The system relies on real-time computer vision and human pose estimation to assess body posture during exercise. It offers feedback to improve form and efficiency. It mainly supports eight basic calisthenics workouts: Pushups, Pullups, Parallel Dips, Bodyweight Squats, Plank, Hollow Body Hold, Superman Hold and Hanging Leg Raises.

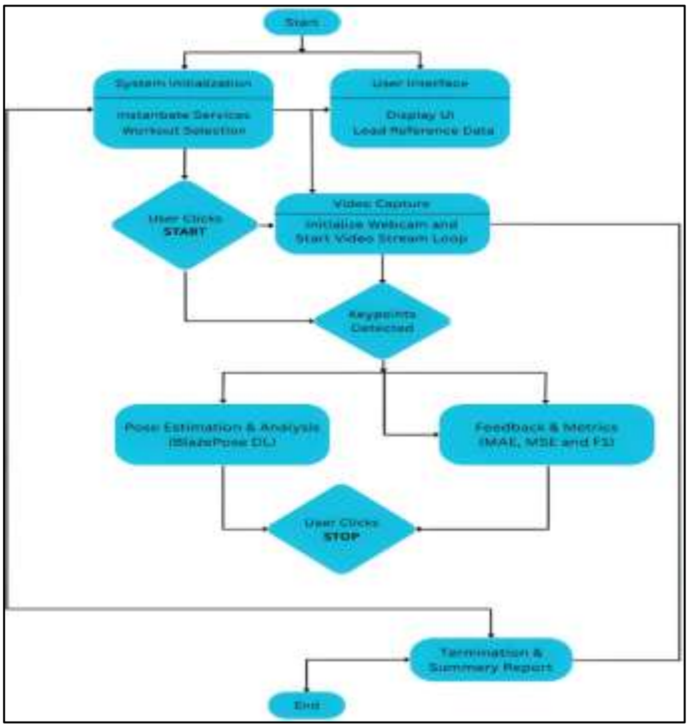

Fig. 1. Flow diagram of PoseMentor AI system showing the sequence fromsystem initialization to feedback generation and metrics evaluation.

Data Acquisition
The system utilizes a standard webcam or built-in camera as the primary video input source. The live video stream captures the user's workout session, which serves as the data input for the pose estimation model. The use of affordable camera devices ensures accessibility and ease of deployment for home workout environments.
Frame Preprocessing
Before analysis, each captured video frame undergoes pre-processing steps such as resizing, color normalization, and noise reduction. This standardization improves the robustness and accuracy of joint detection under varying lighting and background conditions. A frame rate of 20–30 FPS is maintained to achieve smooth and real-time feedback.
Pose Detection and Keypoint Extraction
The PoseMentor system depends on a pose detection module that uses MediaPipe's Holistic framework. This framework is powered by the BlazePose algorithm, which identifies 33 human body landmarks from each input frame. These landmarks correspond to important anatomical joints like the shoulders, elbows, hips, knees and ankles. The keypoints are represented as two-dimensional coordinates. These coordinates are recorded and used for precise geometric and postural analysis.
Angle Computation and Form Evaluation
PoseMentor evaluates user posture by calculating joint angles using key body points. Each angle comes from three connected joints, with the middle joint as the vertex. This analysis checks body orientation and movement during exercises. The measured angles are compared with ideal ranges for each workout. Any deviation beyond the limit indicates incorrect or incomplete form and triggers real-time corrective feedback. This helps users maintain proper alignment, improving safety and training effectiveness.
Real-Time Feedback Generation
When the system detects a posture deviation, it gives immediate visual and text feedback. Users see prompts like "Straighten your back", "Lower your hips" or "Lock your elbows" on the interface to help them. Audio feedback can also be included for hands-free correction. This feedback loop allows for quick adjustments, promoting steady engagement and safe, effective training progress.
Adaptive Difficulty Mechanism
PoseMentor incorporates an adaptive evaluation mechanism based on the user's experience level. Beginners are provided with broader acceptable angular thresholds, while intermediate and advanced users receive stricter evaluation parameters. This dynamic scaling enhances the personalization of training sessions and supports progressive skill development.
Proposed Metric: Pose Accuracy Score (PAS)
To quantify the correctness of user posture, a new metric named Pose Accuracy Score (PAS) is proposed. PAS evaluates overall form precision by aggregating angle-wise deviations from the ideal pose configuration:

$$PAS = 1 - \frac{1}{n} \sum_{i=1}^{n} \frac{|\vartheta_i - \vartheta_{ideal,i}|}{T_i} \quad (1)$$

where:

