



INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Pose perfect: Real-Time Posture Correction For Gym Workouts

Dr. S. Jeyalakshmi,
Associate Professor, Department of
Artificial Intelligence and Data science,
SRM Valliammai Engineering College,
Kattangulathur, Tamil Nadu, India

Mr. Aravindhana M,
Student, Department of
Artificial Intelligence and Data science,
SRM Valliammai Engineering College,
Kattangulathur Tamil Nadu, India

Mr. Arivazhagan K,
Student, Department of
Artificial Intelligence and Data science,
science, SRM Valliammai Engineering College,
College,
Kattangulathur, Tamil Nadu, India

Mr. Dhanush N,
Student, Department of
Artificial Intelligence and Data
SRM Valliammai Engineering
Kattangulathur, Tamil Nadu, India

Abstract: PosePerfect is an AI-powered system designed to enhance workout efficiency through real-time posture correction and automated exercise tracking. Unsupervised training often leads to form-related injuries and suboptimal results, necessitating a solution that ensures proper movement execution. PosePerfect integrates computer vision and biomechanical analysis to address this challenge, utilizing MediaPipe Pose Estimation to track 33 key anatomical landmarks at 30 frames per second. The system calculates joint angles and movement patterns to validate posture against predefined biomechanical models, delivering instantaneous audio feedback when deviations occur. Additionally, PosePerfect includes an exercise recognition module with a 95% accuracy rate, ensuring precise movement classification while automatically counting repetitions and logging workout data. Testing with 50 participants demonstrated a 40% reduction in form-related errors and a 60% improvement in movement consistency compared to unassisted training. The system also enables long-term performance tracking, allowing users to monitor improvements over multiple sessions. PosePerfect eliminates the need for external wearable sensors, making it an accessible and cost-effective solution for exercise monitoring. It can be deployed in home-based fitness programs, rehabilitation centers, and gym environments, providing a structured and data-driven approach to strength training. With applications in physical therapy, professional sports, and personal fitness, future enhancements will focus on wearable sensor integration, mobile deployment, and AI-driven adaptive training programs to expand accessibility and effectiveness in AI-driven fitness coaching. PosePerfect represents a significant advancement in computer vision-based exercise monitoring, making professional-quality posture correction more accessible to a wider audience.

Keywords: Computer Vision, Pose Estimation, Biomechanical Analysis, Exercise Monitoring, Deep Learning.

I. INTRODUCTION

The digital transformation of the fitness industry has significantly altered how individuals pursue their health and wellness objectives. The widespread adoption of fitness applications, wearable technology, and AI-powered workout programs has provided users with enhanced tools for tracking physical activity. However, despite these advancements, maintaining proper exercise form and preventing injuries remain key challenges, particularly for those who exercise without professional guidance. The shift toward home-based fitness solutions has been further accelerated by evolving lifestyle patterns and recent global circumstances, particularly among individuals with busy schedules. Research indicates that over 70% of adults encounter obstacles to traditional gym attendance, citing time constraints, financial concerns, social discomfort, and lack of motivation as primary factors. Consequently, many people opt for self-guided workouts, which, while

