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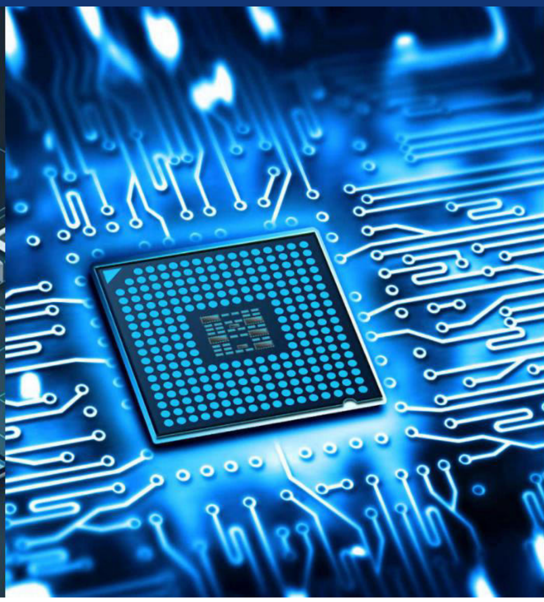

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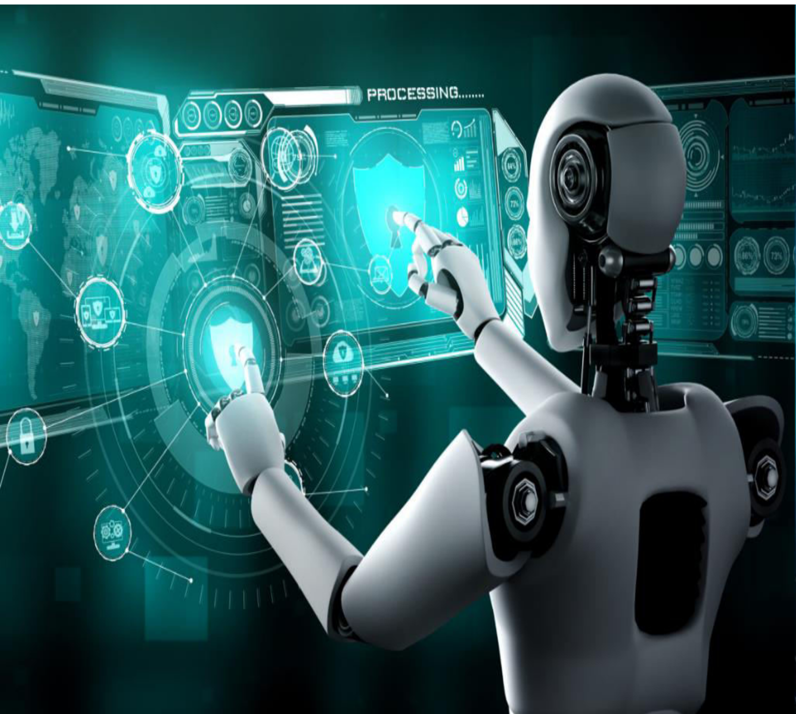