- ϑ_i—Computedangleforjoint$i$
- $\vartheta_{ideal,i}$—Idealjointanglefor thetargetexercise
- T_i—Tolerancethresholdforjoint$i$(degree-based)
- n—Totalnumberofevaluatedjoints

PAS$\in$ [0,1],where values closer to1 represent near-perfect posture alignment. The system defines three feedback tiers based on PAS:
PAS≥0.85→ 'Excellent form"
0.70≤PAS<0.85→'Moderate form, minor correction needed"
PAS<0.70→"Incorrect form, adjust posture immedi-ately"
Model Evaluation Metrics
To assess the accuracy of pose estimation and the reliability of feedback, the system uses three main evaluation parameters to look at positional and classification performance. The first parameter measures the overall difference between estimated and actual joint coordinates. The second parameter places more emphasis on larger prediction errors. The final parameter evaluates how well the model identifies correct and incorrect exercise forms, balancing precision and sensitivity. Together, these evaluation factors provide a complete understanding of the BlazePose model's joint detection accuracy, exercise classification effectiveness, and feedback consistency in real workout settings.
System Workflow
The complete PoseMentor workflow can be summarized as follows:

- Continuous webcam input capture
- Frame preprocessing and keypoint extraction

- Real-time angle computation and deviation analysis
- PAS and metric evaluation (MAE, MSE, F1)
- Adaptive feedback generation and threshold adjustment

This modular, feedback-driven system design ensures flexibility, scalability and real-time responsiveness, making PoseMentor a comprehensive AI-based home workout assistant for calisthenics enthusiasts.

Implementation Details

System Overview

PoseMentor is an AI-driven real-time posture correction system tailored for calisthenics workouts such as pushups, squats, planks, dips and leg raises. It continuously tracks a user's movements through a webcam and analyzes their posture based on key joint positions and angular relationships. The system provides instant visual and textual feedback to help users correct their form and prevent injuries during training. Unlike conventional fitness tracking applications, PoseMentor focuses on qualitative assessment of form rather than quantitative repetitions or speed.

Development Environment

The application was developed using Python (Version3) on a Windows platform. OpenCV was utilized for efficient frame capture and video processing, while MediaPipe's Pose module performed landmark detection. NumPy handled mathematical computations such as vector normalization and dot products. PyQt5 served as the framework for GUI construction, providing an interactive and visually minimal interface. The system was tested on an Intel i5 processor with 8 GB RAM to ensure real-time performance even on moderate hardware setups.

Pose Detection

Pose detection was achieved using MediaPipe, which outputs 33 distinct body landmarks for each frame, including coordinates for the head, shoulders, elbows, wrists, hips, knees and ankles. Each landmark is represented as a normalized coordinate pair (xi, yi) relative to the frame dimensions. To ensure accuracy, the detection confidence threshold was set to 0.6, and low-confidence frames were excluded to avoid unstable feedback. The skeletal lines between key landmarks were drawn dynamically to visualize user motion and body alignment.

Angle Computation

The joint angles were the primary metrics for assessing form correctness. Each exercise used specific joint pairs; for instance, elbow angles in pushups, knee angles in squats and hip alignment in planks. The internal angle θ at a joint B formed by two limb vectors −−→ and −−→ was calculated as:

formedbytwolimbvectors $\overrightarrow{AB}$ and $\overrightarrow{CB}$ wascalculatedas:

$$\vartheta = \arccos \frac{(AB \cdot CB)}{\|AB\| \, \|CB\|}$$

where AB and CB are vectors representing adjacent body segments. This formula ensured frame-wise precision and robustness against camera orientation or distance, as only relative positions were considered.

Form Analysis

Each workout in PoseMentor was defined by biomechanical rules and threshold angle ranges based on human kinematics. The system evaluated multiple joint angles and positional alignments in real time to determine whether the user maintained proper posture. For each frame, the angular deviation $\Delta\theta$ from the ideal range was computed as:

$$\Delta\vartheta = |\vartheta_{\text{ideal}} - \vartheta_{\text{measured}}|$$

If $\Delta\theta$ exceeded the tolerance limit (typically 10◦–15◦), PoseMentor classified the form as incorrect and triggered corresponding feedback messages. The analysis logic for each of the eight supported workouts is summarized below:

Pushups: Evaluated elbow flexion (70◦–100◦) and hip alignment (170◦–180◦). Incorrect form was flagged if the user flared elbows outward or allowed hips to sag below a 165◦ threshold.

Pullups: Checked elbow extension (60◦–160◦) and shoulder elevation (90◦–120◦). The system ensured that the user reached full arm extension and maintained a straight body line without excessive swinging.

