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FitMentor: AI based Fitness Monitoring System

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Abstract: Real-time exercise monitoring is important to ensure proper shape, maximize training efficiency and prevent injuries. In this project, FIT Mentor: AI Fitness Monitoring System, Computer Vision-based Approach, OpenCV and MediaPipe will be used for Skelett-Kypoint detection and exercise duties. The system analyzes user movements and provides immediate feedback on training forms without the need for portable sensors. By integrating dynamic motion analysis with individual iteration counting algorithms, the system closely evaluates training performance. A simple implementation ensures efficient delivery of consumer devices and creates accessible fitness solutions. Experimental results demonstrate the effectiveness of the system in real-time exercise and demonstrate the potential to improve the accuracy and accessibility of training sessions.

I. INTRODUCTION

In the age of artificial intelligence and technological innovation, fitness tracking has evolved beyond simple step counters and calorie monitors. Fit Mentor: AI Fitness Monitoring System is an advanced solution that leverages computer vision and deep learning to provide real-time exercise tracking and performance analysis. Designed for gym enthusiasts, trainers, and fitness-conscious individuals, this system accurately monitors workout movements, ensuring proper form, tracking repetitions, and minimizing the risk of injury.

Traditional fitness tracking methods often rely on wearable devices, which can sometimes be inaccurate or restrictive. Fit Mentor eliminates the need for wearables by utilizing OpenCV and MediaPipe, allowing users to engage with the system using just a webcam or smartphone camera. The AI model precisely detects body posture, joint movements, and exercise patterns, enabling it to count repetitions and provide feedback on form correction.

This project also focuses on building a user-friendly desktop application using Tkinter, making it accessible to a wide audience without requiring complex installations. Fit Mentor is particularly useful for individuals who work out at home, personal trainers who want to monitor clients remotely, and gym-goers who seek an interactive and data-driven approach to fitness tracking.

By combining computer vision, real-time feedback, and intuitive UI, Fit Mentor represents a step forward in AI-powered fitness coaching, ensuring that users achieve their workout goals safely and efficiently. Through this project, we aim to bridge the gap between AI and fitness, empowering users with intelligent workout insights that enhance their exercise experience.

II. Literature Review

1. **Existing Fitness Monitoring Systems and Its Limitations :**
The integration of technology in fitness has been significantly developed using many portable devices, mobile applications, and fitness tracking solutions. These systems are intended to help users monitor workouts, count repetitions and improve performance. Despite technological advances, there are some limitations. Some models provide motor recognition and the accuracy of detection of complex movements such as squats, cross-lifting, and biceps is often limited. Portable sensors have difficulty grasping joint angles, speed of movement and accuracy, which are very important for effective strength training. These apps can help you plan your workouts and progress persecution, but rely on self-report, making them potential inaccuracies in training tracking. Furthermore, there is no real-time AI-driven feedback on shapes, making it less effective for users who want to improve their technology. These systems provide more accurate motion tracking, but are often integrated into cloud-based or subscription-based services where users have a stable internet connection. Furthermore, many AI-based Fitness applications are web-based rather than independent desktop applications.

2. **Limitations to current fitness tracking systems :**
Despite progress in portable technologies, mobile applications and AI-based fitness solutions, there are still major challenges.
Dependency on portable devices: Most fitness tracking systems rely on external devices such as smart watches and sensors. Corrections from an attitude and movement perspective. This can lead to injuries and inefficient training sessions. The Need for an AI-Based Desktop Fitness Monitoring System
Fit Mentor: The AI Fitness Monitoring System was developed to overcome these limitations by providing a real-time AI-controlled fitness tracking solution that does not require wear. By using OpenCV and Mediapipe, the system uses pose estimates to recognize body movements and counts repetitions of exercises such as squats, biceps, and lunch. This system provides immediate feedback on training forms, helping users improve their technology and prevent injuries.