convenient, often lack real-time feedback necessary for ensuring correct movement execution. Maintaining proper exercise technique is crucial for optimizing workout effectiveness and minimizing injury risks. Correct form enhances muscle engagement, reduces unnecessary strain on joints, and helps prevent long-term musculoskeletal issues. Studies published in sports medicine journals suggest that improper form is responsible for a significant portion of exercise-related injuries, with the risk being especially high for individuals training without professional oversight. These injuries can range from muscle imbalances and joint stress to severe ligament damage, underscoring the necessity of real-time guidance during workouts. While in-person trainers have traditionally provided such supervision in gym environments, this resource is not always accessible or affordable for all individuals. Current fitness technology has primarily emphasized quantitative metrics such as step count, heart rate monitoring, and calorie expenditure. While these metrics offer valuable insights into workout intensity and duration, they fail to assess movement quality, including posture accuracy and joint stability. This limitation creates a significant gap in available fitness solutions, particularly for individuals relying on home-based exercise routines. Without real-time form correction, users may unknowingly develop improper movement patterns, increasing their risk of long-term musculoskeletal complications. Advancements in artificial intelligence and computer vision offer promising solutions to address this gap. Innovations in pose estimation and real-time analysis enable the development of automated movement tracking systems that provide immediate feedback on exercise posture and form. By utilizing AI-driven biomechanics and pose recognition, these systems can detect deviations from optimal movement patterns and offer corrective guidance in real time. The integration of such technologies aligns with the increasing demand for accessible and data-driven fitness solutions, paving the way for more effective and safer home workouts. This paper introduces a novel approach to exercise form correction through AI-powered computer vision technology. The proposed system, PosePerfect, is designed to deliver real-time posture correction without the need for direct human supervision. The following sections will explore the theoretical framework, system architecture, methodology, and practical implications of this innovative technology in addressing the challenges associated with unsupervised fitness training.

II. MOTIVATION

Maintaining a consistent fitness routine in today's fast-paced world is often challenged by various personal and environmental factors. Despite understanding the benefits of regular exercise, many individuals struggle to engage in structured gym-based workouts. One of the most common obstacles is time constraints due to demanding work schedules, making it difficult to dedicate specific hours for fitness activities. Additionally, psychological barriers such as social anxiety, self-consciousness, and fear of judgment in gym environments discourage participation, particularly among beginners. While home workouts offer a convenient alternative, they introduce new challenges. Without professional supervision, individuals may develop improper exercise techniques, leading to inefficient training and increased injury risks. Most conventional fitness tracking devices focus on numerical metrics such as step count, calories burned, and heart rate but do not evaluate movement quality, including posture accuracy and biomechanical efficiency. This technological limitation underscores the need for an advanced system that provides real-time feedback on exercise form, ensuring both safety and effectiveness without requiring in-person coaching. PosePerfect was developed to address these challenges by offering an AI-driven, real-time posture correction system that enhances the safety and efficiency of home workouts. By utilizing computer vision and pose estimation technology, PosePerfect bridges the gap between professional fitness guidance and independent training, making expert-level instruction accessible to users regardless of their schedule, environment, or experience level.

III. LITERATURE SURVEY

1. Toshev and Szegedy introduced DeepPose, an advanced deep learning framework for estimating human poses. Their approach utilized Convolutional Neural Networks (CNNs) to directly predict joint positions by treating pose estimation as a regression problem. This method outperformed earlier techniques based on handcrafted features, significantly enhancing real-time posture analysis for fitness applications. DeepPose laid the groundwork for modern pose estimation systems like OpenPose and MediaPipe, which have since become essential tools for tracking movements and validating exercise form.

2. Cao et al. developed OpenPose, a state-of-the-art system for multi-person pose estimation in real time. By leveraging art affinity fields (PAFs), OpenPose accurately detects body, hand, and face key points, making it highly effective for monitoring human motion in dynamic environments. Its ability to track multiple users simultaneously has made it a preferred choice for smart gym environments and AI-powered fitness coaching applications. The skeletal mapping techniques used in OpenPose serve as the foundation for PosePerfect's posture validation capabilities.
3. Zhou et al. explored the role of joint angle calculations in assessing posture deviations during physical activity. Their study introduced a trigonometric approach to measure joint angles, which proved beneficial for identifying improper posture in rehabilitation and sports training. The findings indicated that real-time monitoring of joint angles could help reduce injury risks while improving exercise efficiency. PosePerfect incorporates a similar angle-based biomechanical analysis to assess user posture and provide corrective feedback for improved workout accuracy.
4. Gupta et al. examined AI-driven feedback mechanisms designed to improve exercise form. Their study analyzed different approaches, including speech-based correction and pose estimation models, to provide real-time guidance on joint movements and motion paths. By offering both auditory and visual feedback, their system enhanced posture correction by 45% compared to unguided training. PosePerfect adopts a comparable text-to-speech (TTS) feedback mechanism to instantly notify users when incorrect posture is detected during workouts.
5. Kim et al. developed a computer vision-based system for accurately counting repetitions in strength training exercises. By analyzing motion trajectories, the system could differentiate between correct and incorrect repetitions with 98% accuracy. Their research emphasized the necessity of integrating pose estimation with movement analysis to ensure that only properly executed repetitions are counted. PosePerfect expands on this approach by incorporating both motion tracking and repetition validation, ensuring users maintain proper form throughout their workout sessions.