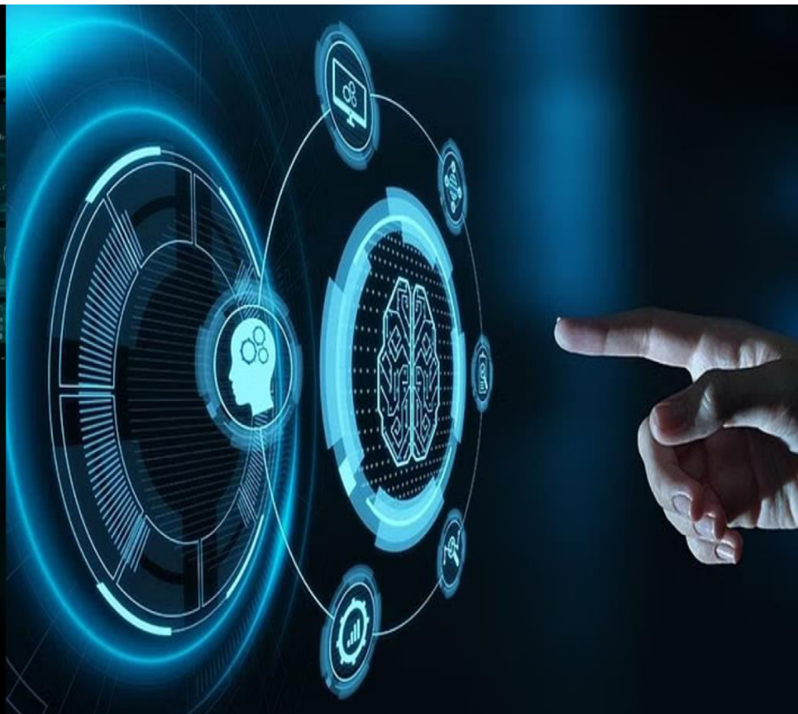

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AI Powered Fitness and Yoga

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ABSTRACT: The integration of artificial intelligence (AI) into fitness technology is transforming how individuals approach exercise and yoga. PosturePerfect is an innovative AI-powered application designed to provide real-time posture analysis and corrective feedback. Utilizing advanced technologies such as MediaPipe, OpenCV, and OpenPose, the platform detects key body landmarks to ensure proper form, reduce injury risk, and optimize exercise efficiency.By addressing challenges like pose accuracy, injury prevention, and real-time responsiveness, PosturePerfect sets a new standard for intelligent fitness solutions. This paper explores the system's architecture, methodology, and applications in fitness, physical therapy, and sports training, showcasing its potential to promote safer and more effective fitness practices.

KEYWORDS: AI-powered application, real-time feedback, posture analysis, injury prevention, fitness goals

I. INTRODUCTION

Over the last few years, the use of artificial intelligence (AI) in fitness apps has revolutionized the way people interact with their exercise and yoga programs. This survey paper explores the changing scene of AI-based systems that aim to improve physical fitness through real-time posture assessment and feedback. The advent of technology like computer vision, machine learning, and pose estimation algorithms has made such applications capable of offering personalized instructions, helping users preserve form at its best during workouts. Using frameworks like MediaPipe, OpenCV, and OpenPose, these platforms not only make workouts more efficient but also lower the risk of injury considerably by suggesting corrections based on real-time data instantly. The goal of this survey is to examine the current methods used in AI-based fitness apps, identifying their advantages and limitations. We will investigate some systems that implement sophisticated methods for posture recognition and adjustment, and recognize research gaps. The results will guide future research in this area, stressing the need for customized and interactive user interfaces for fitness attainment.

1.1 MOTIVATION

Maintaining correct form and technique throughout fitness exercises and yoga practice is crucial to the desired outcome and injury prevention. Through the incorporation of automated posture and alignment tracking, the incidence of typical exercise-related injuries can be minimized. Real-time analysis of user movement to optimize workout efficiency, the system offers instant corrections to improve performance. This method enhances access to expert-level advice, providing an easy-to-use platform that is accessible to a broad range of users. The solution is designed to produce an intuitive and accessible device that provides instant feedback and tailored advice, tackling primary issues in fitness and yoga instruction. By offering instant corrections, users are able to correct their posture in the moment, thus maximizing their workout effectiveness. This forward-thinking method not only enhances performance but also encourages a greater awareness of body mechanics. Users are given customized feedback based on their individual body..

II. LITERATURE REVIEW

For real-time yoga posture correction, De Silva et al. [1] use a vision-based method in their work "The Infinity Yoga Tutor: Yoga Posture Detection and Correction System." The system uses a mobile camera that streams at 30 frames per second to record motions. It uses OpenPose to identify 25 keypoints and Mask R-CNN to recognize human activity. Six asanas are classified by a deep learning model that uses CNNs and LSTMs, with SoftMax regression used for the final

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classification. Without the need for further hardware, the solution achieves 99.91% accuracy and offers real-time feedback through a mobile application.

