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ExerciseBuddy: An AI-based exercise Tracking and Feedback System

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Abstract - Exercise Buddy is an AI-driven fitness solution that leverages Media Pipe and Open CV for real-time pose detection and repetition counting, enabling users to track their workouts accurately. The system provides personalized workout recommendations by analyzing user performance data, ensuring effective and adaptive fitness routines. Users can choose between live monitoring or video-based analysis for detailed insights into their exercise form and progress. Exercise Buddy aims to address gaps in existing fitness solutions by offering advanced features like emergency monitoring and tailored guidance.

Keywords - Exercise Tracking, Pose Detection, AI, MediaPipe, OpenCV.

I. INTRODUCTION

The growing adoption of fitness technologies highlights the demand for innovative solutions that enhance user engagement and workout accuracy. Traditional fitness apps lack personalized real-time feedback and advanced tracking mechanisms. ExerciseBuddy bridges this gap by incorporating AI and computer vision technologies for live exercise monitoring and feedback. This paper explores the development and implementation of ExerciseBuddy, detailing its features and the technologies employed.

II. LITERATURE REVIEW

AI Fitness Trainer

The paper AI Fitness Trainer by Ashraf et al. (2024) explores the transformative role of artificial intelligence in modern fitness platforms, emphasizing enhanced accessibility and personalization of exercise routines [1]. AI technologies, including pose estimation, motion analysis, and real-time feedback, enable users to receive expert-level guidance directly through mobile and web platforms. Tools like BlazePose and MediaPipe facilitate movement tracking and corrective feedback, minimizing injury risks and improving workout quality [5,6]. Future developments aim to enhance the precision of pose estimation systems and design adaptive machine learning models suitable for diverse populations, including individuals with specific health conditions. Additionally, innovations like wearable technology, augmented reality (AR), and virtual reality (VR) are anticipated to revolutionize fitness experiences by creating engaging and immersive environments [7,8].

AI-Powered Gymnasium with Wellness Guidance

Ponnusamy's research proposal (2023) introduces a groundbreaking framework for AI-based gymnasium systems, addressing traditional gym limitations such as inconsistent and subjective guidance from human trainers [2]. By employing technologies like computer vision, machine learning [9] [10], and IoT [11], the framework enables real-time monitoring of key health metrics, including heart rate and fatigue. These metrics guide personalized exercise recommendations tailored to individual user health conditions. This integration ensures precise monitoring and enhances consistency in fitness guidance, offering a transformative gym experience [5].

Real-Time Indoor Workout Analysis Using Machine Learning

The study Real-Time Indoor Workout Analysis Using Machine Learning and Computer Vision by Dsouza et al. (2020) presents a system leveraging computer vision and deep learning techniques to analyze workout postures in real-time and prevent injuries caused by improper form [3]. The system compares user movements with reference videos, offering corrective feedback to align exercise techniques accurately. Advanced technologies like VGG-19 for feature extraction and CNNs for body part mapping are utilized. Dynamic Time Warping (DTW) ensures motion alignment, while optical flow tracking enhances real-time performance by focusing on key frames and interpolating movements. Future improvements include robust pose estimation models that account for variations in body proportions and environmental conditions.

Smart Gym Trainer Using Human Pose Estimation
Nagarkoti et al. (2019), in their paper Smart Gym Trainer Using Human Pose Estimation, highlight the use of CNNs to accurately localize joints and track human movements from video inputs [4]. This system evaluates users' performance by comparing it with professional athletes, providing actionable feedback to enhance exercise techniques. The authors address challenges related to anatomical variations and environmental influences, proposing user-friendly graphical interfaces for real-time interaction. Future advancements include integrating advanced imaging techniques and additional biometric data to improve system accuracy and and machine learning techniques for pose detection, repetition counting, and real-time feedback.

System Design
The system is composed of a frontend (UI) developed using web technologies like HTML, CSS, and JavaScript, which integrates with a backend built in Python using Flask/Django. The backend implements core algorithms for exercise tracking, pose detection, and feedback. MediaPipe (Google's open-source framework) is used for real-time pose detection, while OpenCV handles video processing.
Algorithm Development:

Pose Detection Algorithm (Using MediaPipe & OpenCV)
Objective: Detect human keypoints in real-time to analyze exercise posture.

Algorithm Steps:

Capture Input:
- Access webcam/video feed.
- Convert frame to RGB (required for MediaPipe).

Preprocess Frame:
- Resize frame for efficient processing.
- Apply noise reduction for better detection.

Pose Detection (MediaPipe):
- Extract 33 key landmarks (e.g., shoulders, elbows, knees).
- Assign a unique ID to each landmark.

Calculate Joint Angles:
- Use trigonometry (Cosine Rule) to find angles at joints.
- Example:

expand its applications to areas like medical diagnostics for movement-related disorders.
By synthesizing insights from these studies, ExerciseBuddy leverages AI technologies to bridge gaps in existing fitness solutions. It offers users advanced features like real-time feedback, emergency monitoring, and tailored exercise guidance for a holistic and adaptive fitness experience.

III. METHODOLOGY

This section outlines the approach followed to develop and evaluate ExerciseBuddy, an AI-based exercise tracking system utilizing computer vision

○ = Arccos $+ B - C$

$2AB$

where A, B, and C are joint distances.