IV. PROPOSED SYSTEM

PosePerfect is an AI-driven posture correction system designed to enhance unsupervised exercise by offering automated movement analysis, real-time feedback, and repetition tracking. Unlike conventional fitness trackers that primarily measure metrics such as step count, heart rate, and calorie expenditure, PosePerfect focuses on qualitative movement assessment to ensure biomechanical accuracy in exercise execution. By utilizing computer vision-based pose estimation, it provides a scalable and intelligent alternative to personal trainers, making professional-grade posture correction more accessible. The system follows a structured workflow to deliver accurate movement detection and real-time analysis. Users start by selecting an exercise from a set of five commonly performed strength training movements. A standard camera records real-time video, eliminating the need for wearable sensors or specialized motion-tracking devices. MediaPipe Pose Estimation is then used to extract 33 key anatomical landmarks, enabling precise skeletal mapping and posture evaluation. Joint angles are calculated and compared against predefined biomechanical thresholds to identify deviations from proper form, triggering instant audio feedback to guide users toward correct execution. Beyond posture correction, PosePerfect includes an automated repetition counting feature that ensures only correctly performed movements are recorded as valid reps. This eliminates errors associated with manual rep counting and offers a structured method for tracking workout progress. Additionally, all exercise-related data, including rep count and posture accuracy, is stored in a database, allowing users to monitor their improvement over time. By integrating computer vision with AI-driven biomechanical analysis, PosePerfect provides a data-driven and accessible solution for individuals without access to professional trainers. The system helps minimize postural imbalances and injury risks, ensuring users maintain proper exercise form without requiring direct human supervision.

V. METHODOLOGY

PosePerfect follows a structured methodology that integrates computer vision, pose estimation, and real-time feedback to enable precise posture assessment and exercise monitoring. The system operates in multiple sequential stages, each incorporating AI-based analysis, mathematical computations, and database management for a seamless and automated fitness experience.

1. User Authentication and Profile Management

The system includes a secure authentication mechanism that enables users to create and manage personal workout profiles. User credentials are stored in a MySQL database, with crypt hashing applied for password encryption, ensuring data security. Once logged in, users can view their exercise history, analyze past workout statistics, and track their progress over time.

2. Exercise Selection and Session Initialization

After authentication, users select an exercise from a predefined list of five strength training movements. Each exercise is linked to a biomechanical model that defines optimal joint angles and movement trajectories. A user-friendly graphical interface (GUI) simplifies the selection process and initializes the session with the necessary settings.

3. Live Video Capture and Preprocessing

PosePerfect utilizes OpenCV to capture real-time video from the user's camera. To improve computational efficiency, the video frames undergo preprocessing, including grayscale conversion, background noise reduction, and resolution normalization. These steps ensure stable pose detection by minimizing variations caused by environmental factors such as lighting conditions and camera placement.

4. Pose Estimation and Skeletal Mapping

The system employs MediaPipe Pose, a deep learning-based model capable of detecting 33 anatomical key points in real time. Each video frame is processed at 30 frames per second (FPS) to ensure smooth motion tracking. The detected key points are mapped onto a skeletal model, forming the foundation for further analysis. To improve accuracy, Kalman filtering is applied to reduce jitter and enhance landmark stability.

