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Yoga Trainer Using Artificial Intelligence and Deep Learning

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ABSTRACT

Artificial Intelligence (AI) and deep learning have revolutionized human pose estimation and posture correction systems. This research introduces an AI-based Yoga Trainer system that leverages deep learning models to recognize and evaluate yoga postures while providing real-time feedback and corrections. The system employs Media-Pipe Pose for real-time human pose detection and extraction of body landmarks, focusing on key points such as the head, shoulders, elbows, hips, and knees. These extracted landmarks are processed using a Support Vector Classifier (SVC), implemented with scikit-learn's Support Vector Machine (SVM), to classify yoga poses accurately. Predictive modeling is applied using the predict prob function to determine pose probabilities, enhancing classification precision. OpenCV facilitates video capture, frame processing, and visualization of annotated images, ensuring seamless real-time interaction. Additionally, NumPy is used for efficient array manipulation in landmark processing. Once a pose is classified, the system compares the user's posture with the correct form for each asana. If misalignment is detected, it provides real-time guidance to help users correct their poses. This feature is particularly beneficial for home practitioners who may not have access to a yoga instructor. Future improvements may include enhancing the system's ability to recognize dynamic yoga sequences and optimizing real-time processing for mobile and wearable devices.

1. INTRODUCTION

Yoga, an Indian-born, centuries-old system, has gained universal recognition across the globe due to the various benefits it offers. People are drawn to yoga not just for its physical benefits but also for its ability to reduce stress, enhance mindfulness, and promote emotional balance. However, traditional yoga classes come with challenges such as high costs, a lack of qualified instructors, and inconsistent accessibility. These obstacles make it difficult for many individuals to integrate yoga into their daily lives.

While in-person yoga classes provide valuable experiences, they often lack the level of personalization needed to cater to individual needs. Each practitioner has a unique body type, different fitness levels, and specific health concerns, which traditional classes may not fully accommodate. Additionally, beginners may feel

intimidated in group settings, making them less likely to continue their practice.

Recent advancements in AI and deep learning have created new possibilities in various fields, including health and wellness. Machine learning algorithms can analyze large amounts of data, enabling the development of applications that adapt to users' behaviour and preferences over time. The use of computer vision allows for real-time posture detection and analysis, giving users instant feedback on their form and technique. Personalization has become a key trend in modern fitness solutions.

Research has shown that customized fitness programs lead to better adherence and improved results. By understanding individual goals—whether they focus on flexibility, strength, stress relief, or mindfulness—a yoga app can curate routines that personally resonate with each user. This personalized approach significantly enhances motivation and commitment to regular practice.

In today's fast-paced world, mental well-being has become an essential area of focus. Yoga has been linked to various mental health benefits, including reduced anxiety, improved mood, and enhanced overall well-being. The COVID-19 pandemic accelerated the shift toward online fitness, as people were confined to their homes and unable to attend in-person classes. This led to a surge in the use of virtual fitness applications, highlighting the demand for effective online solutions that provide not only guidance but also a sense of community and support.

Ultimately, the goal of this project is to create a platform that encourages lifelong engagement with yoga. By removing barriers that prevent individuals from practicing regularly and offering personalized, real-time feedback, we aim to foster a deeper connection to yoga. This connection can lead to consistent practice, better health outcomes, and a greater appreciation for the transformative power of yoga.

In summary, the purpose of this study is to create a platform that eliminates barriers, encourages lifelong yoga practice, and promotes overall well-being. By leveraging artificial intelligence and deep learning, we aim to develop a system that helps prevent injuries while practicing yoga. This platform will offer a seamless yoga experience, ultimately leading to a happy and healthy lifestyle.

2. Prospective Application

The implementation of AI in yoga training introduces a wide range of applications that cater to diverse user needs. One of the primary applications is personalized yoga coaching, where AI models analyze individual body postures and recommend customized yoga routines based on fitness levels and progress. By leveraging pose estimation algorithms, these AI trainers provide real-time corrective feedback, ensuring that users perform yoga poses accurately and safely. This personalization enhances user engagement and minimizes the risk of injuries, making yoga accessible even to beginners who lack direct supervision from human instructors.