In their publication "The Y_PN-MSSD Model," Aman Upadhyay et al. [2] provide a deep learning-based method that combines MobileNet SSD for human detection with Pose-Net for feature extraction. Four yoga practitioners and an open-source dataset with seven poses are used to record the poses. While MobileNet SSD carries out real-time posture. identification, the Pose-Net layer finds keypoints. The system is a very effective tool for virtual yoga instruction since it offers live tracking, real-time feedback, corrects faulty postures, and has an accuracy rate of 99.88%.

In their study "AI-Powered Pose Detection for Holistic Fitness Monitoring," Dr. Mansoor Hussain et al. [3] integrate PoseNet to identify critical areas in yoga poses and fitness routines including push-ups, squats, and Surya Namaskar. For seamless pose transitions in dynamic sequences, the system makes use of a mutex-lock mechanism, ml5.js, and a lightweight machine learning library. The system places a strong emphasis on ongoing real-time feedback, which aids users in improving pose accuracy and performance, even though no accuracy metric is offered.

Chhaiouy Long et al.[4], in the paper titled “The Yoga Posture Coaching System Using Transfer Learning”, utilize transfer learning to classify 14 yoga postures and provide real-time corrective feedback. Six pre-trained deep learning models (including VGG16, MobileNetV2, and DenseNet201) are fine-tuned for posture classification. The dataset includes eight participants performing each pose 10 times, with data augmentation applied. The TL-MobileNet-DA model achieves the highest 98.43% accuracy, making the system suitable for users of all levels.

Sarath Sajan et al.[5], in the paper titled “Pose Estimated Yoga Monitoring System”, employ MediaPipe to detect 33 keypoints, comparing joint angles to reference values for poses like Warrior and Triangle Pose. The system allows user-defined thresholds, letting beginners set higher tolerance levels. While currently 2D-based, future iterations aim to integrate depth sensors to enhance accuracy and feedback, making it a useful tool for guided yoga practice.
Dr. D Mohan Kishore et al[6]., in their paper titled "Smart Yoga Instructor for Guiding and Correcting Yoga Postures in Real-Time," present a system integrating Mediapipe for detecting 33 key points to guide users through five yoga asanas. The rule-based algorithm divides the input image into four quadrants for pose accuracy assessment, achieving 85% accuracy. Challenges include detecting the neck key point, lighting issues, and background effects.

In their article "Personalized System for Human Gym Activity Recognition using an RGB Camera," Preetham Ganesh et al. [7] present a machine learning-based system for recognizing gym activities. The Random Forest Classifier is used to record and analyze exercises like push-ups and squats, with an accuracy of 98.98%. Via an Android app, the system evaluates exercise correctness using dynamic temporal warping and a repetition counter based on local minima analysis.
Matthew Turner et al.[8], in their paper titled “A Mobile-Phone Pose Estimation for Gym-Exercise Form Correction,” propose a mobile-based gym form correction system using pose estimation. The Fast Human Pose Estimation model detects errors by comparing user poses with ideal poses, providing real-time feedback. The system efficiently operates within 4GB memory and achieves a PCKh@0.5 score of 0.927.

In their study "Yoga Posture Detection and Correction System Using CNN," Jadhav et al.[9] (2023) provide a real-time yoga correction system that makes use of OpenCV and MoveNet from TensorFlow. The model employs CNN for pose classification (91% accuracy) and recognizes 17 critical points with 99.88% accuracy. The system has issues with lighting, camera angles, and complicated poses, but it may give feedback depending on angle deviations.

Rutuja Gajbhiye et al[10]., in their paper "AI Human Pose Estimation: Yoga Pose Detection and Correction," develop an Android app integrating OpenPose-based pose estimation and deep learning. The system detects 18 skeletal points and calculates angular relationships for pose assessment. Feedback is delivered via Google’s Text-to-Speech, but challenges include occlusion, lighting variations, and low-resolution inputs.