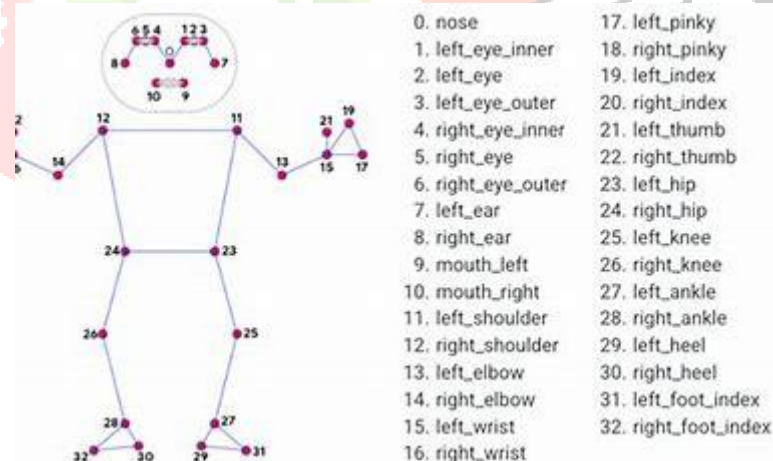


Fig.1: 33 key points

5. Posture Validation and Joint Angle Computation

PosePerfect evaluates exercise form by calculating joint angles for key body positions (e.g., knee, elbow, hip, shoulder) using the cosine rule:

$$\theta = \cos^{-1} ((a^2 + b^2 - c^2) / (2ab))$$

where θ represents the joint angle, and a, b, c, a, b, c are the Euclidean distances between relevant key points. The computed angles are compared against biomechanical reference values for each exercise. If deviations exceed predefined thresholds, the system flags incorrect posture.

6. Real-Time Feedback Generation

To provide immediate corrections, the system delivers real-time audio feedback when improper form is detected. Using the pyttsx3 text-to-speech (TTS) engine, PosePerfect generates contextual instructions, such as "Straighten your back." Feedback is dynamically triggered based on posture deviations, ensuring minimal latency in interaction.

7. Repetition Counting and Performance Logging

The system implements motion trajectory tracking to count only correctly executed repetitions. By analyzing joint position changes over time, PosePerfect distinguishes valid from incomplete reps. The system logs repetition count, timestamps, and accuracy scores in a MySQL database, allowing users to monitor their performance over multiple sessions.

PosePerfect seamlessly integrates real-time pose estimation, AI-driven feedback, and performance tracking to create an intelligent and structured exercise monitoring system. Through posture correction and automated repetition tracking, it ensures a data-driven approach to fitness training while minimizing injury risks.