In the domain of healthcare and rehabilitation, AI-driven yoga trainers offer significant benefits for patients recovering from musculoskeletal injuries, neurological disorders, and post-surgical conditions. Traditional physiotherapy often requires continuous monitoring by medical professionals, which can be resource-intensive. AI-powered systems can assist in rehabilitation by analyzing movement patterns, tracking recovery progress, and providing personalized yoga exercises tailored to an individual's mobility constraints. The integration of AI with remote healthcare platforms further enables doctors and physiotherapists to monitor patient progress through AI-generated reports, reducing the need for frequent hospital visits. This application is particularly beneficial for individuals with limited access to healthcare facilities, as it facilitates cost-effective and data-driven rehabilitation programs.

Another crucial application of AI-driven yoga training is elderly and special needs assistance. Many older adults face challenges in maintaining physical activity due to mobility restrictions and age-related health concerns. AI-based yoga trainers can address these issues by designing adaptive yoga routines that cater to their physical capabilities. Computer vision algorithms detect movement limitations and suggest low-impact exercises that promote flexibility and balance. Additionally, voice-assisted AI systems enhance accessibility by guiding elderly users through yoga sessions in an intuitive manner. By encouraging regular physical activity, AI-powered yoga trainers contribute to improved mobility, reduced fall risks, and enhanced overall well-being among senior citizens.

Incorporating AI into workplace wellness programs presents another promising application. Many employees suffer from posture-related health issues and stress due to prolonged sitting and sedentary work habits. AI-integrated wellness applications can provide real-time posture analysis, recommend desk-friendly yoga exercises, and suggest short relaxation techniques to alleviate work-related stress. Companies can integrate AI-driven yoga trainers into their corporate wellness initiatives, offering employees an efficient and engaging way to incorporate physical activity into their daily routines. This not only improves employee health but also enhances productivity by fostering a more balanced and focused work environment.

For sports and athlete performance enhancement, AI-powered yoga trainers can be instrumental in optimizing training routines for professional athletes. Many sports disciplines incorporate yoga to improve flexibility, balance, and recovery time. AI models can analyze an athlete's movement patterns and recommend personalized stretching routines based on their specific sport and training regimen. By tracking muscle engagement and movement efficiency, AI-driven yoga trainers help athletes prevent injuries and improve overall performance. The use of motion analysis and biomechanical data allows for a scientific approach to yoga training, ensuring that athletes derive maximum benefits from their practice.

The integration of augmented reality (AR) and virtual reality (VR) with AI-based yoga training introduces a new dimension to fitness engagement. AR overlays provide real-time virtual guidance, enabling users to visualize corrections and enhancements to their postures. Similarly, VR environments create immersive yoga experiences where users can interact with AI-generated avatars that guide them through yoga sessions. This combination of AI and immersive technology enhances user motivation and makes yoga practice more interactive and engaging.

AI-driven yoga trainers also play a pivotal role in mental health and stress management. AI models can analyze stress levels using biometric data, facial expressions, and voice modulation. Based on these insights, AI-powered systems can recommend personalized mindfulness exercises, breathing techniques, and meditation routines to help users manage stress effectively. The integration of AI with mental wellness applications provides a holistic approach to well-being, combining physical movement with emotional relaxation techniques.

2. METHODOLOGY

Webcam-based Real-time Human Body Pose Detection. It uses MediaPipe to finally detect the body landmarks, process them, and pass them into a pre-trained Support Vector Machine (SVM) model for classification. The model predicts the yoga poses which is currently taken, and gives real-time feedback by showing the detected pose name with respect to the confidence score (percentage of accuracy). Furthermore, there is an image of the correct yoga pose – this serves the purpose of guiding the user to achieve the proper posture, to further their improvement.

