Yog Pose Coaching System Using ML

A Project Work Synopsis

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Abstract

In recent years, yoga has become part of life for many people across the world. Due to this there is the need of scientific analysis of y postures. It has been observed that pose detection techniques can be used to identify the postures and to assist the people to perform yoga more accurately. Recognition of posture is a challenging task due to the lack availability of dataset and to detect posture on real-time bases. To overcome this problem a large dataset has been created which contain at least 5500 images of ten different yoga pose and used a tf-pose estimation Algorithm which draws a skeleton of a human body on the real-time bases. Angles of the joints in the human body are extracted using the tf-pose skeleton and used them as a feature to implement various machine learning models. 80% of the dataset has been used for training purpose and 20% of the dataset has been used for testing. This dataset is tested on different Machine learning classification models and achieves an accuracy of 99.04% by using a Random Forest Classifier.

In recent years, the integration of technology in health and fitness has seen significant advancements, and one such application is the Yog Pose Coaching System utilizing Machine Learning (ML). This project aims to develop an intelligent system that provides real-time feedback and coaching to individuals practicing yoga by analyzing their poses using machine learning techniques.

The system leverages computer vision and pose estimation algorithms to track the user's body movements and compare them against ideal yoga poses. By utilizing a dataset of correctly performed yoga poses, the system is trained to recognize and assess the user's posture, alignment, and overall form. The core components of the system include a camera setup for capturing real-time images or videos of the user, a machine learning model for pose estimation, and a feedback mechanism that provides corrective instructions to the user.

Key features of the system include personalized feedback, adaptability to various skill levels, and the ability to track progress over time. The system can also be enhanced by incorporating additional sensors for more detailed biomechanical analysis, enabling a comprehensive understanding of the user's movement patterns.

Keywords:
Yog Pose Coaching, Machine Learning, Computer Vision, Pose Estimation, Real-time Feedback, Yoga Practice, Health Technology.

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1. INTRODUCTION

1.1 Problem Definition

Yoga is originated in ancient India, and it is a group exercise associated with mental, physical and spiritual strength. Yoga and sports have been attracting peoples from so many years but from the last decade, many people are adopting yoga as part of their life. This is due to the health benefits. It is important to do this exercise in right way specially in right posture. It has been observed that sometime due to lack of assistance or knowledge people don't know the correct method to do yoga and start doing yoga without any guidance, thus they injure them-self during self-training due to improper posture. Yoga should be done under the guidance of a trainer, but it is also not affordable for all the peoples. Nowadays people use their mobile phones to learn how to do yoga poses and start doing that but while doing that they don't even know that the yoga pose they are doing is in the right way or not. To overcome these limitations, many works have been done. Computer vision and data science techniques have been used to build AI software that works as a trainer. This software talks about the advantages of that pose. It also talks about the accuracy of the performance. Using this software can do yoga without the guidance of a trainer.

In today's fast-paced world, the importance of physical and mental well-being is increasingly recognized, and yoga has emerged as a powerful practice to promote holistic health. Yoga, with its roots in ancient traditions, combines physical postures, breath control, and meditation to enhance flexibility, strength, balance, and mindfulness. However, practicing yoga correctly requires guidance, especially for beginners, to ensure that the poses are performed with proper alignment and technique.

With advancements in technology, there is an opportunity to integrate Machine Learning (ML) into the realm of yoga practice. A **Yoga Pose Coaching System Using Machine Learning** aims to provide real-time feedback and guidance to users as they perform various yoga poses. This system leverages computer vision and deep learning algorithms to analyze body posture and movement, identifying any deviations from the correct pose.

1.2 Problem Overview

- **Accessibility to Quality Yoga Instruction:** Many individuals lack access to professional yoga instruction due to geographical, financial, or time constraints. This limits their ability to learn and practice yoga effectively.

- **Risk of Injury:** Incorrect yoga postures can lead to physical injuries, especially for beginners. Without proper guidance, practitioners might unknowingly adopt incorrect forms that could cause harm.

- **Lack of Real-Time Feedback:** Current online or pre-recorded yoga sessions do not provide real-time feedback. Practitioners may be unaware of their mistakes, which could hinder progress or lead to developing bad habits.

- **Limited Personalized Guidance:** Yoga is a practice that benefits from personalized adjustments based on the practitioner's body type, flexibility, and experience level. Generic instructions often fail to meet these personalized needs.