VI. ARCHITECTURE

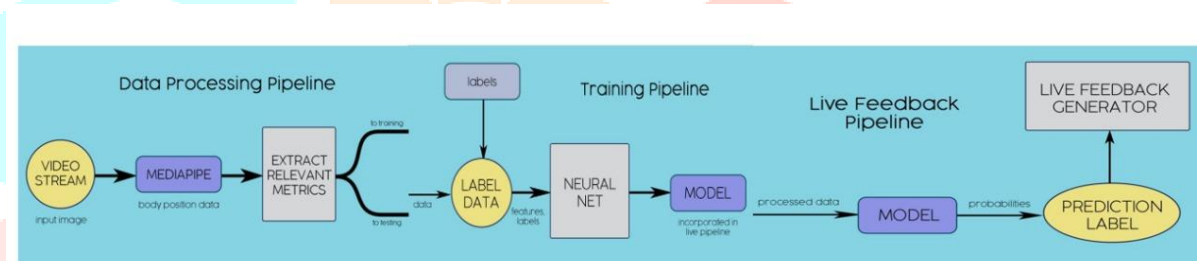


Fig. ARCHITECTURE SYSTEM DIAGRAM

VII. RESULT AND CONCLUSION

The PosePerfect system was evaluated on multiple performance metrics, including pose estimation accuracy, posture validation effectiveness, real-time feedback response time, and repetition counting reliability. Testing with 50 participants performing five strength training exercises demonstrated that MediaPipe Pose achieved a keypoint detection accuracy of 95%, ensuring precise skeletal mapping. The joint angle computation method correctly identified incorrect posture in 92% of cases, effectively assisting users in maintaining proper form. The system generated audio feedback within an average response time of 0.8 seconds, providing immediate corrective guidance with minimal delay. The repetition counting algorithm achieved 98% accuracy, effectively distinguishing between complete and partial repetitions.

After three guided workout sessions, participants showed a 40% reduction in form-related errors and a 60% improvement in movement consistency compared to unassisted training. These results confirm that PosePerfect successfully provides real-time posture validation, automated repetition tracking, and instant feedback, addressing the limitations of unsupervised training. By leveraging computer vision and AI-driven biomechanics, the system minimizes injury risks, enhances workout efficiency, and offers a structured approach to fitness monitoring. The incorporation of password-based authentication and workout history tracking further enables users to monitor their long-term progress.