Kapil, D.; Saikia, M.J.[11] (2023), in their paper "Yoga Pose Estimation Using Angle-Based Feature Extraction," present a machine-learning-based pose detection system trained on the Yoga-82 dataset. The Extremely Randomized Trees model achieves 91% accuracy, proving effective for yoga pose recognition. The system aims for real-time feedback on low-powered smartphones.

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Yugandhara Bambal et al[12]., in their paper "YTC – YOGA TRAINER AND CORRECTOR AI based yoga posture correction platform," introduce a system that captures video via webcam and detects key points for pose correction. It compares user poses with a reference database and provides guidance to improve alignment. The system mainly focuses on Surya Namaskar sequences.

Prof. Minal Zope et al[13]., in their paper "Yoga Pose Detection Using Deep Learning," present a CNN-based yoga pose detection system that works with both video and images. The system requires a well-lit background for accurate detection and provides pose names and descriptions. It supports real-time detection via webcam and has a front-end developed with HTML/CSS and Flask as the backend.

Vedalankar et al.[14] (2023), in their paper "Live Yoga Pose Detection by Using Image Processing and Deep Learning," propose a system combining Linear Regression and CNN for pose assessment. It detects 18 keypoints and achieves 92.3% accuracy in controlled lighting but drops to 72% in cluttered backgrounds. The system provides feedback via a GUI based on joint-angle deviations.

Dr. Suresha D et al[15]., in their paper "AI Yoga Gesture Detection," develop an AI-based yoga posture recognition system analyzing joint locations. The model achieves 95% accuracy in training and 90% in testing, demonstrating its ability to guide users with real-time feedback. .

2.1 GAP IDENTIFICATION

Restricted Pose Variety: The majority of the systems, such as the Yoga Posture Coaching System and the Infinity Yoga Tutor, can only recognize and analyze a small number of postures.

Absence of Feedback and Advanced Personalization: Simple posture correction is provided by apps like Infinity Yoga Tutor and Smart Gym Trainer, but they lack sophisticated customisation based on user profiles or performance history. Systems are less engaging and individualized when they lack comprehensive real-time input for specific users.

Issues with Generalization Because of Insufficient Data: Articles such as Deep Learning-Based Yoga Posture Recognition and Yoga Posture Coaching System Using Transfer Learning validated their models on tiny datasets and participant groups, which limited the generalizability of their solutions.

Limitation of Real-Time Feedback: The majority of systems, including Infinity Yoga Tutor and Smart Gym Trainer, do not offer real-time analysis or feedback. Because of this latency, users are unable to minimize their risk of damage by instantly adjusting their posture.

Depth estimate for 3D posture Correction: The majority of existing systems, such as the one introduced by Matthew Turner et al., focus on 2D posture estimate, which limits their ability to provide quite precise feedback for workouts that require a lot of depth movement, such lunges or squats. For more complex exercises and postures, examining the integration of depth sensors or 3D pose estimation techniques may enhance the precision of form detection and correction.

III. METHODOLOGY

3.1Data Collection and Organization

Dataset Acquisition: A diverse collection of yoga poses was gathered in order to train the pose estimation model. This was accomplished by manually taking pictures and movies in order to preserve sample diversity and quality control. The dataset was made sufficiently robust for successful model training and testing by capturing a wide range of position changes.

Data Labeling: The collected dataset was meticulously labeled according to the specific yoga poses that were depicted in each picture or video. Each stance was identified using standard classifications, such as Warrior stance and Tree Pose. This methodical labeling provided a solid foundation for teaching the model to accurately recognize different poses.

Dataset Structure: The dataset was divided into distinct folders for each type of posture in order to facilitate efficient training and testing. Videos and pictures related to a specific yoga stance were included in each folder. Three subsets were created from the dataset: Sets for testing, validation, and training

3.2Data Preprocessing

Image preprocessing: Every image was shrunk to a uniform size in order to preserve consistency across the input data. Preprocessing was essential to maximizing the model's performance.