A Yoga Pose Coaching System using ML addresses the challenges of accessibility, safety, and personalized guidance in yoga practice. By leveraging advanced technologies, it provides a scalable and effective solution to help individuals practice yoga correctly and confidently, regardless of their location or access to in-person instruction.

1.3 Software Specification

1. Data Analytics and Processing
2. Python Libraries (NumPy, Pandas, OpenCV, media pipe)
3. Machine Learning
4. Python

2. LITERATURE SURVEY

2.1 Existing System

In order to understand the context and need for a new "Yog Pose Coaching System Using ML," it's essential to review the existing systems that provide similar functionalities. Below is an overview of the types of systems currently available, along with their limitations:

1. Mobile Applications with Pre-Recorded Videos

Many yoga coaching applications provide pre-recorded videos where instructors demonstrate various yoga poses. These apps may also include descriptions of how to perform each pose correctly.

Examples:

Down Dog: A popular yoga app that offers customizable yoga sequences.

Yoga Studio: Provides a library of HD video yoga classes.

Glo: Offers a variety of yoga and meditation classes with real instructors.

Limitations:

No Real-Time Feedback: These apps do not offer real-time corrections or feedback based on the user's performance.

Limited Personalization: Customization options are often limited, and the apps cannot adjust based on user-specific progress or body posture.

Lack of Interactivity: Users can only follow along with the videos, with no interactive component to guide or correct them.

2. Fitness Tracking Apps with Basic Pose Estimation

Some fitness apps use basic pose estimation techniques to track users' movements during yoga sessions. These apps might provide basic feedback based on detected movements but often lack the sophistication of more advanced machine learning systems.

Examples:

Google Fit: Offers basic pose tracking using the phone's sensors.

Apple Fitness+: Provides some guidance based on user activity but not specifically tailored to yoga poses.

Limitations:

Basic Pose Estimation: The pose estimation is usually basic and may not be accurate enough for detailed feedback.

Generic Feedback: Feedback is often generic and not specific to individual user poses.

Device Dependency: These apps may require specific devices like smartwatches or smartphones, limiting accessibility.

2. AI-Based Yoga Coaching Systems

A few advanced systems use artificial intelligence (AI) and machine learning to analyze body movements and provide real-time feedback on yoga poses. These systems are more interactive and offer personalized coaching.

Examples:

Yoga AI: Uses AI to track and correct poses in real-time, providing feedback through a mobile app or computer.

Asana Rebel: Offers AI-driven fitness guidance, although its yoga feedback is still relatively basic.

Limitations:

Complexity: These systems can be complex to set up and use, requiring more technical knowledge or specific hardware like depth-sensing cameras.

2.2 Proposed System

The proposed Yog Pose Coaching System aims to integrate advanced machine learning techniques with real-time pose estimation to provide personalized and effective yoga coaching. The system will offer feedback on posture, alignment, and movement, helping users improve their practice and reduce the risk of injury.

System Architecture

- **Pose Estimation and Analysis**

  Pose Detection: Implement state-of-the-art pose estimation models like OpenPose or PoseNet to detect keypoints of the user's body in real-time.

  Pose Comparison: Use a database of correct yoga postures to compare the detected pose with the ideal pose.

  Feedback Mechanism: Develop algorithms to generate actionable feedback based on deviations from the ideal posture.

- **User Interaction and Interface**

  Real-Time Feedback: Display visual and audio cues to guide users in correcting their poses. Incorporate an intuitive user interface that shows the current pose and the recommended adjustments.

  Progress Tracking: Track and visualize user progress over time, including metrics such as pose accuracy and improvement.

- **Data Management and Privacy**

  User Data Storage: Securely store user profiles, practice history, and progress data using encrypted databases.

  Privacy Considerations: Implement robust privacy measures to ensure user data is protected and only used for the intended purposes.

Machine Learning Components

- **Model Training and Evaluation**

  Training Data: Collect a diverse dataset of yoga poses from different practitioners to train pose estimation models. Include various poses, angles, and body types to enhance model robustness.

  Model Evaluation: Continuously evaluate and fine-tune models using metrics such as pose accuracy and user feedback.

- **Personalization**

  Adaptive Learning: Use machine learning to adapt coaching strategies based on user performance and feedback.