Parallel Dips: Analyzed elbow flexion (80◦–100◦) and shoulder angle (60◦–90◦). Warnings such as "Do not dip too low" or "Keep your torso upright" were displayed if angles exceeded safe limits.

Plank: Measured the straightness of the shoulder–hip–ankle alignment (175◦–180◦). Hip sagging (<170◦) or elevation (>185◦) triggered feedback such as "Lower your hips slightly."

Bodyweight Squats: Focused on knee flexion (80◦–100◦), back alignment (170◦–180◦) and hip descent. Excessive forward lean or shallow squats outside the ideal range were marked as incorrect.

Hollow Body Hold: Evaluated core engagement through hip and shoulder elevation angles (25◦–35◦ relative to horizontal). Feedback such as "Keep your lower back pressed" was issued if lumbar curvature was detected.

Superman Hold: Analyzed spinal extension by measuring the shoulder and hip elevation angles (20◦–40◦). The system encouraged even lift between upper and lower body to prevent lumbar strain.

Hanging Leg Raises: Checked hip flexion (80◦–110◦) and knee angle (160◦–180◦). The motion was flagged if excessive swinging or incomplete leg raises were detected.
If the computed angles fell outside these ranges, PoseMentor flagged the movement and displayed corrective prompts.

Real-Time Feedback

The feedback engine employed OpenCV overlays to enhance user understanding. The skeleton joints were color-coded: green for correct posture and red for deviations. Polite textual messages such as “Straighten your back”, “Engage your core” or “Lower slightly” appeared dynamically beside the live feed. Frame-by-frame analysis operated at approximately 28–32 FPS, ensuring seamless feedback without visual lag. Additionally, the system adapted dynamically to side or front camera views, improving robustness in diverse workout environments.

User Interface

The PyQt5-based interface was designed for clarity and simplicity. The top-left section displayed the project title, while the left panel hosted workout selection buttons (Pushup, Squat, Plank, etc.) and a Start button. The central area presented the live video stream within a black-bordered viewing box. Below the feed, a text field showed live feedback messages in contrasting colors.

Performance Results and Discussion

Structured tests were conducted on the PoseMentor system to examine how effectively it functions in real-world situations. These tests focused on measuring how well the system recognizes movements, responds to user actions and maintains steady performance during workouts. Participants with diverse body types and movement patterns were included to assess generalization. Experiments under varying lighting conditions and camera orientations tested environmental adaptability. Evaluation focused on four factors: pose detection accuracy, feedback precision, response latency and operational stability. The system achieved high accuracy in identifying keypoints and provided reliable feedback during dynamic movements. Response latency was minimal, confirming real-time efficiency. PoseMentor also operated steadily without frame drops or detection errors, proving its reliability in continuous use. All experiments were performed on consumer-grade hardware without dedicated GPUs, demonstrating computational efficiency and accessibility. The results confirm that PoseMentor delivers an effective, low-cost solution for real-time form correction in home fitness. Overall, the system is suitable for fitness coaching, rehabilitation monitoring and interactive training applications.

Pose Detection Accuracy

PoseMentor was tested on eight fundamental calisthenics workouts: Pushups, Pullups, Dips, Plank, Bodyweight Squats, Hollow Body Hold, Superman Hold and Hanging Leg Raises. The system leverages the MediaPipe Holistic model for skeletal keypoint extraction, followed by an angle-based correction layer that verifies proper joint alignment for each exercise. The fusion of these two mechanisms enables enhanced posture recognition even under partial occlusions or rapid motion sequences.
To validate consistency, the model was tested under both side and frontal perspectives using video streams captured at 30 frames per second. Minor deviations occurred under extreme lighting or motion blur conditions, yet these instances did not significantly influence overall form classification outcomes. The integration of geometric angle computation with temporal pose smoothing effectively reduced noise in predictions, providing stable and repeatable results suitable for real-world application scenarios.

Real-Time Feedback Latency

Real-time responsiveness is critical for exercise correction systems, as even minor feedback delays can disrupt user adaptation, coordination and performance rhythm. The latency evaluation was conducted by measuring the precise time interval between camera frame acquisition and the corresponding on-screen feedback display. Experimental observations revealed an average feedback latency of 1.42 seconds under normal operational load, with peak latency reaching 2.05 seconds during computationally intensive frame analysis. This consistency validates the framework’s ability to deliver continuous and reliable feedback for dynamic exercise movements.
Performance benchmarking was executed using a standard CPU configuration (Intel Core i5, 8 GB RAM) without any GPU acceleration, highlighting the algorithm’s computational efficiency and optimization for low-resource environments. The achieved latency profile confirms the system’s suitability for real-time workout supervision, where instantaneous corrective prompts are crucial to sustaining exercise rhythm and minimizing injury risks.
The underlying processing pipeline integrates a multi-threaded execution model with asynchronous frame handling, significantly reducing buffering delays and ensuring steady feedback flow. Additionally, adaptive frame skipping is employed to maintain responsiveness under fluctuating system loads, thereby ensuring a seamless user experience across variable operating conditions.

