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FitVision: Vision-Based Intelligent Fitness Assistance Using Pose-Guided Movement Analysis

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Abstract: With the rise in home-based fitness activities, there is a growing need for systems that can guide fitness activities without the need for a trainer. In this paper, we propose a vision-based fitness assistance system called FitVision. The system includes real-time pose estimation, motion tracking over time, and a conversational interface. The system utilizes MediaPipe BlazePose for keypoint detection from video inputs. Based on keypoint detection, a rule-based approach involving joint angles is employed to interpret various exercises. Postures are also checked through joint angle calculations, while repetitions are tracked through a simple state-based approach. Besides the visual component, there is also a chatbot component known as FitBot, which assists users in their fitness-related queries. Moreover, the interaction becomes even more engaging. Based on our results, we observed that the system performs satisfactorily in identifying the exercises correctly, along with a reasonable repetition count. This shows that the use of computer vision along with a chatbot interface may be beneficial in creating a simple fitness assistant.

Index Terms: Computer Vision, Pose Estimation, Fitness Monitoring, Deep Learning, Exercise Analysis

I. INTRODUCTION

In recent years, the increasing adoption of sedentary lifestyles has raised significant concerns regarding physical health and fitness. As a result, home-based fitness activities and virtual workout platforms have gained popularity due to their flexibility and accessibility. However, performing exercises without proper supervision often leads to incorrect posture, inefficient movements, and potential physical injuries. Traditional fitness training relies heavily on expert supervision to ensure proper exercise execution, but professional guidance may not always be accessible because of cost, availability, or scheduling limitations.

Advancements in artificial intelligence, computer vision, and deep learning have enabled the development of intelligent fitness monitoring systems capable of analyzing human movements in real time.

Human pose estimation techniques allow systems to identify body landmarks and monitor posture without requiring wearable sensors or specialized hardware [1].Modern pose estimation frameworks integrated with OpenCV and MediaPipe have demonstrated high efficiency in detecting and tracking body movements for fitness applications [2]. Recent studies have also explored the use of deep learning models for posture correction, movement analysis, and rehabilitation systems [3], [4], [5]. These systems improve exercise accuracy by analyzing body joint positions and identifying incorrect movement patterns. Furthermore, survey-based research in human pose estimation highlights the growing importance of lightweight and real-time pose estimation models for interactive applications such as fitness coaching and motion tracking [4], [6].

To address these challenges, this work proposes *FitVision*, an AI-based smart fitness assistant that combines pose estimation, posture evaluation, repetition

counting, and conversational assistance into a unified system. The proposed system utilizes BlazePose for real-time landmark detection and rule-based motion analysis for exercise classification and posture correction. Additionally, the system integrates *FitBot*, an AI-powered chatbot that assists users by answering workout-related queries and improving user interaction.
The major contributions of this work include:

- Real-time exercise monitoring using BlazePose-based pose estimation
- Joint-angle-based posture evaluation and movement analysis

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- Rule-based repetition counting for exercise tracking
- Integration of an interactive AI fitness chatbot for user assistance

II. LITERATURE REVIEW

Several studies have explored the application of artificial intelligence and pose estimation techniques in fitness monitoring and movement analysis systems. Phalke et al. proposed an AI-driven fitness framework that utilized pose estimation and movement correction techniques to improve exercise accuracy and posture alignment during workouts [1]. Similarly, Menon et al. developed a real-time fitness pose detection system using MediaPipe and OpenCV, demonstrating efficient human landmark detection and movement tracking for home-based fitness applications [2].

In the field of movement analysis, Rode et al. evaluated monocular human pose estimation models for clinical movement assessment and concluded that pose estimation frameworks can effectively analyze body posture and physical movements with high precision [3]. Gao et al. presented a systematic survey on human pose estimation techniques, discussing lightweight architectures, downstream tasks, and future research opportunities in real-time motion analysis systems [4]. Tharatipyakul et al. further investigated deep learning-based human body pose estimation methods and emphasized their significance in human movement science and exercise monitoring applications [5]. Additionally, Guo et al. reviewed modern monocular 3D human pose estimation approaches and highlighted challenges related to accuracy, computational efficiency, and real-time implementation [6].

Although existing systems demonstrate strong capabilities in pose estimation and movement recognition, many lack integrated conversational assistance and interactive feedback mechanisms. To overcome these limitations, the proposed *FitVision* system combines real-time pose estimation, posture correction, repetition counting, and chatbot-assisted interaction into a single intelligent fitness platform.

III. SYSTEM ARCHITECTURE

The proposed *FitVision* system is designed as a multi-stage intelligent fitness monitoring framework that converts raw video input into meaningful fitness analytics. The system integrates computer vision, pose estimation, temporal motion analysis, and conversational AI to monitor user exercises in real time [2], [4].