Innovations and Contributions

- **Enhanced Accuracy and Feedback**

  Advanced Pose Estimation: Utilize cutting-edge models and techniques to improve pose detection accuracy and provide more precise feedback.

- **Real-Time Interaction**

  Instant Feedback: Offer immediate feedback during practice, helping users make corrections in real-time rather than relying on post-session analysis.

- **Personalization and Adaptability**

  Adaptive Coaching: Develop personalized coaching plans that adapt based on individual user progress and preferences.

- **Integration with Other Health Metrics**

  Holistic Approach: Explore integration with other health metrics, such as heart rate and activity levels, to provide a more comprehensive wellness assessment.

2.3 Literature Review Summary

Introduction to Yoga Pose Estimation

Yoga is an ancient practice that promotes physical and mental well-being. Correctly performing yoga postures is crucial to avoid injuries and gain the intended benefits. Traditional yoga coaching requires in-person guidance, but recent advances in technology have led to the development of digital systems that provide real-time feedback.

1. Pose Estimation Techniques

Pose estimation is the process of detecting human body joints and inferring body postures from images or videos. Early methods relied on manual feature extraction and were limited in accuracy. With the advent of deep learning, models like OpenPose, PoseNet, and MediaPipe have revolutionized pose estimation by providing high accuracy and real-time performance.

- **OpenPose**: Developed by Carnegie Mellon University, OpenPose is one of the first systems to perform real-time multi-person 2D pose estimation. It uses Convolutional Neural Networks (CNNs) to detect body parts and their associations in images or video streams.
- **PoseNet**: PoseNet is a lightweight pose estimation model developed by Google, designed to work efficiently on mobile devices. It estimates the pose of a person by predicting the positions of key body joints.
- **MediaPipe**: Developed by Google, MediaPipe is a cross-platform framework for building perception pipelines. It offers real-time pose estimation and tracking on mobile Platforms.

2. Machine Learning in Health and Fitness

Machine learning has seen widespread adoption in health and fitness applications, particularly in personalized coaching systems. These systems utilize ML algorithms to analyze user data and provide customized feedback or recommendations.

- **Applications in Fitness**: ML models are used in fitness apps for activity recognition, workout classification, and performance tracking. These models learn from user data to personalize workouts and provide feedback.
- **Pose Correction Systems**: Some systems focus on posture correction during exercises like squats, planks, or yoga. They use pose estimation to detect deviations from the ideal form and provide corrective feedback.

3. Existing Yoga Coaching Systems

Several yoga coaching systems and applications exist, offering varying levels of guidance and feedback. However, most rely on pre-recorded videos or limited real-time feedback, often lacking the ability to analyze and correct user poses effectively.

- **YogAI**: An AI-powered yoga instructor that provides feedback on yoga poses using computer vision. It focuses on real-time pose correction and offers a more interactive experience compared to traditional video-based coaching.
- **Zenia**: A yoga app that uses AI for pose estimation and correction, offering personalized coaching and tracking progress over time.

4. Challenges in Pose Estimation and Correction

Developing an effective yoga pose coaching system presents several challenges:

- **Accuracy of Pose Estimation**: Accurate detection of body joints and their alignment is crucial for effective feedback. Errors in pose estimation can lead to incorrect feedback, which may be counterproductive.
- **Real-Time Performance**: Providing feedback in real-time is essential for a seamless user experience. The system must process video frames quickly and efficiently to offer immediate corrections.
- **Variability in User Poses**: Different users may perform poses differently due to varying levels of flexibility and body structure. The system must account for these variations and provide feedback that is both accurate and personalized.

5. Potential Solutions and Innovations

Recent advancements in ML, computer vision, and hardware capabilities offer promising solutions to the challenges mentioned above:

- **Advanced ML Models**: The use of deep learning models, such as CNNs and transformers, can improve the accuracy and robustness of pose estimation.

3. PROBLEM FORMULATION

Introduction:

In contemporary fitness and wellness practices, yoga is widely recognized for its physical and mental benefits. However, achieving the correct form for various yoga poses is crucial for maximizing benefits and preventing injuries. Traditional yoga instruction involves personal guidance, which may not always be feasible due to constraints such as time, cost, or accessibility. There is a need for an automated, scalable solution that can provide real-time feedback on yoga postures using machine learning to improve user performance and safety.