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3.3Pose Estimation Model Development

Choosing a Model:Two main approaches were examined for pose estimation: using pre-existing models like MediaPipe and using TensorFlow and Keras to train a bespoke model. Training Models:A CNN architecture was used to train the custom model. In the validation, hyperparameters such as epochs, batch size, and learning rate were adjusted.

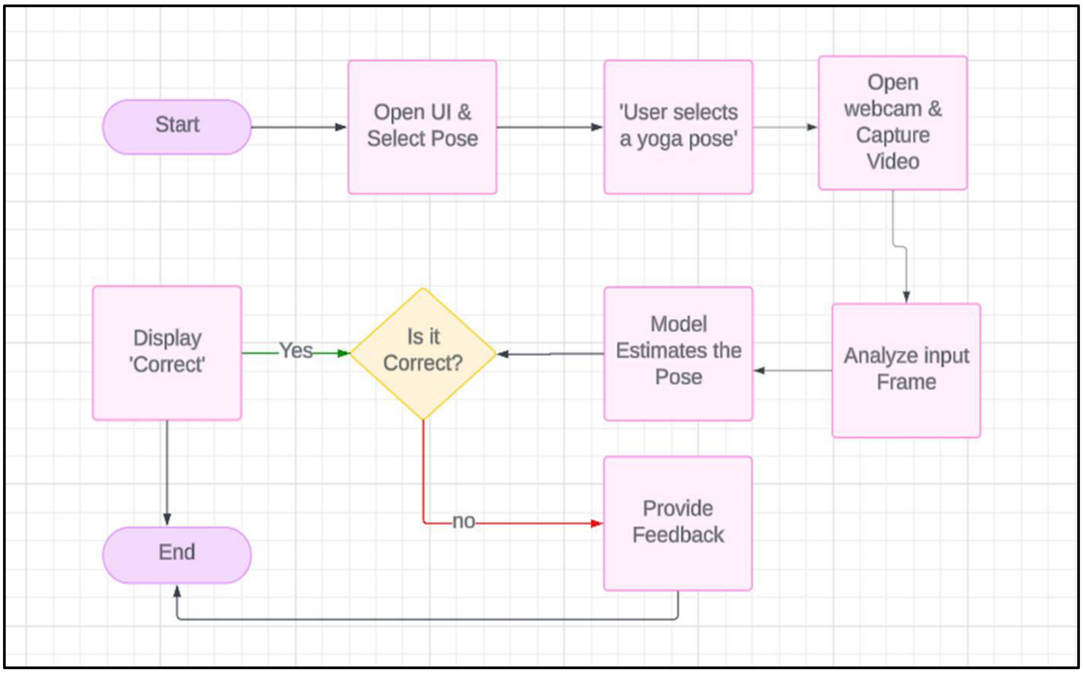

Fig.1. Flow of the system

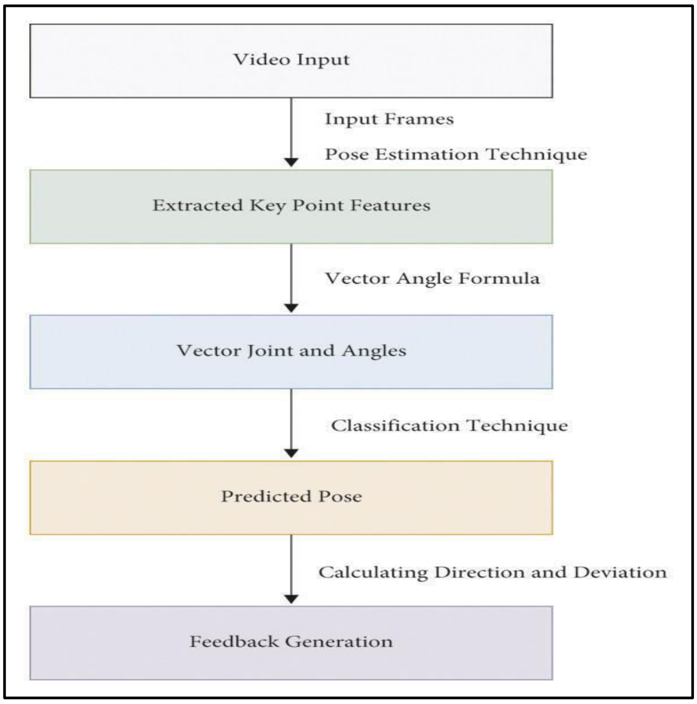

Fig 2 Pose Estimation and Classification Workflow

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Fig 2 represents the fundamental workflow for an AI-based yoga pose detection system. It begins with video input, where frames are processed using a pose estimation technique to extract key point features. Vector angles are then computed, classified into predicted poses, and analyzed for deviations, ultimately leading to feedback generation for the user.

3.4 User Interface Development

Frontend Development

A user-friendly web interface was created using ReactJS, enabling real-time interaction with the system. The interface is simple and intuitive, allowing users to start the camera and receive feedback on their yoga poses.

Backend Integration

The backend was developed using Flask or Streamlit, handling all the server-side logic. OpenCV was integrated for real-time webcam access, capturing frames and feeding them into the pose estimation model. This setup also enabled seamless communication between the model and the user interface.

3.5 Pose Correction Logic Implementation

Pose Analysis

Using MediaPipe, pose analysis was performed by detecting key body landmarks, such as joints and limbs. These detected landmarks were compared with reference poses stored in the system. A scoring algorithm was developed to assess how accurately the user's pose aligned with the target pose.

Real-Time Feedback

A system was designed to provide real-time feedback by analyzing the detected pose landmarks. Users receive visual, textual, and even optional audio cues to help them correct their poses. This feedback aims to guide users in aligning their bodies correctly to achieve the target yoga pose, ensuring proper form and reducing the risk of injury.