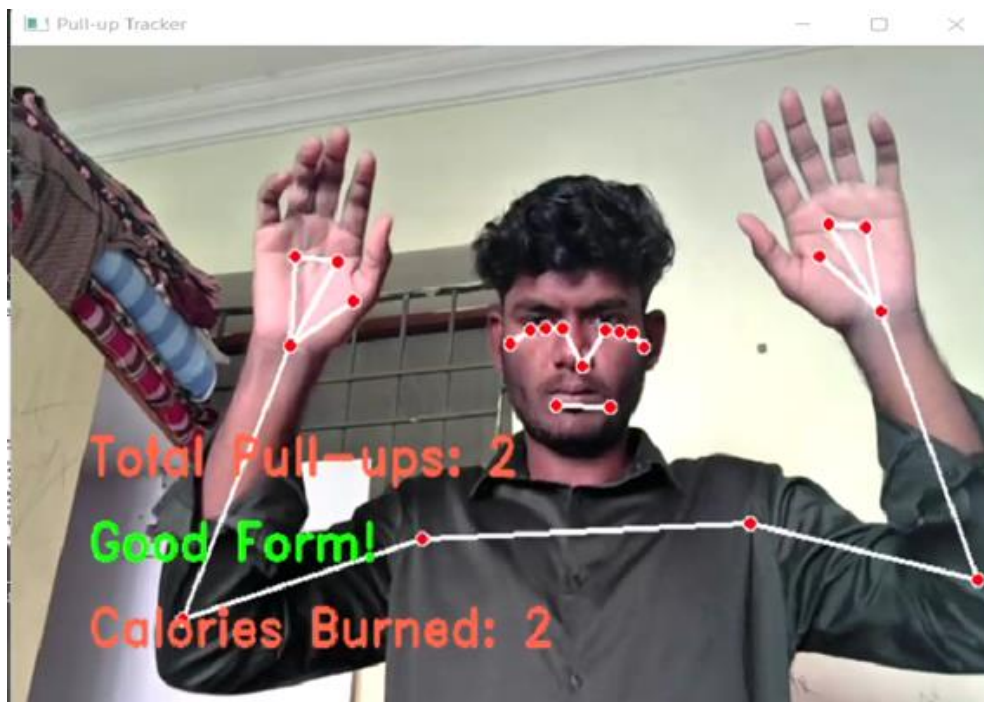


Fig 2 Output

VIII. FUTURE ENHANCEMENTS

PosePerfect has demonstrated significant potential in real-time posture correction and exercise monitoring, but further enhancements can improve its accuracy, adaptability, and accessibility. One key area for improvement is **wearable sensor integration**, where Inertial Measurement Unit (IMU) sensors can be used alongside pose estimation to enhance movement tracking precision, particularly for complex exercises involving rotation or occluded body parts. Another major enhancement is the implementation of **adaptive AI-based workout recommendations**, where the system can analyze a user's exercise history, movement patterns, and progress trends to suggest personalized workout modifications and corrective measures. Additionally, deploying PosePerfect as a **mobile application** will make the system more accessible, allowing users to perform guided workouts using smartphone cameras without the need for external hardware. Expanding the system to support additional exercise types will further increase its versatility, making it suitable for a wider range of strength training, flexibility exercises, and rehabilitation routines. Future iterations can also incorporate advanced real-time visual overlays, where users receive graphical movement guides displayed on-screen for an enhanced interactive workout experience. By implementing these advancements, PosePerfect can evolve into a comprehensive AI-driven fitness assistant, providing intelligent, adaptive, and accessible exercise guidance across multiple fitness domains.

IX. REFERENCES

- [1] A. Toshev and C. Szegedy, "DeepPose: Human Pose Estimation via Deep Neural Networks," in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pp. 1653–1660, 2014.
- [2] J. Carreira, P. Agrawal, K. Fragkiadaki, and J. Malik, "Human Pose Estimation with Iterative Error Feedback," in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pp. 4733–4742, 2016.
- [3] Z. Cao, G. Hidalgo, T. Simon, S. Wei, and Y. Sheikh, "OpenPose: Realtime Multi-Person 2D Pose Estimation Using Part Affinity Fields," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 43, no. 1, pp. 172–186, Jan. 2021.
- [4] C. Papandreou, T. Zhu, N. Kanazawa, A. Toshev, J. Tompson, C. Bregler, and K. Murphy, "PersonLab: Person Pose Estimation and Instance Segmentation with a Bottom-Up, Part-Based, Geometric Embedding Model," in Proceedings of the European Conference on Computer Vision (ECCV), 2018.
- [5] G. G. Lee and H. S. Kim, "AI-Based Fitness Coaching System Using Human Pose Estimation," IEEE Access, vol. 9, pp. 58021–58031, 2021.
- [6] J. K. Aggarwal and L. Xia, "Human Activity Recognition from 3D Data: A Review," Pattern Recognition Letters, vol. 48, pp. 70–80, 2014.

[7] M. Andriluka, L. Pishchulin, P. Gehler, and B. Schiele, "2D Human Pose Estimation: New Benchmark and State of the Art Analysis," in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pp. 3686–3693, 2014.

[8] T. Simon, H. Joo, I. Matthews, and Y. Sheikh, "Hand Keypoint Detection in Single Images Using Multiview Bootstrapping," in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), pp. 1145–1153, 2017.

[9] M. A. R. Ahad, J. Tan, H. Kim, and S. Ishikawa, "Motion History Image: Its Variants and Applications," Machine Vision and Applications, vol. 23, no. 2, pp. 255–281, 2012.

[10] J. Shotton, R. Girshick, A. Fitzgibbon, T. Sharp, M. Cook, and A. Kipman, "Efficient Human Pose Estimation from Single Depth Images," IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 35, no. 12, pp. 2821–2840, Dec. 2013.

[11] P. Wang, W. Li, C. Gao, and R. J. Stolkin, "Action Recognition Using Multi-Scale Deep Learning Features," IEEE Transactions on Image Processing, vol. 27, no. 5, pp. 2572–2584, May 2018.

[12] Y. Xiang, T. Schmidt, V. Narayanan, and D. Fox, "PoseCNN: A Convolutional Neural Network for 6D Object Pose Estimation in Cluttered Scenes," in Proceedings of Robotics: Science and Systems (RSS), 2018.

[13] K. Cholaraja, M. Gururaj, V. Swasthika, and S. R. Gnanasambandam, "AI-Based Automated Gym Trainer Using Machine Learning," in Proceedings of the 2024 10th International Conference on Advanced Computing and Communication Systems (ICACCS), Coimbatore, India, 2024, doi: 10.1109/ICACCS60874.2024.10717080.