III. Methodology

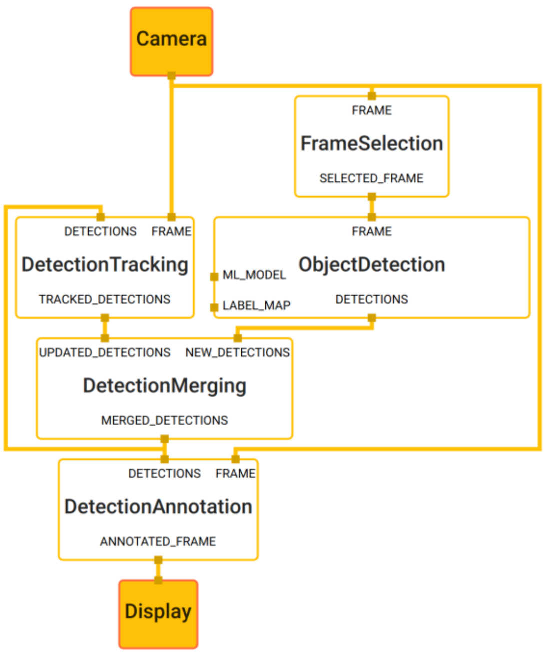

Fig 3.1. Methodology of FitMentor

Fit Mentor: AI Fitness Monitoring System follows a structured methodology that integrates computer vision, machine learning and real-time recognition tracking to provide an accurate and interactive exercise experience. The system uses OpenCV and MediaPipe for evaluation and migration analysis to ensure accurate repetition numbers and formation corrections.

1. Camera input and frame processing
The system starts with accessing the camera. This includes real-time video input from the user's training session. Recorded videos are processed according to frames to extract meaningful data. Object detection and tracking
To accurately grasp the most important points and movements of the human body, the system uses machine learning (ML_MODEL), trained with body-specific movement patterns. position.

These recognitions are continuously updated to form data records for updatated_detections.
The model uses Label_map to classify the movements recognized by predefined movement categories (squat, Biceps Curl, Lung, etc.). Consistency.
A new movement is started, new_detections is dynamically added.

3. Detection and Annotation Aggregation Modules are introduced to adjust and combine the recognition of several successive frames to improve accuracy. Commentary.
Detect annotation steps are duplicated in motion specifications for key moment points, recognized joints, and video feeds:

Annotated_frame is generated to display real-time tracking and motion classification. Finally, the system displays the edition processed by an interactive interface:

Annotated_frame is sent to the display module, and the user sees that their movements are tracked in real time. Users are appropriate in real time. Enable fitness feedback feedback and repeat indicators.

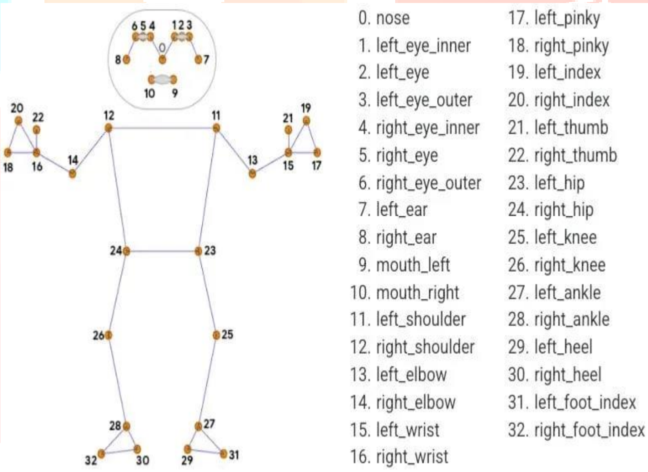

Fig 3.2. Methodology of FitMentor

1. Capturing and Preprocessing Frames

- OpenCV captures video frames and converts them into RGB using `cv2.cvtColor()`.
- Frames are resized and normalized for efficient processing.

2. Pose Detection using MediaPipe

- MediaPipe detects landmarks on the face, upper body, and lower body, including:
  - Face & Head: Nose, eyes, ears, mouth (`0-10`)
  - Upper Body: Shoulders, elbows, wrists (`11-16`)
  - Lower Body: Hips, knees, ankles, feet (`23-32`)

3. Movement Tracking & Repetition Counting

- Joint angles are calculated to track exercise movements (e.g., squats, biceps curls).
- OpenCV updates repetition count and ensures proper form using vector-based analysis.

4. Visualization & Real-time Feedback

- OpenCV overlays landmark connections and displays annotated frames using `cv2.imshow()`.
- Users receive real-time posture correction and performance insights.