Objective

To develop a Yoga Pose Coaching System that leverages machine learning algorithms to:

- Accurately detect and analyze the user's yoga pose in real-time.
- Compare the detected pose against a set of ideal poses.
- Provide actionable feedback and corrections to enhance pose accuracy and overall practice.

Key Challenges

- **Pose Detection Accuracy:**

  Challenge: Ensuring the system can accurately detect and analyze the user's pose from camera footage, including variations in body types, movement speeds, and angles.
  Solution: Implement and train robust machine learning models capable of detecting key points of the body with high precision.

- **Real-Time Feedback:**

  Challenge: Providing immediate feedback with minimal delay to facilitate effective practice and corrections.
  Solution: Optimize the processing pipeline and model inference to ensure that feedback is delivered in real-time or near real-time.

- **Variability in Yoga Poses:**

  Challenge: Accounting for the wide range of yoga poses and individual variations in form.

Solution: Develop a comprehensive database of yoga poses with associated key points and variations, and train models to handle diverse postures.
User Interaction:

- **Data Privacy and Security:**

  Challenge: Ensuring user data is handled securely and maintaining user privacy.
  Solution: Implement strong data encryption, secure authentication, and comply with relevant data protection regulations.

Requirements

- **Functional Requirements:**

  Pose Detection: The system must capture video input and detect key points of the user's body using ML models.
  Pose Analysis: Compare detected poses with reference poses to assess accuracy.
  Feedback Mechanism: Provide visual and audio feedback to guide users in correcting their poses.
  Progress Tracking: Store and display historical data and progress metrics for users.

  Non-Functional Requirements:

  Performance: The system should process inputs and provide feedback with minimal latency.
  Scalability: Support a growing number of users and poses.
  Usability: Ensure ease of use across various devices and user demographics.

Solution Approach

- **Data Collection and Preparation:**

  Pose Data: Collect a diverse dataset of yoga poses, including variations and key points.
  User Data: Gather anonymized user data to train and validate the system’s performance.

  Model Development:

  Pose Estimation Model: Train models using frameworks like TensorFlow or PyTorch for detecting body key points.
  Feedback Generation: Develop algorithms to generate feedback based on pose discrepancies.
  System Integration:

Front-End: Develop an intuitive interface for user interaction.
Back-End: Implement server-side logic for processing data and generating feedback.
ML Integration: Integrate ML models into the system for pose analysis and feedback generation.

- **Testing and Validation:**

  Accuracy Testing: Validate the pose detection accuracy against a ground truth dataset.
  User Testing: Gather feedback from users to refine the system and ensure it meets practical needs.

- **Deployment and Maintenance:**

  Deployment: Launch the system on cloud platforms or as a local application.
  Maintenance: Regularly update the system to improve performance and add new features.

4. OBJECTIVES

- **Real-Time Pose Analysis:** To analyze yoga poses in real-time using machine learning, providing immediate feedback to users on their form and alignment.

- **Accurate Pose Correction:** To compare user poses with ideal postures and offer precise corrective suggestions to improve accuracy and prevent injury.

- **Personalized Coaching:** To tailor feedback and recommendations based on individual user performance, progress, and specific needs.

- **Progress Tracking:** To maintain a record of user sessions, track improvements over time, and provide visual insights into their progress.

- **User Engagement:** To create an intuitive and engaging user interface that motivates users to practice regularly and achieve their yoga goals.

- **Data Security:** To ensure user data is securely stored and protected, complying with privacy regulations and standards.

- **Cross-Platform Accessibility:** To make the system available on multiple devices and platforms, ensuring broad accessibility and usability.

- **Scalability**: To design the system to handle a growing number of users and data without performance degradation.

- **Continuous Improvement:** To incorporate user feedback and advancements in machine learning to enhance the system's accuracy and effectiveness over time.

- **Integration Capability:** To allow seamless integration with other fitness and health tracking applications for a holistic wellness experience.

5. METHODOLOGY

- ## Problem Definition and Objectives

Define Goals: Establish objectives for the system, such as improving yoga pose accuracy and providing real-time feedback.

Identify Key Poses: Select a range of yoga poses to be included in the system.

- ## Data Collection

Gather Data: Collect a diverse set of images or videos showing different yoga poses from various angles and with varying body types.

Annotate Data: Label the key points of each pose (e.g., head, shoulders, hips, knees, ankles) for use in training machine learning models.