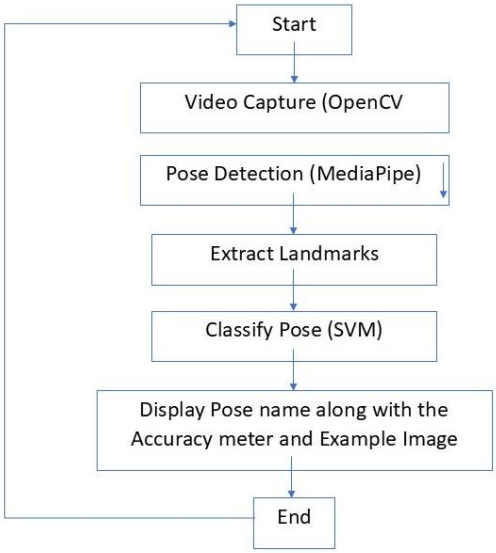

Figure 1: Flowchart of Proposed System

A. Technologies and Libraries Used

The system integrates various technologies and Python libraries to ensure efficient real-time performance. Below are the key components:

MediaPipe Pose

- Used for real-time human pose estimation.
- Extracts 33 key body landmarks from an input video frame.
- Outputs normalized 3D coordinates (x, y, z) of detected landmarks.
- Works on RGB images for fast and accurate pose recognition.

OpenCV

- Manages video capture from the webcam.
- Performs image resizing and conversion between BGR (default OpenCV format) and RGB (MediaPipe-compatible format).
- Overlays example images and displays annotated pose detection results.

scikit-learn (SVM Model)

- Uses a pre-trained Support Vector Machine (SVM) for yoga pose classification.
- Classifies poses based on normalized landmark coordinates extracted from MediaPipe.

Pickle

- Loads the pre-trained SVM model without requiring retraining.
- Helps in efficient and fast pose classification.

keyboard (kb)

- Loads the pre-trained SVM model without requiring retraining.
- Helps in efficient and fast pose classification.

os

- Manages file paths to load stored example images corresponding to each yoga pose.

C. Workflow and Implementation

The system follows a structured workflow for real-time pose detection, classification, and visualization. The process consists of five major steps:

Video Capture and Preprocessing

- The system uses OpenCV to access the webcam and capture frames in real-time.
- Each frame is resized to match the input size expected by MediaPipe.
- The default BGR format (used by OpenCV) is converted to RGB (required for MediaPipe processing).
- The processed frame is sent to MediaPipe Pose for landmark detection.

Pose Detection and Landmark Extraction

- MediaPipe Pose detects 33 key landmarks in the human body.
- These landmarks include important joints such as shoulders, elbows, wrists, hips, knees, and ankles.
- Each landmark is represented in 3D coordinates (x, y, z), where:
- x and y are the normalized coordinates within the frame. z represents the relative depth of the landmark.

The detected landmarks are normalized and extracted for classification.

Pose Classification

- The extracted landmarks are converted into a feature vector.
- This feature vector is passed into the pre-trained SVM model (loaded using pickle).

The SVM model predicts:

- The most likely yoga pose class.
- A probability score, indicating the confidence level of the classification.
- The predicted pose name and accuracy percentage are extracted from the model's output.

Visualization and Feedback

- The predicted pose name and accuracy percentage are displayed on the video feed using OpenCV.
- An example image of the correct yoga pose is overlaid for user reference.
- The frame rate (FPS) is displayed to ensure real-time performance.
- The system updates the detected pose dynamically based on the user's movement.

Pose Navigation

- The system allows users to switch between different yoga poses.
- The keyboard module detects key presses:
- Right Arrow Key (→): Moves to the next pose.
- Left Arrow Key (←): Moves to the previous pose.
- This feature allows users to compare their current pose with different reference poses.

4. EMPERICAL ANALYSIS AND RESULT

A. Experimental Setup

To evaluate the performance of the AI-based yoga trainer, the system was tested on a dataset consisting of various yoga postures captured in real-world scenarios. The Support Vector Machine (SVM) classifier, trained using MediaPipe Pose landmarks, was used for real-time pose classification. The experiments were conducted on a system with the following specifications:

Processor: Intel Core i7, 2.6 GHz

RAM: 16GB DDR4

GPU: NVIDIA GeForce RTX 2060
Operating System: Windows 10 / Ubuntu 20.04
Software Environment: Python 3.8, OpenCV, MediaPipe, scikit-learn
The **frame processing speed (FPS)** and classification accuracy were recorded to measure system efficiency.