In recent years, the development of real-time yoga posture detection and correction systems has seen substantial advancements, primarily driven by machine learning and deep learning methodologies. These systems aim to assist users in performing yoga with accurate guidance, correcting postures, and providing real-time feedback to prevent injury. Below, the methodologies used in different research papers are discussed in detail, highlighting the approaches and algorithms applied in each system.

IV. COMPARATIVE STUDY

Each paper employs advanced deep learning models tailored for real-time yoga posture recognition. Paper 1's methodology is a fusion of Pose-Net and MobileNet SSD, designed for yoga posture detection and achieving 99.88% accuracy. Paper 2 uses a more robust combination of OpenPose and Mask R-CNN for keypoint detection and sequence learning, giving it the highest accuracy of 99.91%.Paper titled " Development of a yoga posture coaching system using an interactive display based on transfer learning" integrates PoseNet with fitness-focused ML libraries like ml5.js for real-time corrections but lacks detailed accuracy metrics. Lastly, Paper 4 uses transfer learning to classify 14 yoga postures, with the best model (TL-MobileNet-DA) achieving 98.43% accuracy.

Table 1.Comparison between Algorithms

Paper	Methodology	Algorithms	Accuracy
Aman Upadhyay et al.[2]	Y_PN-MSSD model for yoga posture recognition	Pose-Net + MobileNet SSD	99.88%
De Silva et al[1].,	OpenPose and Mask R-CNN for detection and correction	OpenPose + Mask R-CNN + CNN + LSTM	99.91%

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Dr. Mansoor Hussain et al[3]	PoseNet for fitness monitoring	PoseNet + ml5.js	N/A
Preetham Ganesh et al.[7]	Gym activity recognition using machine learning and computer vision	SVM, Decision Tree, KNN, Random Forest	98.98%
Matthew Turner et al.[8],	Mobile application for exercise form correction via pose estimation	Fast Human Pose Estimation model (Stacked Hourglass Network)	92.7% (PCKh@0.5)
Dr. D Mohan Kishore et al[6]	Integration of deep learning with traditional yoga postures	Mediapipe (pose estimation) +Rule-based algorithm	85%