IV. Architecture of Application

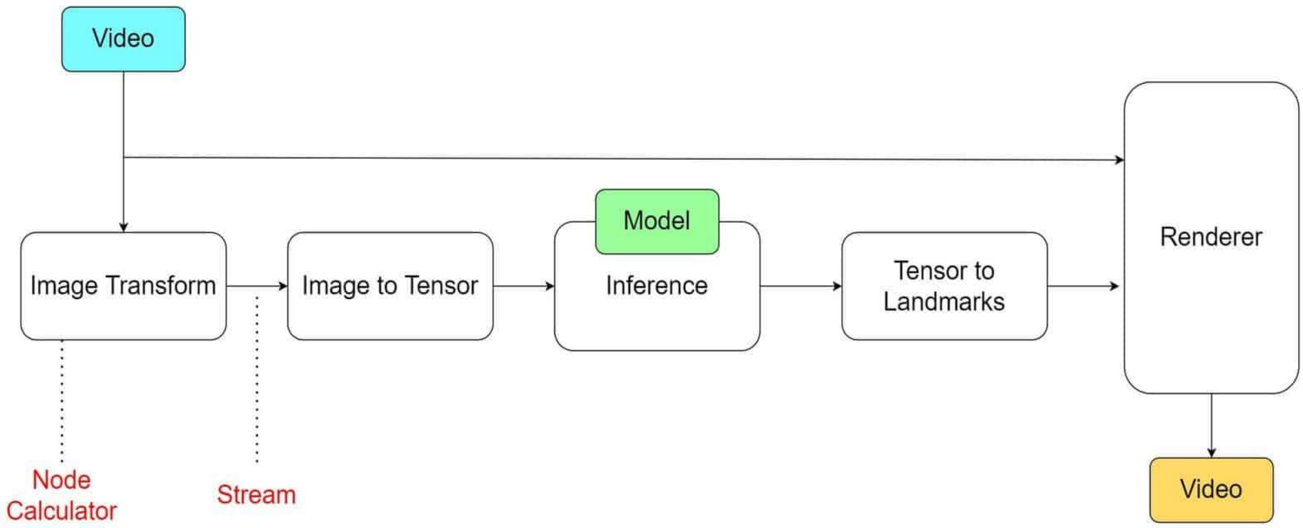

Fig 3.3. Architecture of FitMentor

1. Capturing and Processing Video Input

The system begins by capturing live Video from a camera to monitor user movements.

- The frames undergo Image Transform operations, such as resizing and contrast adjustments, to improve clarity.
- The transformed image is converted into a numerical format using Image to Tensor, making it compatible for machine learning processing.

2. Model Processing and Pose Estimation

To analyze movements, the system utilizes a deep learning-based Model trained for pose estimation and motion tracking.

- The model output is then mapped to body key points via Tensor to Landmarks, assigning coordinates to joints such as shoulders, knees, and elbows.
- The extracted landmarks assist in detecting correct posture and tracking exercise performance.

3. Motion Analysis and Visual Rendering

The system ensures real-time exercise monitoring by continuously tracking pose data.

- A Node Calculator processes landmark coordinates to compute angles and distances, ensuring accurate posture evaluation.
- The Renderer overlays visual feedback on the video feed, highlighting body movements and corrections needed for better form.

4. Real-time Streaming and Display

For smooth and continuous tracking, the system incorporates a Stream module.

- The analyzed video, along with pose-tracking overlays, is streamed with minimal delay.
- Users receive instant feedback through the Renderer, helping them make necessary posture adjustments.

5. Performance Evaluation and Progress Tracking

- The system records and analyzes past workout data to assess improvements over time.
- Key metrics such as repetition count, posture accuracy, and workout consistency are stored for tracking progress.
- Users receive personalized feedback based on their performance, helping them refine their exercise techniques

V. Results

The FitMentor system efficiently tracks and evaluates user movements in real time using video input and AI-driven pose estimation. The results are analyzed based on accuracy, responsiveness, and user experience.

1. Accuracy of Pose Detection

The system accurately identifies and tracks 32 key body landmarks, including joints such as shoulders, elbows, knees, and wrists. By leveraging OpenCV and MediaPipe, it ensures precise recognition of different exercise postures. The Node Calculator measures joint angles to validate movement accuracy.

2. Instant Feedback and Responsiveness

The Renderer overlays real-time visual cues onto the video, helping users adjust their posture immediately. With the Stream module, the system ensures smooth and continuous motion tracking with minimal latency, allowing users to receive quick and effective feedback during workouts.

3. Performance Monitoring and Analysis

The system records essential workout data, including repetition count, movement range, and posture accuracy. This allows users to track their progress over time, identify areas for improvement, and maintain consistency in their training.

4. User Engagement and Experience

FitMentor offers an interactive experience by providing real-time corrections and guided movements. The combination of gesture recognition and movement validation enhances user engagement, ensuring that workouts are both structured and effective.

VI. Conclusion

The FitMentor project leverages AI and computer vision to monitor exercises in real-time. Using OpenCV and MediaPipe, it accurately tracks body movements, evaluates posture, and provides immediate feedback, enhancing workout precision and user experience.

Future enhancements may introduce additional exercises, personalized training insights, and wearable sensor integration. In summary, FitMentor contributes to AI-driven fitness solutions, helping users maintain proper form effectively.

VII. References

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