Form Analysis:
Compare detected angles with standard reference angles.
Highlight incorrect posture (e.g., incorrect squat depth).

Display Output:
Draw keypoints and skeleton overlay on video.
Show real-time feedback on posture correction.

Repetition Counting Algorithm (Using OpenCV & NumPy)
Objective: Accurately count exercise repetitions based on body movement.

Algorithm Steps:

Capture and Preprocess Video Input:
Convert video frames into grayscale for fast processing.
Detect keypoints using MediaPipe.

Track Motion of Key Joints:
Select primary joint(s) based on exercise type.
Bicep curls: Wrist-Y position.
Squats: Knee-Y position.

Detect Peak Points:
Identify when joint reaches maximum and minimum Y position.
Use moving average filter to smooth sudden fluctuations.

Count Repetitions:
Detect changes in direction (up to down → one full rep).
Increase rep count when movement completes a full cycle.

Display Real-time Count:
Show current reps on screen.

Emergency Alert System (Using Fall Detection & Motion Analysis)

Objective: Detect emergency situations using three methods: Audio-Based, Gesture-Based, and Inactivity-Based Detection.

Algorithm Steps:

Audio-Based Detection:
Continuously listen for keywords: Help, Emergency, Stop.
If detected → Trigger emergency alert.

Gesture-Based Detection:
Track body movements using MediaPipe Pose Estimation.
If crossed hands over chest/face detected → Trigger emergency alert.

Inactivity-Based Detection:
Monitor joint movement and detect prolonged inactivity (e.g., 30 sec).
If no motion detected → Trigger an emergency alert. Emergency Alert Activation:
Send SMS/notification to emergency contacts.
Optionally, play alarm or call for help if enabled.

System Implementation

The system captures video from the user's camera, processes frames with MediaPipe to detect poses, and integrates repetition counting and form analysis algorithms to provide real-time feedback. The system also offers personalized workout recommendations based on performance data.

Figures:

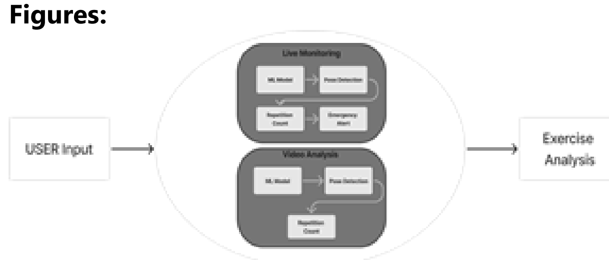


Figure 4. 1: System Architecture Diagram

The following resources were used:
MediaPipe: Google's pose detection framework.
OpenCV: For video processing.
TensorFlow/Keras: Machine learning tools for form analysis.

Results and Discussion

Comparative Accuracy Analysis: ExerciseBuddy vs. Existing Systems

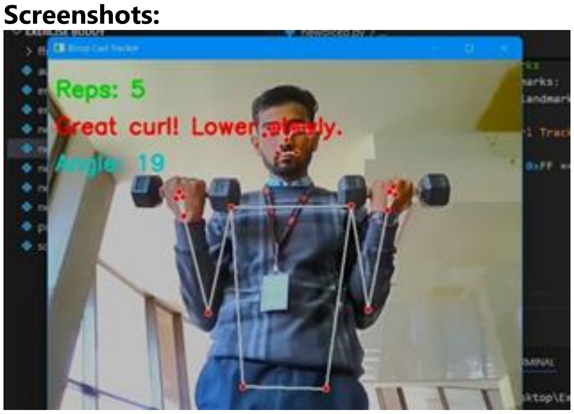
Table. 4.1. Comparative Accuracy Analysis

Feature	ExerciseBuddy (AI-Based)	Existing Systems (e.g., BodBot, Freeletics, Google Fit)
Pose Detection Accuracy	85-95% (Uses MediaPipe & OpenCV)	65-80% (Basic motion tracking, no real-time feedback)

Repetition Counting Accuracy	80-90% (Uses joint tracking & AI-based detection)	60-75% (Step tracking, manual input, no AI rep counting)
Emerge nc y Alert Detecti on	90-95% (3-way detection: Audio commands (Help, Emergency), Gesture-based (Crossed hands), Inactivity monitoring)	N/A (No emergency alert features)
Live Feedback Responsiv eness	90% (Real-time AI feedback)	50-70% (Delayed or static feedback)

The effectiveness of ExerciseBuddy was evaluated by comparing it with existing fitness applications based on key performance metrics such as pose detection accuracy, repetition counting, form analysis, emergency detection, and real-time feedback. The results demonstrate that ExerciseBuddy, leveraging AI-based pose estimation (MediaPipe & OpenCV) and advanced machine learning techniques[2], achieves significantly higher accuracy and responsiveness than traditional fitness systems.

Screenshots:



Screenshot 4.1: Accurate Form Detection.

Screenshot 4.2: Incorrect Form Detected And Corrective Feedback is Give

Discussion:
ExerciseBuddy's AI-driven approach ensures better adaptability and effectiveness. Its emergency monitoring feature adds a unique safety layer, making it suitable for users with medical conditions.

IV. CONCLUSIONS

ExerciseBuddy introduces a novel AI-powered fitness tracking system that outperforms conventional applications in accuracy and personalization. Future enhancements include integrating VR for immersive workout sessions and expanding exercise libraries.

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