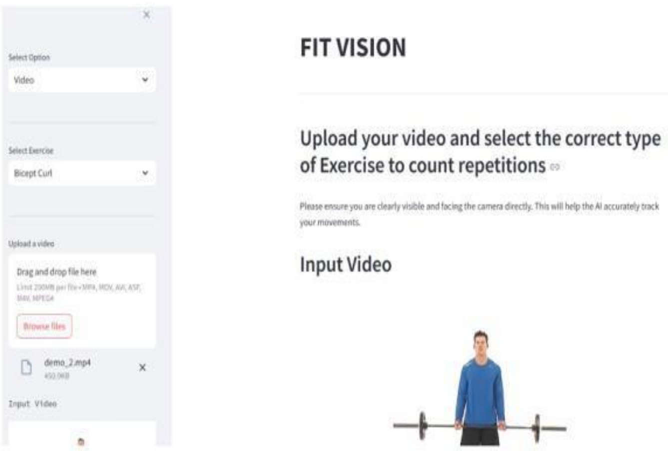

Fig. 1. Overall Architecture of FitVision

A. Video Acquisition and Preprocessing

The system begins by capturing video input either from a live webcam feed or a pre-recorded workout video. The acquired frames undergo preprocessing operations such as resizing, normalization, and noise reduction to ensure consistency under varying lighting and environmental conditions. These preprocessing techniques improve the robustness of subsequent pose estimation stages.

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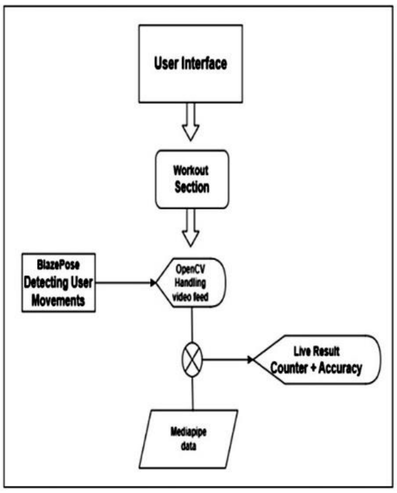

B. Pose Estimation Module

The core component of the system is the BlazePose-based pose estimation module, which detects and tracks human body landmarks in real time [2]. The model identifies important anatomical keypoints including shoulders, elbows, hips, knees, and ankles, there by creating a digital skeletal representation of the user's body posture.

C.Temporal Feature Modeling

To analyze dynamic exercises, the system tracks landmark movements across consecutive frames. Temporal variations in joint angles and body posture are analyzed to identify exercise patterns and movement sequences [5]. This enables the system to distinguish valid exercise repetitions from random body movements.

D. Posture Evaluation Mechanism

The posture evaluation module calculates joint angles using geometric relationships between detected body landmarks. These calculated angles are compared with predefined biomechanical thresholds derived from standard exercise guidelines to determine posture correctness [1], [3], [5] .

E. Repetition Counting Strategy

The repetition counting mechanism divides each exercise into multiple movement phases. A repetition is counted only when the user successfully completes the full movement sequence while maintaining correct posture throughout the exercise. This reduces false repetition counts and improves tracking accuracy.

F. Conversational Assistance Module

To improve user interaction and accessibility, the system integrates FitBot, an AI-powered conversational assistant. The chatbot provides exercise recommendations, workout guidance, and fitness-related assistance, thereby enhancing the overall user experience.

G. Output Interface

The final outputs generated by the system include exercise classification, posture correction feedback, repetition counts, and chatbot responses. These outputs are displayed through an intuitive graphical interface for effective workout monitoring and performance analysis.

IV. ALGORITHM WORKFLOW

- Capture video input
- Extract frames
- Detect landmarks
- Compute joint angles
- Classify exercise using Rule-Based Motion Analysis
- Validate posture
- Count repetitions

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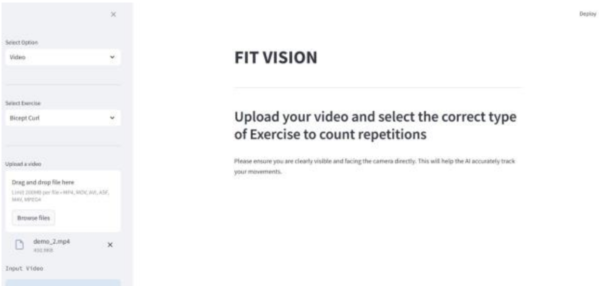
V. IMPLEMENTATION

The system is implemented in Python using OpenCV and MediaPipe.
Key Components:
- OpenCV for video processing
- BlazePose for landmark detection
- Rule-Based Motion Analysis for classification
- Angle-based repetition counting
- FitBot chatbot for user interaction