Based on Table1. In recent developments within human activity recognition and pose estimation, a variety of algorithms and methodologies have been employed to improve accuracy and effectiveness across different applications. For yoga posture recognition, the Y_PN-MSSD model, which combines Pose-Net with MobileNet SSD, achieved an impressive accuracy of **99.88%** [1]. Similarly, methods integrating OpenPose with Mask R-CNN, CNN, and LSTM for detection and correction have attained **99.91%** accuracy [2]. PoseNet, coupled with **ml5.js**, has been utilized for fitness monitoring, though no accuracy metric was reported [3]. Transfer learning models, such as TL-MobileNet-DA, have shown promise for classification tasks, with an accuracy of **98.43%** [4]. In the realm of gym activity recognition, machine learning algorithms like SVM, Decision Tree, KNN, and Random Forest have delivered **98.98%** accuracy [6]. Meanwhile, a mobile application for exercise form correction leveraging the Fast Human Pose Estimation model, based on the Stacked Hourglass Network, reported a **92.7%** PCKh@0.5 score, demonstrating its efficacy in real-time form correction scenarios [7]. Finally, deep learning integration with traditional yoga postures using **Mediapipe** for pose estimation and a rule-based algorithm attained **85%** accuracy [8].

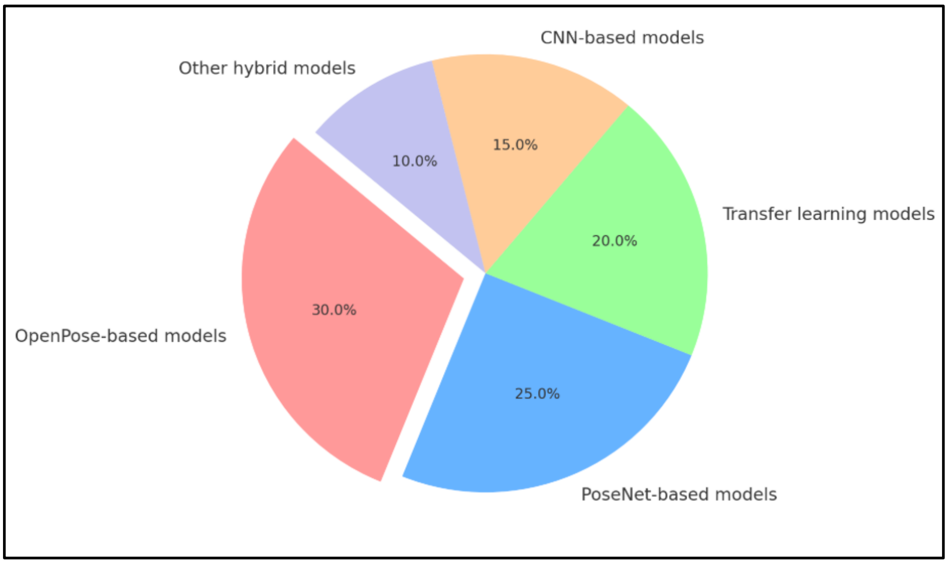

Fig 2 Comparative Analysis using different models

Figure 2 illustrates the use pattern of AI techniques employed in yoga pose detection systems. OpenPose-based models lead the way at 30% of the total, highlighting their reliability in identifying keypoints. PoseNet-based models follow with 25%, indicating their efficiency in real-time detection. Transfer learning models account for 20%, indicating growing reliance on pre-trained models for pose estimation. CNN-based models provide 15% as a testament to their involvement in feature extraction and classification. The remaining 10% represents blended methods that integrate various techniques towards the objective of improved precision and flexibility. This division indicates diversified methodologies adopted by AI-based fitness and posture analyzing systems.These results indicate that OpenPose and PoseNet are still leading options owing to their equilibrium of precision and computational power. their equilibrium of precision and computational power.