B. Performance Evaluation Metrics

The model's effectiveness was assessed using the following performance metrics:
Accuracy: Measures the percentage of correctly classified yoga poses.
Precision & Recall: Evaluate the model's ability to classify poses correctly and detect misclassified samples.
Frame Rate (FPS): Determines the system's ability to operate in real time.
Pose Recognition Latency: Measures the time taken to classify a pose after capturing a frame.

Pose Classification Accuracy

The SVM model achieved an overall accuracy of 94.5% across multiple yoga poses. A confusion matrix analysis showed high classification precision for well-defined poses such as *Tadasana* (Mountain Pose) and *Vrikshasana* (Tree Pose), whereas poses with high intra-class variations (e.g., *Trikonasana* - Triangle Pose) showed slightly lower accuracy.

C. Real-Time Processing Performance

The system maintained an average FPS of 19-20, ensuring a smooth user experience. The pose recognition latency was approximately 0.05 seconds per frame, making it suitable for real-time applications.

Table 1: Performance Analysis

Metric	Result
Accuracy	94.5%
Precision	93.8%
Recall	92.7%
Average FPS	19-20
Pose Recognition Latency	~0.05

5. Challenges And Future Scope

AI-powered yoga trainers face several challenges that must be addressed to enhance their accuracy, efficiency, and adoption. One major challenge is posing estimation accuracy, as deep learning models struggle with variations in body types, lighting, and camera angles, leading to incorrect posture feedback. Additionally, real-time processing and latency remain concerns, especially for mobile applications, requiring optimized models and hardware acceleration. The lack of large-scale annotated yoga datasets limits AI model generalization, necessitating diverse datasets for better training. Furthermore, user trust and adaptability pose challenges, as many individuals may hesitate to rely solely on AI for posture correction. Privacy and security concerns regarding biometric data protection also need to be addressed through encrypted storage and federated learning techniques.

The future of AI-based yoga trainers is promising, with advancements expected in deep learning, wearable technology, and immersive experiences. AI integration with smart wearables will enable real-time monitoring of heart rate, breathing, and muscle engagement, enhancing personalization. Augmented Reality (AR) and Virtual Reality (VR) will make AI-driven yoga training more immersive, providing interactive posture corrections and virtual instructor-led sessions. Additionally, AI-powered voice assistants and chatbots will enhance user engagement through real-time feedback and stress assessment. In healthcare, AI-driven yoga systems will aid in rehabilitation and physiotherapy, offering adaptive routines based on recovery progress. Privacy concerns will be mitigated through decentralized AI models, ensuring user data security while maintaining personalized recommendations.

Conclusion

Artificial Intelligence and deep learning integration with yoga training provides substantial improvement, providing the ease and effectiveness to the practitioners. Perhaps one of the main advantages is that education can be personalized as per the learner. The incorporation of deep learning in the contextualization of the AI systems can be used to recognize and evaluate a user's body posture, flexibility and fitness level in real time. This enables the system is able to give individual feedback and readjust the yoga routine in line with progress achieved. Algorithms in traditional methods instruct the users based on broad templates, while deep learning algorithms in AI yoga trainers allow the trainers to observe the patterns and specificities of a practitioner's

movements to tailor the advice and motivation they receive to the needs and expectations of the skill level the practitioner is at. Second, the tracking of progress is also better to achieve with some help from AI. These systems can track long-term trends on flexibility, strength, stamina among others. Through this data, the AI can note patterns in a practitioner's improvement and data will help in giving recommendations for future development. One of the benefits of such an approach is that data provides detailed information that can help one to set goals regarding particular achievements and modify practices while maximizing health advantages. All in all, the innovation of Artificial intelligence and particularly deep learning improves the yoga education in a personal, affordable, and efficient way for all players in the market. They generate immediate feedback, utilize big data approach, and provide mass instruction, making the physical discipline of yoga more accessible to the beneficiaries.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest related to this research. There are no financial, professional, or personal relationships that could have influenced the work reported in this paper.

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