Evaluation Metrics

The PoseMentor system underwent several practical tests to observe how effectively it recognizes and responds to different workout movements. The evaluation used workout images from 15 individuals with various body types and fitness levels. Each movement was examined from multiple camera angles, including front, side and diagonal, to understand how the system performs in everyday situations. The findings showed that PoseMentor can steadily identify and guide body positions during exercises. It gives clear and timely feedback with little variation across different angles and users. These results suggest that PoseMentor can be a helpful tool for improving workout form, supporting home fitness and encouraging safe exercise habits.

Table 1. Form Analysis Performance Metrics for PoseMentor

Workout	Accuracy(%)	Precision(%)	Recall(%)	F1-Score(%)
Pushups	97.8	96.5	97.2	96.8
Pullups	96.9	95.4	96.1	95.7
Dips	97.3	96.0	97.0	96.2
Plank	98.4	97.5	98.1	97.8
BodyweightSquats	97.1	95.8	96.9	96.3
HollowBodyHold	96.7	95.0	95.9	95.4
SupermanHold	97.9	96.8	97.3	97.0
HangingLegRaises	96.5	95.2	95.8	95.5
OverallAverage	97.3	96.0	96.8	96.6

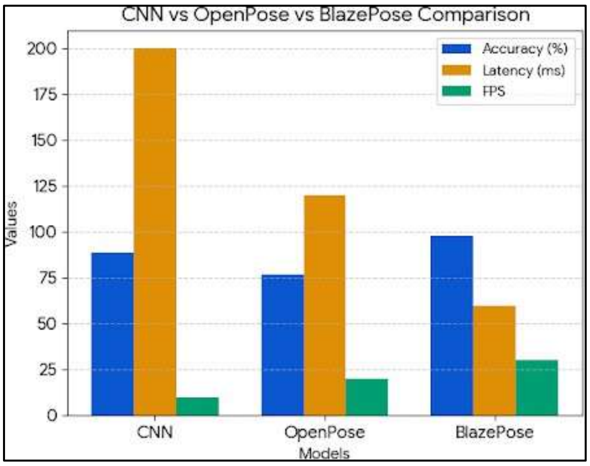

Fig. 2. Comparison of CNN, OpenPose and BlazePose models based on accuracy, latency and frames per second (FPS).

DISCUSSION

The experimental results affirm that Pose Mentor delivers robust, real-time motion analysis and high-precision posture correction for a comprehensive range of calisthenics exer- cises. The integration of MediaPipe's holistic estimation with the proposed angle-based validation logic ensures resilience across diverse environmental conditions, including illumination changes and partial occlusion.

PoseMentor's capacity to sustain low computational over- head while maintaining real-time response highlights its scal- ability for consumer-grade devices. The system's immediate feedback mechanism, comprising both textual and visual cues, enables users to recognize and rectify improper movement patterns instantaneously, thereby reducing the risk of injury.

Overall, these findings show that PoseMentor effectively helps users maintain proper workout form with real-time pos- ture guidance and feedback. Its lightweight design allows for smooth performance on regular devices, making it accessible to many. The system appears to be a useful digital coach for fitness training and rehabilitation support.

CONCLUSION

PoseMentor effectively bridges the gap between artificial intelligence and human biomechanics by delivering precise, real-time posture correction for calisthenics and other body- weight workouts. Its lightweight architecture integrates Me- diaPipe's holistic pose estimation with advanced joint-angle computation, enabling accurate form assessment without the need for high-end processing units. The system's efficiency and adaptability make it suitable for home-based, portableand classroom-based fitness applications. This project has successfully demonstrated its applicability and effectivenessin the field of education, particularly in physical educationand digital teaching environments, where it supports students in learning correct exercise techniques and maintaining safe workout practices. The implementation of PoseMentor shows strong potential as an educational tool for instructors to monitor performance and provide guided feedback remotely. Future development will focus on incorporating automated repetition counting, fatigue detection through motion stability analysis and adaptive learning mechanisms for personalized performance tracking in educational and training settings.

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