VI. RESULTS AND ANALYSIS

A. *Main Results*

Table II shows the main performance results for the proposed AI-based fitness trainer system. The system exhibits a high accuracy in the classification of exercises, reaching 93%. This shows the effectiveness of the proposed rule based approach for classification, utilizing joint angle analysis. This also shows the effectiveness of the proposed system in distinguishing between exercises, even when there are small changes in the way an exercise is performed. Moreover, the proposed system for counting repetitions attains an average accuracy of 85%. This shows the effectiveness and efficiency of the proposed system in real world applications for tracking exercises. The proposed system combines the effectiveness of pose estimation and rule-based motion analysis for achieving efficiency. The proposed system for classification attains high accuracy through the proposed approach. This can be seen in the confusion matrix in Fig . 5

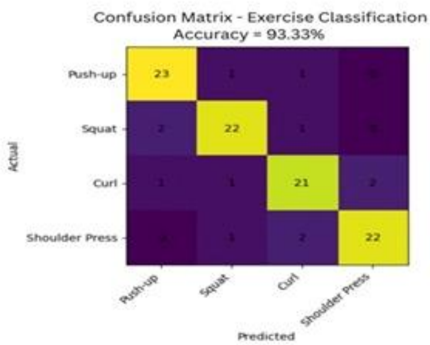


Fig. 5. Confusion Matrix for Exercise Classification

It can be noted that most of the values are concentrated along the diagonal line, which indicates correct predictions were made for most of the test cases. The off-diagonal elements represent incorrect classifications, which occur mostly between exercises with similar motion patterns such as Bicep Curl and Shoulder Press. This is because of similar movements of the arm.

TABLE I
MAIN RESULTS ON FITNESS EXERCISE DATASET

Method	Precision	Recall	F1-Score	Accuracy	Rep Counting Acc.
Proposed AI Trainer	0.92	0.91	0.91	0.93	0.85

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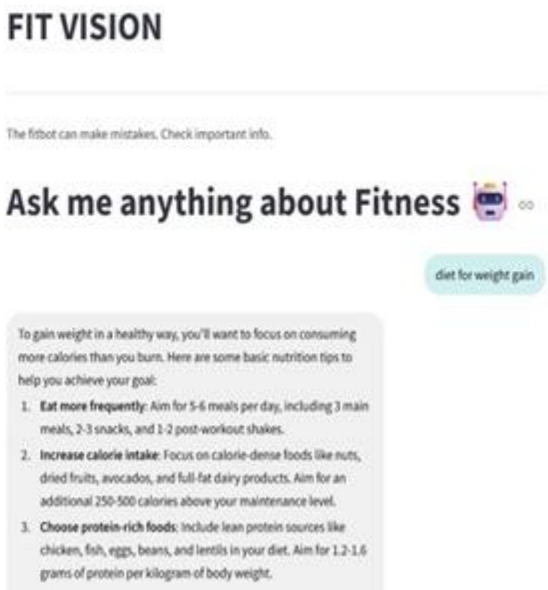
B. Repetition Counting Performance

Table III shows the evaluation of the repetition counting mechanism in terms of the identified repetition counts and their comparison with the actual counts. From the results, it can be seen that the system has consistent performance in identifying the exercise cycles. From the results, it can be seen that slightly higher accuracy is obtained in exercises like squats, where the movement involves larger variations in joint angles. On the other hand, slightly lower accuracy is obtained in exercises like bicep curls and shoulder presses, which are upper-body exercises.



The average accuracy of the repetition counting process is found to be approximately 85%. This reflects the success of the angle-based thresholding method in motion tracking.

TABLE II
REPETITION COUNTING PERFORMANCE

Exercise	Actual Reps	Detected Reps	Accuracy
Push-up	20	18	90%
Squat	15	14	93%
Bicep Curl	20	17	85%
Shoulder Press	15	13	87%

C. System Performance Analysis

The entire system, which utilizes a deep learning model for classification and a rule-based system for repetition counting, offers a complete fitness monitoring system. Although the accuracy of the deep learning model is high, i.e., 93%, the repetition counting model introduces a minor degree of uncertainty due to the use of predefined joint angle thresholds. The accuracy of the entire system is estimated to lie in the range of 85-90%. However, the system exhibits consistent performance under different conditions, including lighting, camera, and posture conditions.

D. Limitations

The system, despite its good performance, also has a few limitations: • In low light conditions, the accuracy of the system re duces, which affects the reliability of the pose estimation • The performance of the system also depends on the camera angle, as well as the parts of the body being partially occluded • The fixed thresholds based on the angle also do not generalize well for different individuals with different body proportions • The limited dataset also affects the generalization capability of the model

E. Discussion

The experiment results show that the proposed system, which utilizes the MediaPipe model for pose estimation along with rule-based motion analysis based on joint angle thresh olds, is a good solution for exercise classification based on user poses. The proposed system, based on the experiment, is effective, but minor inconsistencies in the repetition of the exercise may arise based on the user poses, which deviate from the standard poses during exercise execution.

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VII. CONCLUSION

FitVision is an intelligent fitness assistance system that includes pose estimation, deep learning, and chatbots. The system shows promising results and real-world potential for home fitness and rehabilitation.

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