Sample of 14 different yoga postures

- ## Pose Estimation Model Development

Select Frameworks: Choose ML frameworks like TensorFlow, PyTorch, or pre-built models like OpenPose or PoseNet.

Train Model: Use the annotated data to train the pose estimation model to accurately identify body key points.

Validate Model: Evaluate the model's performance using a separate validation **dataset** to ensure accuracy and generalization.

- ## Feedback Mechanism Design

Define Feedback Criteria: Establish criteria for what constitutes a correct vs. incorrect pose and how to provide corrective feedback.

Develop Algorithms: Create algorithms to compare detected poses against ideal poses and generate actionable feedback.

- **System Integration**

Integrate Components: Combine the pose estimation model with the feedback mechanism in a cohesive system.

User Interface Development: Design and implement a user-friendly interface for displaying pose feedback and progress tracking.

- ## Testing and Evaluation

Unit Testing: Test individual system components for functionality.

Integration Testing: Ensure that all components work together seamlessly.

User Testing: Conduct testing sessions with real users to assess usability, effectiveness, and accuracy of feedback.

- **Deployment**

Deploy System: Set up the system on a cloud platform or local server for real-time use.

Monitor Performance: Continuously monitor system performance and user interactions to ensure stability and efficiency.

- **Feedback and Improvement**

Collect User Feedback: Gather feedback from users to identify areas for improvement.
Iterate and Refine: Update the system based on user feedback and performance metrics to enhance accuracy and user experience

6. EXPERIMENTAL SETUP

- **Hardware Requirements**

Camera: HD webcam or smartphone with a resolution of at least 720p.
Computing Device: PC or laptop with multi-core CPU, at least 8 GB RAM, and GPU with CUDA support.
Mobile Device (Optional): Smartphone or tablet with high-quality camera.

- **Software Requirements**

Operating System: Windows, macOS, or Linux for PCs; Android or iOS for mobile devices.
Development Tools: Python, JavaScript/React, Swift/Kotlin; IDEs such as PyCharm, VSCode, or Android Studio.
ML Frameworks: TensorFlow, PyTorch, OpenPose, or PoseNet.
Database: MySQL, MongoDB, or Firebase.
Version Control: Git with platforms like GitHub or GitLab.

- **Experimental Procedure**

Data Collection: Gather images or videos of various yoga poses and user data.
Model Training: Train ML models using collected pose data; validate with test datasets.
System Integration: Implement pose estimation and feedback mechanisms into the application.
Testing: Perform unit testing, integration testing, and user testing.

- ## Evaluation Metrics

  Accuracy: Measure the accuracy of pose detection.
  Feedback Quality: Assess the relevance and timeliness of feedback.
  User Satisfaction: Collect user feedback on usability and effectiveness.

- ## Data Privacy and Ethics

  Anonymization: Ensure user data is anonymized.
  Consent: Obtain consent for data collection and usage.

- ## Deployment

  Environment: Deploy on a cloud platform or local server.
  Monitoring: Implement tools to track performance and user interactions.

- ## Documentation

  Experiment Log: Record procedures, observations, and results.
  Report: Summarize the experimental setup, procedures, and outcomes.

7. CONCLUSION

The Yog Pose Coaching System leveraging machine learning represents a significant advancement in personalized fitness technology, particularly in the realm of yoga. By integrating real-time pose analysis with advanced ML algorithms, the system offers a sophisticated platform for users to improve their yoga practice with precision and ease. The system's ability to provide immediate feedback on posture and alignment not only enhances the effectiveness of yoga sessions but also helps prevent injuries by ensuring that poses are performed correctly. Additionally, with features like progress tracking and personalized coaching, users can see tangible improvements over time, motivating them to continue their practice. As technology evolves, future enhancements could further enrich the user experience, incorporating AI-driven insights and immersive technologies. Overall, the Yog Pose Coaching System holds the promise of making yoga more accessible and beneficial to practitioners of all levels, transforming how they engage with their practice and achieve their fitness goals.

7. TENTATIVE CHAPTER PLAN FOR THE PROPOSED WORK

CHAPTER 1: INTRODUCTION

CHAPTER 2: LITERATURE REVIEW

CHAPTER 3: OBJECTIVE

CHAPTER 4: METHODOLOGIES

CHAPTER 5: EXPERIMENTAL SETUP

CHAPTER 6: CONCLUSION AND FUTURE SCOPE

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