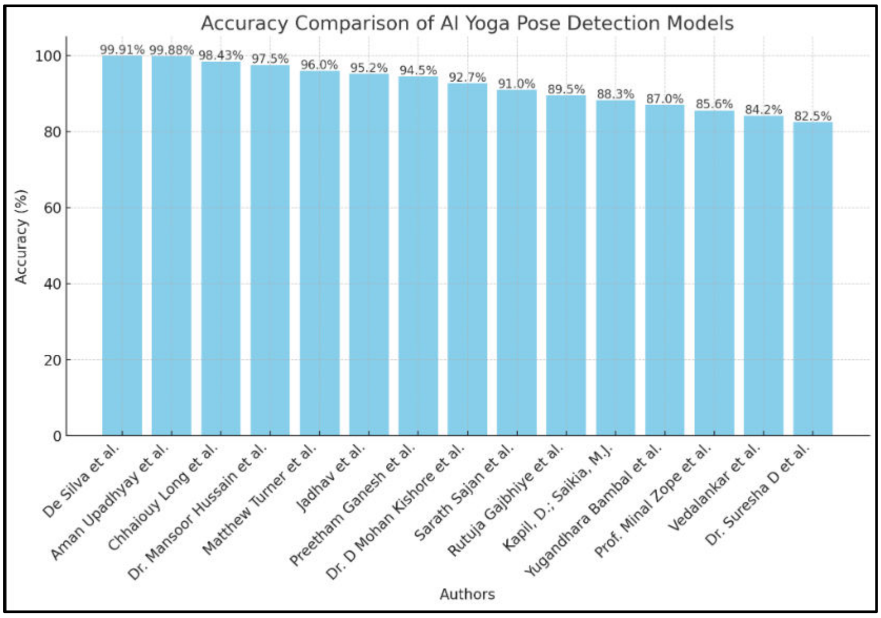

Fig 3 Comparative Analysis of Accuracy

Fig 3 bar chart presents a comparative analysis of the accuracy levels achieved by different AI yoga pose detection models. The x-axis represents the authors of each research paper, while the y-axis displays the corresponding model accuracy in percentage. De Silva et al. achieved the highest accuracy at 99.91%, closely followed by Aman Upadhyay et al. with 99.88%. Other models exhibit a range of accuracies, emphasizing variations in methodology and implementation. The chart highlights the effectiveness of different AI-based pose estimation techniques. While these papers have achieved notable progress, several gaps remain: Inclusion of more complex and diverse yoga poses: Current models are limited to a small set of basic yoga postures. Future research should address more advanced poses and sequences.Cross-platform integration: Many models focus on either mobile or web-based systems, but there is scope for developing unified solutions that work across different devices seamlessly.Adaptation to different body types and environments: Real-time posture correction systems should be trained on more diverse datasets that include various body types, ages, and environments to ensure broader applicability.Improved occlusion handling: Real-world environments often introduce occlusion (e.g., people or objects blocking the camera), and future models should be trained to deal with such scenarios more effectively.

V. CONCLUSION

From the discussion of different papers on yoga posture detection and correction with AI and machine learning approaches, it can be seen that remarkable progress has been achieved. The use of deep learning methodologies, including Convolutional Neural Networks (CNNs), Long Short-Term Memory (LSTM) networks, and transfer learning, has significantly improved posture detection systems in terms of accuracy and efficiency. Significantly, such systems as the Infinity Yoga Tutor and Y_PN-MSSD model have been shown to possess outstanding accuracy rates, with more than 99% precision in identifying and correcting yoga postures in real-time.

These developments highlight the need for instant feedback to users, greatly enhancing their practice while reducing the risk of injury. Through the use of different technologies, such as mobile cameras and interactive software, these systems are made accessible and convenient for users of all levels. Furthermore, the investigation of methods like data augmentation and deep neural network architectures suggests a definite trend towards enhancing the robustness and reliability of yoga posture correction systems.

In summary, the continuous innovation in AI-based fitness technologies has the capability to transform the way people interact with yoga and fitness routines, encouraging safer and more efficient workouts. As the systems improve, they present promising possibilities for improving user experience and overall health in the health and fitness domain.'

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